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Understanding Public Risk Perception and Responses to Changes in Perceived Risk

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INTRODUCTION

This chapter will introduce scholars and policy-makers interested in the public's perception of risk and its effect on individual and collective responses to some psychological literature on these topics. Depending on the reader, the sections below will contain either too much or too little information. The latter (too little information) can be remedied by consulting the provided references to specific facts, theories, or arguments for more information. The former (too much information) can be solved by reading just the remainder of this introduction and the conclusions and by sampling from the intervening sections as needed.

The section "Function of Risk Perception" argues that the general public only distinguishes between a small number of risk levels (present/absent or negligibly low/need to monitor/unacceptably high) and that triggering events shift their perceptions from one level to another. This results in either an under- or overreaction to existing risks in most situations, as illustrated in Figure 4.1. Real-world examples of such rapid shifts in reaction are provided in Boxes 4.1 to 4.3.

"Individual Risk Perception" provides more background on several psychological processes that give rise to the discrepancy between actual and perceived levels of risk. Risk often is a feeling rather than a statistic based on objective outcomes, and this feeling is influenced by reactions (dread, feeling out of control) that may not closely connect to objective loss or risk statistics. Importantly, it is this feeling of being at risk that motivates action. However, this flag goes down when some action has been taken, giving rise to a single-action bias that discourages sustained attention to complex risks.

BOX 4.1 *Hormone Replacement Therapy*

For several decades until recently, hormone replacement therapy (HRT) was a widely used medical intervention for menopausal women in the US that was designed to decrease the risks of coronary heart disease and osteoporosis, but it could also result in possible increases in the risk of breast cancer. HRT was a \$3.3 billion market in 2001. Even though the possible risks of HRT were always known and evidence about their magnitude accumulated gradually, press coverage and public narrative about its risk-benefit ratio showed a far less gradual trajectory, with (in hindsight) initial underestimates of the actual risks and more recently probably occasional overestimates (Katz 2011). Perceived risk increased dramatically following the results of a randomized control clinical trial by the Women's Health Initiative of the National Institute of Health in 2002, which showed reduced incidence of colorectal cancer and bone fractures, but also larger incidence of breast cancer, heart attacks, and strokes, concluding that the benefits did not outweigh the risks. This assessment was confirmed in a large national study done in the UK in 2004. The number of women taking hormone replacement therapy has dropped steeply as a result. NIH's Women's Health Initiative and the United States Preventive Task Force have drastically reduced recommendations for such therapy.

“Social Amplification of Risk” makes the point that social, institutional, and cultural processes also play a role in the perception of risk, typically by amplifying individual responses to triggering events that increase the perceptions of risk. Social amplification provides one or multiple narratives for why risk levels have changed and what needs to be done in response. Agreement on a narrative contributes to action. Multiple competing narratives may increase perceptions of risk, but they discourage corrective action.

“Individual Action and Choice under Risk and Uncertainty” argues that normative models of action from economics or finance fail to capture much observed behavior. Risk-return models for the pricing of risky investment options in finance can be adapted to describe the observation that responses to risk and risky situations involve a trade-off between the expected returns and the perceived riskiness of the situation. However, in contrast to the finance models that price risky investment options as

BOX 4.2 *Nuclear Power*

Nuclear power accidents provide a good example of the type of event that leads to a rapid step-function increase in perceived risk, as the result of a perceived loss of control over possible adverse catastrophic consequences. The American public's opposition to nuclear power in the late 1950s triggered the investigation of the psychological risk dimensions discussed above. That is, the nuclear power industry commissioned psychologists to explain why public risk perceptions of nuclear power generation (compared to the use of other fuels like coal) were so different from engineering estimates. Presumably it was the better understanding of the sources of these public fears that led to greater public acceptance of nuclear power, and during the 1970s the number of reactors under construction increased continuously. The Three Mile Island accident in 1979, a partial nuclear meltdown, put a halt to that, despite the fact that only small amounts of radioactive gases and radioactive iodine were released into the environment (International Atomic Energy Association 2008). Public fear about insufficient understanding and control over a dangerous and complex technology was expressed and amplified by the media, who used sorcerer's apprentice storylines in movies like "The China Syndrome." The 1986 Chernobyl accident reinforced concern about gaps in our understanding of the risks of the technology, and the recent Fukushima Daiichi accident showed that existing backup plans to provide coolant to reactor cores had dangerous gaps under conditions of natural disasters in the form of tsunamis. Long-term regulatory and political reactions to the most recent nuclear power accident are still unclear in most countries, but at least in one major Western democracy, namely Germany, it has led to a public decision to phase out nuclear power by 2022, and countries like Japan, Switzerland, and Italy have announced reductions in their reliance on nuclear power generation (Clayton 2011).

a trade-off between option outcomes' expected value and variance, psychophysical models of risk-return trade-offs model expected returns and perceived risk as a psychological variable (a feeling) that can vary between individuals or groups as a function of cultural beliefs or expectations or past experience.

BOX 4.3 2008 Subprime Mortgage Crisis

The 2008 subprime mortgage crisis is an example of an unexpected regime change. Prior to the crisis, US investors widely believed that real-estate prices would or could never fall, a belief that had been supported by over 30 years of steady and sometimes quite dramatic price increases (www.census.gov/const/uspriceann.pdf). Once this belief was challenged by empirical events to the contrary, panic resulted, as existing models and narratives no longer provided guidance for action. When real-estate prices started to fall in 2007/2008, the worst financial crisis since the great depression emerged.

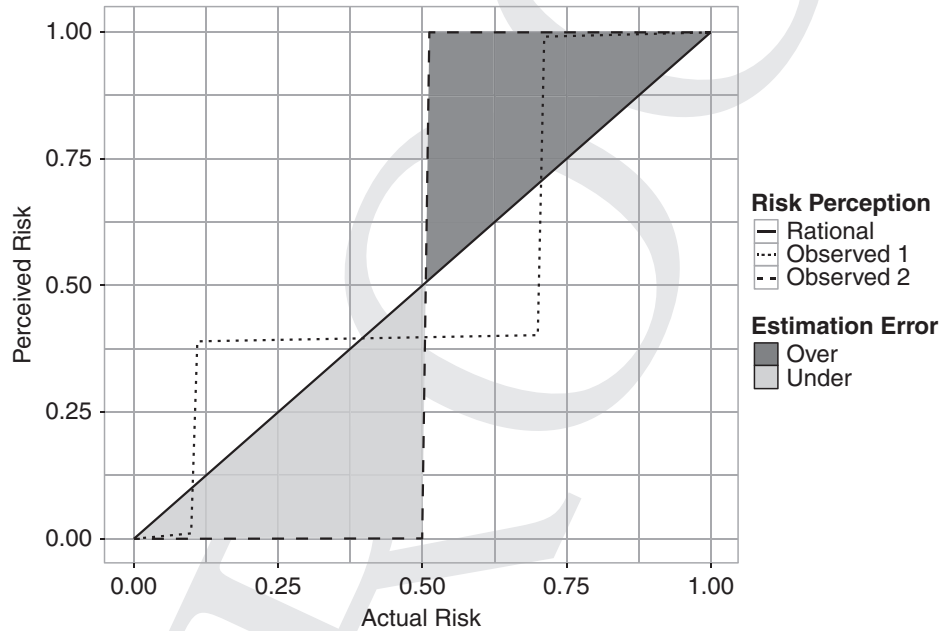


FIGURE 4.1 Perceived risk versus actual risk

“Regulatory Responses” reviews similarities and differences in the responses by members of the general public vs. domain experts and policy-makers to risks and changes in perceived risk. One large difference is the way in which the two groups receive and seek out information about the possible outcomes of different risks or risky choice options, either by trial-and-error exposure and personal experience of consequences over time (decisions from experience, more common among the general public) or

by statistical description of possible consequences based on existing data or theories and models (decisions from description, more common among technical experts). Decisions from experience put a lot of weight on recent experiences, which explains some of the apparent fickleness on the part of the general public in their perceptions of risk. Some of the biases that describe individual responses to risk and uncertainty, in particular the single action bias (i.e. the tendency to take one protective action against a perceived risk, but to then take down the flag that indicates that some action is necessary) may also explain some failings on the part of policy-makers, e.g. the absence of spontaneous ex-post regulatory review. Theories like the garbage can model of organizational decision-making question the application of rational choice model assumptions at corporate or governmental levels and substitute them with more anarchic processes.

“Causes of Changes in Perceived Risk” discusses two different attributions of apparent changes in perceived risk, namely previous failure to accurately assess risk levels or a change in external circumstances (i.e. a regime change). Different attributions call for different solutions. “Reactions to Changes in Perceived Risk” suggests that the presence or absence of trust in regulatory agencies or other groups that can help control risks will play an important role.

FUNCTION OF RISK PERCEPTION

Human perception, judgment, and choice are complex. They have evolved to allow decision-makers to function in a broad range of environments that change with seasons or political regimes and over time, and to satisfy a great variety of often-contradictory goals. Thus human actors need to procure sustenance on a regular basis, which may require exploration and risk-taking, but at the same time need to ensure safety and survival, which require protection and caution. Within the rational actor framework, dominant in policy circles, actions are modeled as the product of deliberations that involve analyses of the probabilistic costs and benefits of different response options (Becker 1976). In contrast, psychological models of action selection allow for a far broader range of triggers and processes (Weber and Johnson 2009), including emotional responses to situations. Proverbial emotions of greed vs. fear or subjective feelings of confidence vs. caution give rise to exploration or novelty seeking vs. retreat to the known and familiar, respectively. In many situations it is the perception of an imminent threat that triggers

a switch from exploration and opportunity seeking to self-protective behavior.

Change is inevitable, and adaptation to change is necessary and happens eventually, either on individual or evolutionary time scales. Nevertheless, change is effortful and poses risks, and people dislike it *ex ante*, giving rise to a strong status quo bias (Samuelson and Zeckhauser 1988). Motivation to overcome this status quo bias typically comes in the form of a strong affective signal that business as usual is no longer an option, which at an analytical level may be encoded as an increase in perceived risk of the status quo. Bracha and Weber (2012) argue that the human need for predictability and control is central to a psychological account of confidence and to an understanding of perceptions of risk, fear, and panics. Confidence in a system, say in a technology or a financial market, results when citizens or investors believe they understand how things work, which leads to a sense of predictability and being in control (Einhorn 1986) and the perception of low risk (E. U. Weber, Siebenmorgen, and Weber 2005). A feeling of control legitimizes opportunity seeking, i.e. reaping benefits without fear of catastrophic losses.

The presence of risk or potential for adverse consequences is a continuous variable, as shown in Figure 4.1. Without professional training in probability theory and probabilistic reasoning, people have a tendency to simplify probabilistic situations and may distinguish only between two (absent or present) or three (absent, moderate, severe) different levels of risk, also shown in Figure 4.1. What this means is that for low levels of risk, existing risks are given less attention and weight than their probability warrants (Hertwig et al. 2004). Events that destroy the sense of predictability and control tend to trigger rapid and drastic shifts in the perception of risk, taking it up to the next or other level of concern, often resulting in overreactions or panics. Behavior at the individual level includes retreat to safe and familiar choice options (be they investment vehicles or technologies) to minimize exposure to perceived danger, until a new account/model of how things work has been established (Bracha and Weber 2012). Real world examples of such responses can be found in Boxes 4.1 to 4.3. Reassessments of risk at the individual level may, in turn, trigger expert reassessment at the regulatory level to examine whether prior evaluations of risk levels were correct in light based on the new information (the triggering accident or crisis) and/or to diagnose a regime change and identify its causes.

INDIVIDUAL RISK PERCEPTION

Uncertainty refers to a state in which decision-makers are unable to predict what exactly will happen if they engage in a given action. The degree of this uncertainty can vary, with endpoints on a continuum that ranges from no to partial to full information about outcomes and their probabilities (Knight 1921). In economics this is represented by the probability distribution over future states of the world, where “decision under risk” refers to decision made when the probability distribution over future states of the world is known and “decision under uncertainty” or “ambiguity” refers to decisions made when this probability distribution is unknown. The less that is known about future probability distributions of outcomes based on past experience, i.e. the greater the degree of uncertainty, the more room there is for individual and situational differences in the assessment of existing risk, as the result of differential attention to either the upside potential of an uncertain outcome distribution (wishful thinking or optimism) or the downside potential (precaution or pessimism) (E. U. Weber 2010).

RISK AS A FEELING

In contrast to the economic or engineering mathematical assessments of risk as the likelihood and severity of adverse events, psychology depicts *risk perception* as an intuitive assessment of such events and their consequences. Popular uses of the term risk often also refer to either the probability of an aversive event (the risk of rain) or its severity (value at risk), rather than some combination of the two. Evidence from cognitive, social, and clinical psychology indicates that risk perceptions are influenced by past experiences that result in associations – connections between objects or events contiguous in space or time, resembling each other, or having some causal connection (Hume 2000) – and affective responses – feelings or emotions – and that these influence risk perception as much or even more than analytic processes (E. U. Weber 2010). Kahneman (initially in his 2003 Nobel address (Kahneman 2003) and more extensively in his 2011 book) has captured decades of behavioral research by characterizing two modes of thinking, called System 1 and System 2. The associative and affective processes that give rise to intuitive perceptions of risk are typical of System 1 thinking, which operates automatically and quickly with no effort or voluntary control, and is available to everyone from an early age. Analytic assessments of risk, on the other

hand, are typical of System 2 processes, which work by algorithms and rules such as probability calculus, Bayesian updating, and formal logic. System 2 processes must be taught explicitly and require conscious effort and control, and thus operates more slowly. Even though these two processing systems do not map cleanly onto distinct regions of the brain and often operate cooperatively and in parallel (E. U. Weber and Johnson 2009), Kahneman (2011) argues that the distinction between System 1 and 2 helps to make clear the tension between automatic and largely involuntary processes and effortful and more deliberate processes in the human mind. Psychological research over the past decade has documented the prevalence of System 1 processes in the intuitive assessment of risk, depicting them as essentially effort-free inputs that orient and motivate adaptive behavior, especially under conditions of uncertainty (Finucane et al. 2000; Loewenstein et al. 2001; Peters et al. 2006).

PSYCHOLOGICAL RISK DIMENSIONS

Puzzled by the American public's perception of the riskiness of nuclear power that did not coincide with engineering or public safety estimates of morbidity or mortality risks associated with nuclear-generated vs. other (carbon-based) sources of power, the nuclear power industry in the 1970s commissioned several psychologists to investigate this discrepancy. Slovic identified two psychological risk dimensions that influence people's intuitive perceptions of health and safety risks in ways common across numerous studies in multiple countries and that explain differences between the risk perceptions of members of the general public vs. those of technical experts (Slovic 1987). The first dimension, *dread risk*, captures emotional reactions to hazards like nuclear reactor accidents, or nerve gas accidents. That is, things that make people anxious because of a perceived lack of control over exposure to these events and because their consequences may be catastrophic. The second dimension, *unknown risk*, refers to the degree to which a risk (e.g. DNA technology) is seen as new, with a perceived lack of control due to unforeseeable consequences. Responsiveness to these factors shows that the human processing system maps both the severity and the uncertainty component of the risk of future events into affective responses and represents risk as a feeling rather than as a statistic (Loewenstein et al. 2001), consistent with System 1 processing.

The fact that *dread* and the *unknowability* of a risk increase risk perception provides an explanation for the moderating effect of familiarity on the perceptions of the risk of a hazard or risky choice option,

holding objective information about the probability distributions of possible outcomes constant (e.g. E. U. Weber, Siebenmorgen, and Weber 2005). Knowing a certain product, investment, person, or environment gives rise to the feeling of familiarity. Empirical research shows that familiarity not only breeds liking, but also breeds greater comfort, i.e. reduces dread and feelings of risk, and increase the feeling of control (E. U. Weber et al. 2005). The association between familiarity and lower levels of risk can be legitimate, when greater personal experience with a risky option (e.g. 20 years of working in a nuclear power plant without any accidents) provides a more reliable data base to assess existing danger), but it may also be spurious, as when a stock simply has a familiar name or is of a local firm (see Huberman 2001).

DETECTING CHANGES IN RISK

Detecting changes in risk can be challenging for multiple reasons. The fact that humans habituate to changes in magnitude or intensity makes gradual change very hard to detect. Ernst Heinrich Weber's Law (1834) specifies the magnitude of a just noticeable difference (JND) for sensory perception and finds that the increase in magnitude necessary to perceive a JND is proportional to the starting value, meaning that greater increments are necessary to detect increases at higher levels.

People's default mental model, at least during periods of stability, is one of perseverance of conditions, meaning that people require a very strong signal to believe that there has been a regime change, i.e. that conditions have changed to a regime with either greater or lesser risks.

Few events are deterministic, and the fact that outcomes are often probabilistic makes the detection of regime changes more difficult, as a more negative or positive outcome than expected can also be simply an extreme draw from the distribution of outcomes under the old regime. People's expectations of change (or stability) are important in their ability to detect trends in probabilistic environments, as illustrated by a historic climate example (Kupperman 1982, reported in E. U. Weber 1997). English settlers who arrived in North America in the early colonial period assumed that climate was a function of latitude. Newfoundland, which is south of London, was thus expected to have a moderate climate. Despite repeated experiences of far colder temperatures and resulting deaths and crop failures, colonists clung to their expectations based on latitude and generated ever-more complex explanations for these deviations from expectations. In another example, farmers in Illinois were asked to recall

salient growing season temperature or precipitation statistics for seven preceding years (E. U. Weber 1997). Farmers who believed that their region was undergoing climate change recalled temperature and precipitation trends consistent with this expectation, whereas farmers who believed in a constant climate, recalled temperatures and precipitations consistent with that belief. Similarly, Leiserowitz and colleagues (2008) found that differences in political ideology between segments of the US population, associated with beliefs about climate stability shape climate change perceptions.

SOCIAL AMPLIFICATION OF RISK

Social, institutional, and cultural processes have been shown to amplify individual responses to a risk (Kasperson et al. 1988). Such amplification by scientists or engineers who communicate the risk assessment, news media, interpersonal networks, and other groups and institutions occur in the transfer of information about the risk and in the protective response mechanisms of society (Weinstein et al. 2000; Taylor 1983). Evidence from the health literature, the social psychological literature, and the risk communication literature suggests that these social and cultural processes serve to modify perceptions of risk in ways that can both augment or decrease response in ways that are presumably socially adaptive and that constitute a battle for individual and public attention. Media and public attention, just like individual attention, tends to be focused on adverse events ("if it bleeds, it leads;" E. U. Weber 1994), and thus most social amplification has the effect of increasing perceptions of risk. Only occasionally does the absence of widely anticipated adverse events (such as the millennium or Y2K computer program bug that was erroneously predicted to bring down computer systems around the world) garner media attention, leading to an amplification of decreases in perceived risk.

Fundamental worldviews also shape how people select some risks for attention and ignore others. Douglas and Wildavsky (1982) identified five distinct "cultures" (labeled hierarchical, individualist, egalitarian, fatalist, and hermitic) that are said to differ in their patterns of interpersonal relationships in ways that affect perceptions of risk. Hierarchists tend to perceive industrial and technological risks as opportunities and thus less risky, whereas egalitarians see them as threats to their social structure (Dake 1991). Leiserowitz (2006) provides evidence for the value of this approach to understanding group differences in the US in their perceptions of climate change risks. Other researchers trace differences in risk

perceptions to differences in fundamental value priorities, following the work of Schwartz (1992) or in worldviews such as the New Ecological Paradigm (Dunlap and Van Liere 1978).

