

## Risk Perception

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In industrialized societies, the question "How safe is safe enough?" has emerged as one of the major policy issues of the 1980's. The frequent discovery of new hazards and the widespread publicity they receive is causing more and more individuals to see themselves as the victims, rather than as the beneficiaries, of technology. These fears and the opposition to technology that they produce have puzzled and frustrated industrialists and regulators and have led numerous observers to argue that the public's apparent pursuit of a "zero-risk society" threatens the nation's political and economic stability. Political Scientist Aaron Wildavsky commented as follows on this state of affairs:

How extraordinary! The richest, longest-lived, best-protected, most resourceful civilization, with the highest degree of insight into its own technology, is on its way to becoming the most frightened.

Is it our environment or ourselves that have changed? Would people like us have had this sort of concern in the past? . . . today, there are risks from numerous small dams far exceeding those from nuclear reactors. Why is the one feared and not the other? Is it just that we are used to the old or are some of us looking differently at essentially the same sorts of experience? (Wildavsky, 1979, p. 32).

Over the past decade, a small number of researchers have been attempting to answer such questions by examining the opinions that people express when they are asked, in a variety of ways, to evaluate hazardous activities, substances, and technologies. This research has attempted to develop techniques for assessing the complex and subtle opinions that people have about risk. With these techniques, researchers have sought to discover what people mean when they say that something is (or is not) "risky," and to determine what factors underlie those perceptions. If successful, this research should aid policy makers by improving communication between them and the lay public, by directing educational efforts, and by predicting public responses to new hazards, events (e.g., a good safety record, an accident), and management strategies (e.g., warning labels, regulations, substitute products). A broad agenda for this research includes the following questions:

(1) What are the determinants of perceived risk? What are the concepts by which people characterize risks? How are those concepts related to their attitudes and behavior toward different technologies? To what extent are risk perceptions affected by emotional factors? Are they really sensitive, as is often claimed, to perceived controllability of risks and the dread they evoke? How adequate are the methods used to study perceptions of risk?

(2) How accurate are public perceptions? When laypeople err, is it because they are poorly informed or because they were unable to do better? Are people so poorly informed (and uneducable) that they require paternalistic institutions to protect them? Would they be

better off letting technical experts make most of the important decisions? Or do they know enough to be able to make their own decisions in the marketplace? When experts and laypeople disagree about risk, is it always the latter who are in error?

(3) What steps are needed to foster enlightened behavior with regard to risk? What information do policy makers and the public need? How should such information be presented? What indices or criteria are useful for putting diverse risks in perspective? How can the news media and the schools help to educate people about risk and its management?

(4) What is the role of judgment in technical assessments of risk? When experts are forced to go beyond hard evidence and rely on educated intuition, do they encounter judgmental difficulties similar to those experienced by laypeople? How well do experts assess the limits of their knowledge? How can technical judgments be improved?

(5) How do people perceive the benefits of risky technologies? Almost all questions asked about risk perceptions have analogs with benefit perceptions.

(6) What determines the relative acceptability of hazardous technologies? How are assessments of their various risks and benefits combined subjectively? What role do considerations such as voluntariness, catastrophic potential, and equity play? What risk-benefit considerations motivate people to political action? Are some kinds of risks unacceptable, no matter what benefits they are expected to bring?

(7) What makes a risk analysis "acceptable"? Some analyses are able to guide society's responses, whereas others only fuel debate. Are these differences due to the specific hazards involved, the political philosophy underlying the analytical methods, the way that the public is involved in the decision-making process, the results of the analysis, or the manner in which the results are communicated? Can policy makers responsibly incorporate social values into risk analysis?

(8) How can polarized social conflict involving risk be reduced? Can an atmosphere of trust and mutual respect be created among opposing parties? How can we design an environment in which effective, multiway communication, constructive debate, and compromise can take place?

#### The Psychometric Paradigm

One broad strategy for studying perceived risk is to develop a taxonomy for hazards that can be used to understand and predict responses to their risks. A taxonomic scheme might explain, for example, people's extreme aversion to some hazards, their indifference to others, and the discrepancies between these reactions and experts' opinions. The most common approach to this goal has employed the psychometric paradigm (Fischhoff, Slovic, Lichtenstein, Read, Combs, 1978; Slovic, Fischhoff, and Lichtenstein, 1984), which uses psychophysical scaling and multivariate analysis techniques to produce quantitative representations or "cognitive maps" of risk attitudes and perceptions. Within the psychometric paradigm, people make quantitative judgments about the current and desired riskiness of diverse hazards and the desired level of regulation of each. These judgments are then related to judgments about other properties, such as

(1) the hazard's status on characteristics that have been hypothesized to account for risk perceptions and attitudes (e.g., voluntariness, dread, knowledge, controllability), (2) the benefits that each hazard provides to society, (3) the number of deaths caused by the hazard in an average year, (4) the number of deaths caused by the hazard in a disastrous year, and (5) the seriousness of each death from a particular hazard relative to a death due to other causes.

The remainder of this paper briefly reviews some of the results obtained from psychometric studies of risk perception and outlines some implications of these results for risk communication and risk management.

#### Revealed and Expressed Preferences

The original impetus for the psychometric paradigm came from the pioneering effort of Starr (1969) to develop a method for weighing technological risks against benefits in order to answer the fundamental question "How safe is safe enough?" His revealed preference approach assumed that, by trial and error, society has arrived at an "essentially optimum" balance between the risks and benefits associated with any activity. One may therefore use historical or current risk and benefit data to reveal patterns of "acceptable" risk-benefit tradeoffs. Examining such data for several industries and activities, Starr concluded that (1) acceptability of risk from an activity is roughly proportional to the third power (cube) of the benefits for that activity, and (2) the public will accept risks from voluntary activities (e.g., skiing) that are roughly 1000 times greater than it

would tolerate from involuntary hazards (e.g., food preservatives) that provide the same level of benefits.

The merits and deficiencies of Starr's approach have been debated at length (see, e.g., Fischhoff, Lichtenstein, Slovic, Derby, & Keeney, 1981). They will not be elaborated here, except to note that concern about the validity of the many assumptions inherent in the revealed preferences approach stimulated Fischhoff et al. (1978) to conduct an analogous psychometric analysis of questionnaire data, resulting in expressed preferences. In recent years, numerous other studies of expressed preferences have been carried out within the psychometric paradigm (see, for example, Brown & Green, 1980; Gardner, Tiemann, Gould, DeLuca, Doob, & Stolwijk, 1982; Green, 1980; Green & Brown, 1980; Johnson & Tversky, 1984; Lindell & Earle, 1983; Macgill, 1983; Renn, 1981; Slovic, Fischhoff, & Lichtenstein, 1980, 1984; Tiemann & Tiemann, 1983; Vlek & Stallen, 1981; von Winterfeldt, John, & Borchherding, 1981).

These studies have shown that perceived risk is quantifiable and predictable. Psychometric techniques seem well suited for identifying similarities and differences among groups with regard to risk perceptions and attitudes (see Table 1). They have also shown that the concept "risk" means different things to different people. When experts judge risk, their responses correlate highly with technical estimates of annual fatalities. Lay people can assess annual fatalities if they are asked to (and produce estimates somewhat like the technical estimates). However, their judgments of "risk" are sensitive to other factors as well (e.g., catastrophic potential,

threat to future generations) and, as a result, tend to differ from their own (and experts') estimates of annual fatalities.

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Insert Table 1 about here

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Another consistent result from psychometric studies of expressed preferences is that people tend to view current risk levels as unacceptably high for most activities. The gap between perceived and desired risk levels suggests that people are not satisfied with the way that market and other regulatory mechanisms have balanced risks and benefits. Across the domain of hazards, there seems to be little systematic relationship between perceived existing risks and benefits. However, studies of expressed preferences do seem to support Starr's claim that people are willing to tolerate higher risks from activities seen as highly beneficial. But whereas Starr concluded that voluntariness of exposure was the key mediator of risk acceptance, expressed preference studies have shown that other characteristics such as familiarity, control, catastrophic potential, equity, and level of knowledge also seem to influence the relationship between perceived risk, perceived benefit, and risk acceptance (see, e.g., Fischhoff et al., 1978; Slovic, et al., 1980).

Various models have been advanced to represent the relationships between perceptions, behavior, and these qualitative characteristics of hazards. As we shall see, the picture that emerges from this work is both orderly and complex.

### Factor-Analytic Representations

Many of the qualitative risk characteristics are highly correlated with each other, across a wide range of hazards. For example, hazards rated as "voluntary" tend also to be rated as "controllable" and "well-known"; hazards that appear to threaten future generations tend also to be seen as having catastrophic potential, and so on. Investigation of these interrelationships by means of factor analysis has shown that the broader domain of characteristics can be condensed to a small set of higher-order characteristics or factors.

The factor space presented in Figure 1 has been replicated across groups of laypeople and experts judging large and diverse sets of hazards. The factors in this space reflect the degree to which a risk is understood and the degree to which it evokes a feeling of dread. A third factor, reflecting the number of people exposed to the risk, has been obtained in several studies. