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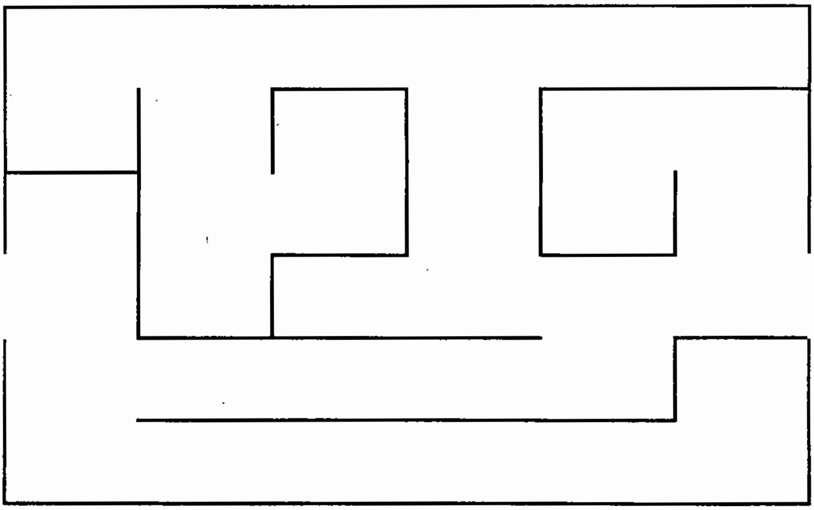
Risk Perception and Communication



An anomaly of human behavior known to casualty insurers is the "earthquake paradox." Sales of insurance policies rise dramatically following an earthquake, then gradually fall off. By contrast, the risk of another disaster is lowest immediately following a serious temblor, and rises steadily with the passage of time. Even populations in which the time course of the risk is widely known exhibit the paradoxical behavior, which redounds to the insurer's benefit, but leaves the society ill-served. Mathematically irrational behaviors, such as the earthquake paradox, arise when the scale in which a behavior is valued by an individual is not a linear function of expected return.

Economic Reason and the Quantification of Risk

Statisticians quantify chancy behavior with the idea of the "expected value" of a decision. The expected value is a summation taken over all the possible outcomes of a chance process. In the present case, we consider the chance process that is set in motion by a particular course of action. We might thus talk about the expected value of cardioversion in the treatment of arrhythmia, the expected value of a pollution control law, or the expected value of buying a lottery ticket.

In each case, the same formal logic applies. The value of every possible outcome is assessed in terms of a measurable result: the number of lives or days of life gained or lost, the gains from each degree of remediation of an environmental ill, the cost of a losing lottery ticket, or the value of the jackpot. For each possible outcome, the corresponding value is multiplied by the probability that the outcome will ensue from the decision taken. The products of value times probability, summed over all the possible outcomes, yield the expected value of the decision.

$$E(\text{Value}) = \Sigma\ \text{Value}_i f_i$$

where "Value_i" is the value of the ith outcome, which occurs with probability, or relative frequency, f_i.

The procedure is straightforward when the decision is whether to enter into a wager. Place a hundred dollar bet on the black numbers in a game of roulette. The value of the ball's landing on black is a gain of $100, the value of its landing on red is a $100 loss, as is the value of the ball's landing on green. The corresponding probabilities are 18 parts in 38, 18 in 38, and 2 in 38, so that the value of the bet is $100x(18/38) - $100x(18/38) - $100x(2/38) or a loss of $5.26.

A probability is an expected average of real outcomes, forecast into the future. As noted at the beginning of this book, attaching the word probability to a particular event is really a statement of the class to which the event belongs. With a fair roulette wheel, there is no ambiguity in specifying the class to which a single spin belongs, and probabilistic statements accurately characterize the long-run performance of the system.

The economic basis for considering the expected value of a decision is solid when the number of decisions to be made is large. The casino earns money in the gaming example because the long run return on many bets averages out to $5.26 per $100 bet. An insurance policy is akin to a bet. The wager is the premium and the payoff is the avoidance of loss. The expected return on an insurance policy is the sum of the probability of each possible payout multiplied by its value. The difference between the expected returns of many policies (bets) and the total premium (wagers) is the insurer's profit. A lottery ticket analogously has an expected return equal to the size of the jackpot multiplied by the probability of winning, and the difference between the ticket's expected value and the price is the state's average take. The average take has only a highly theoretical meaning on the level of the individual ticket, but the sum over many tickets is a favorite means of state finance.

The expected value of a probabilistic decision has a close connection to the worth that an individual attaches to the decision. The arena in which the relation holds is that within which the individual can experience a sufficient number of repeated times at risk that his total return or loss can be predicted with precision from the sum of expected values. A scofflaw who parks his car in an illegal spot may observe that the expected value of his action is cheaper than paying for a parking lot. If the probability of paying for a parking citation multiplied by the amount of the fine is less than the cost of parking legally for a day, then the choice is economically rational.

When the chance decision involves outcomes that are very rare and either very costly or very advantageous, expected value becomes a poor index of the perceived utility of a decision. Humans place a worth on the possible catastrophe or bonanza that exceeds the expected value. This is the basis of both insurance schemes and lotteries. In Massachusetts, the state with the highest per capita sales of lottery tickets in North America, the public readily accepts a jackpot that is less than 70 percent of the total take.[68] Similarly, and with good reason, I am willing to pay for automobile liability insurance a premium that exceeds the expected value, or the product of the chance of my having a costly accident multiplied by the damages. An excess cost of automobile insurance over and above the expected value of the policy of 20 or 30 percent does not seem

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68. Branch T. What's wrong with the lottery? New England Monthly 1989;7:40-9

unacceptable to most buyers. In both these instances, note that paying out more than the expected value does not result from lack of information on the part of the insured or the bettor.

The psychology that may underlie decision making in risky situations has been characterized by the "minimax" criterion. The term "minimax" is a shorthand for a strategy that involves "minimizing the maximum foreseeable loss." If I buy catastrophe insurance, I reduce the loss in case of catastrophe to the amount of the insurance premium. The cost in the absence of catastrophe is higher than it would have been had I not purchased insurance, but the expected small loss (paying the premium) is irrelevant to a minimax player. Minimax strategies are appealing when the individual is unlikely to experience all possible outcomes in the course of his risk-taking career. Pascal's wager was an example of minimax: he reasoned that the inconvenience of professing Catholicism was an acceptably small known loss, since it permitted the faithful to avoid the alternative (however unlikely) of perpetual damnation.

Insurance systems and lotteries provide a satisfactory social arrangement because they present a collaboration between two kinds of entities: the individual and the collective. The individual, with little expectation of great loss or major gain, plays the minimax strategy. He pays a surcharge over an expected value that has no direct meaning to him. The collective plays a game of expected value. The casino, the state, the underwriter all anticipate so many wagers that the overall return will approximate the expected value. Both sides win, in a sense, but observe that the system works because the collective interest (in selling the insurance policy or the lottery ticket) is just the opposite of the individual interest.

The Attribution of Risk

An analysis of expected value depends on the idea that the magnitude of risk is well understood, and can be entered into a mathematical balance.

Although gaming strategies such as minimax may have an intuitive, even genetic, basis that guides daily behavior, risk quantification is a relative newcomer to the intellectual scene.[69] Until the Renaissance, there was no recorded mathematical treatment of

69. Hacking, I. The Emergence of Probability. Cambridge University Press. Cambridge 1975

chance, and even then the relation between the long-range behavior of dice and inference about the nature of dice was not evident. The notion of probabilistic evidence that emerged around 1660 drew on two completely separate sources. One had to do with degree of belief. Teachings that enjoyed the approbation of church authorities (teachings that were "probable") were judged more likely to be true than were heretical positions. The second drew on the low sciences of alchemy and medicine. "Signs," empirical correlates of past events, were accepted as having predictive value.

Attribution of the individual to a risk class is based entirely on what would have been called "signs" in the Middle Ages. Signs then and now may be misread, and the resulting misclassification of individuals results in a misattribution of the causes of risk.

The element of risk attribution that follows after classification is the assertion that a proportion of the members of the class will manifest an outcome. The experience of the analysis of dice is particularly apropos: the behavior of fair dice can be approached empirically, in a thousand or ten thousand throws; or it can be investigated theoretically, utilizing the abstract concept of "fair dice" to derive a probability distribution. The sad connection to environmental risk assessment, however, is that neither approach seems to hold promise. The interrelations of environmental toxins with one another and with the environment are sufficiently varied that there is little opportunity to gain repeated or repeatable empirical data on health effects in the field. At the same time, the theoretical approach that comes out of isolated laboratory observation cannot yet begin to address the expected behavior of real systems. For risk assessments based on intense and repeated exposures, such as tobacco smoke, workplace toxins, alcohol, or drugs, the basis for inference is much stronger. In every case, epidemiologists or their critics ought to be alert to define the limits of that which can be reasonably achieved.

The Perception of Risk

The social and political assessment of risk bears more kinship to the approbation of church fathers than it does to the search for the operational rules of a pair of dice. Most frequently, despite expert assessments, the likely outcomes are only guessed at. Here the psychology of wagers and insurance schemes may still apply, but the choices are predicated on perceived risk.

Try a thought experiment. Imagine yourself in Québec, a city for conventioneers and tourists in a region that has experienced little seismic activity for three centuries. Across the continent there has been a disaster in another attractive city, San Francisco, and seismologists are predicting that "the big one," a devastating earthquake, will occur within the next 30 years with near certainty. Go in your thoughts from Québec to San Francisco for a few days. Most people who seriously engage their imagination in the fantasy can sense the anxiety of change from a region of low risk to one of high risk. The thrill of speeding in a car is similarly related to the transition from a low-risk state (driving slowly or not at all) to a high-risk one.

Residents of New York City, who are accustomed to muggings and street crime, feel immediately safer, they "unwind," when they vacation in the countryside. The change in risk is acutely perceived.

For comparison, now carefully imagine that you move with your family to San Francisco. You experience some trepidation at first. No earthquake occurs for a month, a year, ten years. Can you feel the "earthquake paradox" taking hold? You *are* more comfortable. In the same way the New Yorker adapts to his world. These illustrations suggest that we are more conscious of change-in-risk than we are of absolute levels of danger. Whatever level of risk we find ourselves in for a long period, we adapt to. Whenever the level changes, we are alert.

Many examples of risk seeking or risk aversion seem intuitively obvious to observers brought up in widely different cultures, to such an extent that studies that demonstrate these behaviors could almost be performed as thought experiments. My personal speculation is that the sensitivity to change has a survival value when the change is between levels of risk that are uncertain. New, but unknown, risk levels may be unacceptably high, may be catastrophic, or may require special precautions. If australopithecus scanning the savannah to protect his migrating band is too romanticized an image, consider the Manhattan dandy who drives by mistake into South Bronx: there is a survival value to anxiety in the face of change in risk. A life-preserving choice of action in the face of imperfect risk data would confer a Darwinian advantage comparable to that of the opposing thumb. Put aside for a moment the evidence that evolution involves as much happenstance as direction; we may wonder whether risk-taking behavior, like color vision, the sense of time, or the visual calculus of depth, has not in some way been optimized for safe behavior.

How much change alerts us? Consider your lifetime risk of myocardial infarction. If you are male, aged 40, a nonsmoker, and a vegetarian, your risk may be on the order of 20 percent. If you eat animal products, the risk may be 25 percent or so. Does the difference justify a change in diet? The cost is more modest than moving out of an earthquake zone, the change in risk many orders of magnitude larger in absolute terms, yet very few persons, even among those who accept the data, actually change their habits. Absolute change in risk seems not to be key to behavior change.

Studies of risk perception have included attempts to have people estimate the relative ranking of commonly discussed risks, such as the probability of being struck by lightning, of having an automobile accident, or of developing cancer within the next year. Study subjects can distinguish risks that differ from one another by a factor of ten with some reliability, but risks closer to one another are frequently confused. The relation holds over a wide range of absolute risks. Relative risk, the epidemiologic measure that compares the ratio of risk in one group to risk in another, appears to correspond, largely by accident, to a measure that people can grapple with.

Implications for Communication

There are a number of rules for discussing risk that arise from the points presented here:

Perhaps the most important is *do not expect quantitative discussions of risk to carry the day*. Neither the proponent of a decision nor the antagonist has a sufficiently well-developed intuition about the meaning of risk. The issue is not one of training, but rather of the neuropsychology of risk perception.

The next is *accept minimax*. Worst-case scenarios are not a perversion or a rhetorical tool. They are a natural manifestation of the psychology of risk perception. When the risks involved are societal, when an entire population is at risk for a single event, then the expected value rationale may not be justifiable.

Translate linear decisions into economic terms. Risk comparisons in personal perception and public debate are inherently nonlinear. If you are working in a situation in which expected value is meaningful, then set an economic meaning for expected value, and discuss that. A 30 percent risk reduction has less appeal than a 30 percent cut in taxes.

Finally recognize that *the rhetoric of risk is subject to manipulation.* Choose your baseline with care, but do not pretend to do so with the object of conveying a uniquely valid truth. Suppose that we believe that a novel chemical exposure causes leukemia in a small fraction of exposed persons. The risk may be smaller than that of cancer from a sunburn, yet still it may be advertised as a hundred times larger than the leukemia risk attributable to all manmade sources of radiation combined; opponents may counter that the same risk is less than a tenth of the risk is that attributable to viral infections, or a thousandth of the lifetime all-cause cancer mortality risk. The "meaning" is what you choose to make of it.