Social amplification can be seen as a process that provides one or multiple narratives for why risk levels have changed and what needs to be done in response. As Frederick W. Mayer's conceptual essay (Chapter 6) for this volume argues, agreement on a narrative contributes to action and shapes the specific dimensions of any response. Multiple competing narratives may increase perceptions of risk but discourage corrective action.

INDIVIDUAL ACTION AND CHOICE UNDER RISK AND UNCERTAINTY

Perception of risk or detection of changes in risk are not an end in themselves, but are signals to motivate protective action, which often suggest changes from business as usual to counteract the status quo bias (Samuelson and Zeckhauser 1988). Different models of risky choice put a different emphasis on the role of perceptions of risk. Neither objective nor subjective risk perception plays any role in expected utility theory (von Neumann and Morgenstern 1944/47), the ruling normative model of risky choice in economics, or in its widely known, behaviorally more descriptive psychological version, prospect theory (Kahneman and Tversky, 1979). However, the risk – return framework of finance provides such a role for the perception of risk. Markowitz (1952) proposed to model people's willingness to pay (WTP) for risky option X as a trade-off between the option's return $V(X)$ and its risk $R(X)$, with the assumption that people will try to minimize level of risk for a given level of return:

$$\text{WTP}(X) = V(X) + bR(X)$$

Traditional risk-return models in finance equate $v(X)$ with the expected value of outcomes that can occur under option X and $R(X)$ with the variance of these possible outcomes. Model parameter b describes the precise nature of the trade-off between the maximization of return and minimization of risk and serves as an individual difference index of risk aversion. This model is widely used in finance, e.g. in the Capital Asset Pricing Model (CAPM) (Sharpe 1964).

Behavioral extensions of this normative risk – return framework (Sarin and Weber 1993) question the equating of risk with outcome

variance. Psychological studies have examined the perception of risk, both directly – by assessing people’s judgments or rankings of the riskiness of risky options and modeling these, often using axiomatic measurement models – and indirectly – by inferring the best fitting metric of riskiness from observed choices under the assumption of risk-return trade-offs (see E. U. Weber 2001). These studies are unanimous in their verdict that the variance or standard deviation of outcomes fails to account for perceived risk, i.e. for the intuitive feeling of being at risk that people can quantify by judging riskiness of different choice options or action alternatives, e.g. on a scale from 0 to 100. Risk judgments deviate from the variance or standard deviation of possible choice outcomes for a variety of reasons. First, deviations above and below the mean contribute symmetrically to the mathematically defined variance, whereas perceptions of riskiness tend to be affected far more by downside variation (e.g. Luce and Weber 1986). Second, variability in outcomes is perceived relative to average returns. A standard deviation of +/- \$100 is huge for a risky option with a mean return of \$50 and amounts to rounding error for a risky option with a mean return of \$1 million. The coefficient of variation (CV), defined as the standard deviation (SD) that has been standardized by dividing by the EV, i.e.

$$CV(X) = SD(X)/EV(X)$$

provides a relative measure of risk, i.e. risk per unit of return. The most important implication of using the CV as a measure of perceived risk for the current discussion is the fact that increases in risk will be harder to detect, the larger the average level of existing risk is, following E. H. Weber’s (1834) psychophysical law. The CV is used in many applied domains and provides a vastly superior fit to the risk-taking data of foraging animals and people who make decisions from experience, as discussed in the next section. E. U. Weber, Shafir, and Blais 2004). E. U. Weber et al. (2004) show that simple reinforcement learning models that describe choices in such learning environments predict behavior that is proportional to the CV and not the variance.

Psychophysical risk – return models thus allow for both return (V) and risk (R) to be psychological variables that may need to be directly assessed from members of the general public and that may show individual, group, cultural, or situational differences, rather than just being objective and immutable attributes of risky options (E. U. Weber, Blais, and Betz 2002). Whereas technically trained scientists and policy experts may use the

formalizations of risk used in the normative models of their discipline, members of the general public can be expected to assess risk more intuitively and thus be influenced more by the psychological risk dimensions described earlier. Psychophysical risk – return models agree with the risk–return models used in finance on the assumption that preference (including willingness-to-pay) for risky option X is a trade-off between its expected value and its perceived risk:

$$\text{WTP}(X) = V(X) - bR(X)$$

This assumption has been verified in numerous studies and forms the basis of a psychometric scale (the Domain SPECific Risk Taking, or DOSPERT scale, E. U. Weber, Blais, and Betz 2002) that outperforms expected-utility based measures of risk attitude (e.g. the Holt–Laury measure of risk attitude) and other psychometric scales in a broad range of lab and real world settings (Enkavi et al. 2014).

DECISIONS FROM DESCRIPTION VS. FROM EXPERIENCE

There are important differences in the way people make decisions when information about uncertain choice options comes from repeated personal experience rather than a statistical (numeric or graphic) description of possible outcomes and their likelihood (E. U. Weber, Shafir, and Blais 2004). This distinction between learning about risk and risky outcome distributions from experience versus from description matters because ostensibly the same information about events and their likelihoods can lead to very different perceptions and actions (Hertwig et al. 2004), as the result of the engagement of different psychological processes. Learning from repeated personal experience involves the System 1 associative and affective processes described above, that are fast and automatic, while learning from statistical descriptions requires analytic processing and cognitive effort. Possibly for this reason, when given the choice between attending to information provided in the form of statistical summaries or to information provided by personal experience, personal experience is more likely to capture most people’s attention, and its impact dominates statistical information, even though the latter is often far more reliable (Erev and Barron 2005). These findings help to explain a key pattern identified by Thomas A. Birkland and Megan K. Warnement in their conceptual essay in this volume (Chapter 5) – that a repetition of similar crisis events in a given society has a much bigger impact than a single event.

There is evidence that individuals draw different lessons from experience than from description, especially when small-probability events are involved. Decisions from description are described well by prospect theory (Kahneman and Tversky 1979; Tversky and Kahneman 1992), which is based on hundreds of studies of choices between described risky options, typically in the form of monetary lotteries. In such choices, decision-makers tend to overweight the impact of small probability events, especially when such events have large positive or negative valence (e.g. a .001 chance of making \$5,000, or a .005 chance of brain damage as the side effects of vaccinating against measles). In contrast, decisions from experience follow classical reinforcement learning that gives recent events more weight than distant events (E. U. Weber, Shafir, and Blais 2004). Such updating is adaptive to dynamic environments where circumstances might change. Because rare events (e.g. large financial losses) have a smaller probability of having occurred recently, they tend (on average) to have a *smaller* impact on the decision than their objective likelihood of occurrence would warrant. When they do occur, however, they have a much *larger* impact on related decisions than warranted by their probability. This makes learning and decisions from experience more volatile across respondents and past outcome histories than learning and decisions from description (Yechiam, Barron, and Erev 2005). These reinforcement learning models and their predicted more volatile responses to small probability risks seem to describe the general public's dynamic and fluctuating reactions to small probability risks far better than rational choice models or their psychological extensions like prospect theory.

REGULATORY RESPONSES

The social environment, including its social structures and formal or informal institutions, can be seen as a way of extending individual capabilities and/or correcting for existing individual-level problems or biases (Ostrom 1990; Boyd and Richerson 1985). Given human finite attention and processing capacity and the resulting tendency to allocate scarce capacity to decisions and events close in time and space (E. U. Weber and Johnson 2009), human society has developed a division of labor whereby different individual or social problems that require longer time horizons or greater attention are assigned to designated professional groups, who are charged with developing the required professional knowledge and expertise and with using their available attention to monitor opportunities as well as risks within

their designated sphere. Thus epidemiologists and medical researchers are in charge of health risks, climatologists in charge of climate risks, and so on. Similarly, government agencies like the Department of Health or the EPA are designated to take action on behalf of and in the interest of their citizens in their designated domain, in situations where individual knowledge, interest, or attention is deemed inadequate or where individual action would be insufficient to address social problems, as in common pool resource dilemmas.

Domain-specific regulatory oversight of different sources of risks to individual citizens and the social collective (i.e. some divide and conquer strategy) is as good an idea at the social level as it is at the individual level (Clemens 1997). At the individual level, it is very hard to keep some (let alone an optimal level of) attention on all possible sources of risk. Instead, as worry increases about one type of risk, concern about other risks has been shown to go down, as if people had only so much capacity for worry or a finite pool of worry (E. U. Weber 2006). Illustrations of the finite pool of worry effect are provided by the observation that increases in the concern of the American public about terrorism post-9/11 resulted in decreased concern about other issues such as restrictions of civil liberties as well as climate change (Leone and Anrig 2003), or that the 2008 financial crisis reduced concern about climate change and environmental degradation (Pew Research Center 2009).

Regulatory guidance and oversight in areas of important societal risks is needed from a behavioral decision theoretical perspective not only to supplement individual perceptions of risk, but also to supplement individual action. E. U. Weber (1997) coined the phrase *single action bias* for the following phenomenon observed in contexts ranging from medical diagnosis to farmers' reactions to climate change. Decision-makers are very likely to take a single action to reduce a risk that they are concerned about, but are much less likely to take additional steps that would provide incremental protection or risk reduction. The single action taken is not necessarily the most effective one, nor is it the same for different decision-makers. Regardless of which single action was taken first, decision-makers tend not to take further action, presumably because the first action reduces the feeling of worry or vulnerability. E. U. Weber (1997) found that farmers who showed concern about global warming in the early 1990s were likely to change either something in their production practice (e.g. irrigate), their pricing practice (e.g. ensure crop prices through the futures market), or lobbied for government interventions (e.g. ethanol taxes), but hardly ever engaged in more than one of those actions, even

though a portfolio of protective actions might have been advisable. The fear of climate change seemed to set a “flag” that some action was required, but remained in place only until one such action was taken, i.e. any single protective action had the effect of taking down the “impending danger flag.” While such behavior might have served us well in our evolutionary history, when single actions generally sufficed to contain important risks, in more complex environments where a portfolio of risk management actions is advised, purely affect-driven, single-action biased responses may not be sufficient. Hansen, Marx, and Weber (2004) found evidence for the single-action bias in farm practices that can be interpreted as protective actions against climate change and/or climate variability. Thus, farmers who indicated that they had the capacity to store grain on their farms were significantly less likely to indicate that they used irrigation or that they had signed up for crop insurance, even though all three actions in combination would provide greater protection against climate risks.

The relationship between public and technocratic perceptions of risk as well as responses to risks or to perceived changes in risk is complex. E. U. Weber and Stern (2011) describe some of the differences between the risk assessment by scientists and non-scientists. Scientists use multiple methods to guard against error in their assessment of causal relationships and uncertainty, including observations and experiments, systematic observation and measurement, mathematical models that incorporate theories and observational data and are tested against new data, systems of checking measurements and peer-reviewing research studies to catch errors, and scientific debate and deliberation about the meaning of the evidence, with special attention given to new evidence that calls previous ideas into question. Scientific communities sometimes organize consensus processes such as those used by the IPCC and in NRC studies to clarify which conclusions are robust and which remain in dispute. Although these methods do not prevent all error, the scientific methods identify unresolved issues and allow for continuing correction of error. Non-scientists’ ways of perceiving risks and responding to risk and uncertainty, briefly reviewed above, leave them more vulnerable to systematic misunderstanding. Personal experience can easily mislead (E. U. Weber 1997), mental models of causal relationships can be too simple or wrongly applied (Bostrom et al. 1994), judgment can be driven more by affect, values, and worldviews than by evidence (Slovic 1987), and attention and response can be very selective and incomplete (E. U. Weber and Johnson 2009).

In situations where expert and public perceptions of risk disagree, the way in which the two perceptions affect each other is also complex and typically does not follow a rational model of influence. In other words, while one would expect that people would let their personal perception of risk be informed and influenced by the more comprehensive and systematic expert risk assessment, which they have at least indirectly commissioned, public and media attention and response to risk is typically swayed less by diagnostic personal exposure and memorable events than by statistical summaries or theoretical arguments or models (E. U. Weber 2006; Zaval et al. 2014). At the same time, regulatory bodies often need to respond to public perceptions or changes in public perceptions of risk, even when domain experts disagree with these assessment, because public fear, even when unfounded, has negative consequences for public health and creates barriers to responses or non-responses that might be advocated by technical experts.

Some of the less than functional behavioral patterns in the face of risk described above for members of the general public may also help to explain the behavior of regulatory agencies. The single action bias, for example, may be responsible for the preference of regulators to solve problems in single steps, rather than by a sequencing of gradual interventions, where the results of Step 1 interventions are observed and used to inform Step 2 or 3 interventions. Even if interventions are intended to be an initial step in a sequence of regulatory actions, regulatory attention wanders away from the risk, and the issue becomes “cold.” Similar dynamics may contribute to the absence of spontaneous ex-post regulatory review, necessitating the existence of meta-regulatory agencies like the Office of Information and Regulatory Affairs (OIRA) and Presidential Executive Orders (e.g. #13,563 or #13,610).

Some descriptive frameworks for organizational decision-making embrace the assumption that the actions of companies, regulatory agencies, or governing bodies may not be best described as the result of rational deliberation and belief updating as new information about the risks and benefits of different courses of action becomes available. The garbage can model (Cohen et al. 1972), for example, breaks the causal chain between problems and their solutions and assumes instead that organizations tend to produce “solutions” which may be discarded because no appropriate problem currently exists or because the solution is not acceptable in the current political climate. However problems may eventually arise for which a search of the garbage might yield fitting solutions. As Birkland and Warnement (Chapter 5, this volume) emphasize, focusing events that

change public and regulatory perceptions of risk, such as Hurricane Katrina in 2005, may have long-term effects, such as the National Flood Insurance Reform Act of 2012.

REASONS FOR CHANGE IN PERCEIVED RISK

There appears to be some asymmetry in the mechanisms and thus the speed with which perceptions of perceived risk change in the direction of decreased vs. increased risks. Perceived risk tends to decrease slowly and steadily, in a continuous fashion, as people fail to experience adverse consequences when engaging in potentially risky activities or when being exposed to potentially risky environments. The mechanism for such decreases in perceived riskiness is the absence of negative feedback in decisions from experience and the increasing familiarity with the sources of potential risk. Familiarity not only breeds liking (and increased choice), but also decreased perceptions of risk (E. U. Weber, Siebenmorgen, and Weber 2005).

Increases in perceived risk, on the other hand, tend to be far more rapid and typically not gradual. Major accidents or financial, public health, or other crises can send a strong signal that prior assessments of risk were too low, either as the result of insufficient information about existing dangers or because the “regime” has changed. Such rapid increases in perceived risk tend to be mediated by emotional rather than analytic assessment, supporting the notion that risk typically is a feeling, rather than a statistic (Loewenstein et al. 2001). Perceived risk increases when the ability to predict and control outcomes in probabilistic environments is put into question.

The need for control is a basic human need (Maslow 1954). Persistent failures to do so can lead to depression and learned helplessness (Seligman 1975), while having a sense of control is associated with better health (Plous 1993). The illusion of control refers to the human tendency to believe we can control or at least influence outcomes, even when these outcomes are the results of chance events. For example, individuals often believe they can control the outcome of rolling dice in a game of craps – throwing the dice hard for large numbers and softly for low numbers (Langer 1975). Outside of the casino, most outcomes require a combination of skill and chance, but the illusion of control also gets people to overestimate their degree of control over adverse consequences in such situations, believing for example that driving is a safer means of transportation than air travel, contrary to accident statistics (Slovic 1987).

The illusion of control is more commonly found in familiar situations and in situations associated with the exercise of skill, e.g. situations that provide involvement in the choice and competition (Langer and Roth 1975), and in stressful and competitive situations, including financial trading (Fenton O’Creivy et al. 2003). Social psychologists argue that the illusion of control is adaptive, since it motivates people to persist at tasks when they might otherwise give up and because there is evidence that it is more common in mentally healthy than in depressed individuals (Taylor and Brown 1988).

New and complex environments or technologies are potential threats, and we manage the perceived risks by forming a mental model of how the new technology and/or environment work. This model gets tested by repeated trial-and-error exposure, i.e. by engaging with risky and also rewarding options and by observing resulting outcomes and consequences. The absence of negative consequences and the occurrence of essentially predicted outcomes make us confident in our understanding of how things work and our ability to control adverse consequences. However, both the complexity and riskiness of these new technologies or environments may be underestimated in the face of positive feedback.

Events suggesting that existing mental models might be incomplete or faulty and that beliefs of control are therefore illusory – when individuals or groups realize that they can no longer predict and hence control important (financial, social, or technological) events and outcomes in their lives – trigger rapid and drastic shifts in the perception of risk, often resulting in panics. Such emotional reactions can be seen as an adaptive early warning system, evolution’s way to jolt us out of our habitual way of doing things, counteracting our strong status-quo bias (Samuelson and Zeckhauser 1988).

Black swan events, i.e. the occurrence of something previously considered outside of the plausible range of events, are a signal that our current mental model of the risky or uncertain processes is inadequate or faulty. Hence a reassessment of risks and benefits of different choice options is necessary and short-term protective action may be required. Such a fear or panic reaction in response to a signal indicating that we do not have a correct model of how things work and hence are not able to control consequences essentially reactivates the second psychological risk dimension, discussed above, fear of the unknown, which previously may have been assuaged by repeated personal successful experience with the risky choice options.

Increases in our perceptions of risk are aversive events that motivate us to turn away from newly dangerous technologies or environments and to turn to the old and familiar, whether this means embracing a known technology like coal-generated power with its known risks of climate-changing emissions, or moving from mortgage-backed securities to holding gold. Just as social processes amplify individual responses and reactions during periods of perceived control and (over)confidence, so do social processes also amplify the perceived loss of control and feelings of panic (Kasperson et al. 1988).

REACTIONS TO CHANGES IN PERCEIVED RISK

People's reactions to trigger events indicating that some activity entails much greater risk than previously assumed will depend at least in part on the attribution of this change in perceived risk, i.e. whether it is seen as an indication of a regime shift (i.e. that something important in the environment has changed) or as an indication that existing knowledge and control over the potential risk is smaller than previously assumed. The distinction between regime shifts (something changing in the external environment that may or may not have been predictable) and the revelation of incomplete or faulty mental models of the situation is of course not clear cut, but more on a continuum, as a complete and omniscient mental model of the situation would anticipate multiple regimes as well as the reasons and timing of regime shifts.

In addition to withdrawal to known and safe choice options, as discussed above, in either situation, a response to insufficient knowledge about the situation and inadequate appreciation of its risk or its complexity (including the existence of regime changes) will be a public request for safe guards on the one hand and additional research into the existing risk, until better predictive models are in place. If trust has not been irreplaceably lost as the result of the triggering accident or crisis, the general public will turn to the regulatory bodies to which it has outsourced vigilance and action in this particular content domain to provide the necessary remedial research and regulation. If trust has been lost, other more general institutions may come into play, like investigating commissions staffed by trusted organizations like national academies.

CONCLUSIONS

This chapter proposes a psychological account of perceived risk and changes in the perception of risk that applies dual process theory, where

System 1 associative, motivational, and emotional processes (e.g. wishful thinking or fear) influence and often compete with System 2 analytic or deliberative processes (Kahneman 2011). Psychological accounts of the public's and policy experts' responses to risk and changes in perceived risk allow for a much broader range of individual and situational differences in response than the rational actor framework of economics. At the individual level, decision-makers appear to be too strongly influenced by recent events and their perceptions and responses thus too volatile compared to responses based on a rational analysis of events that should trigger reassessments of risk. Social amplification of risk tends to contribute to the discrepancy between public and expert assessments of risk, rather than to a solution. Narratives of sources of risk and of control play a larger role than rational choice models would predict, and thus need to be considered more explicitly, both as obstacles and as tool, in regulatory responses to changes in perceived risk.

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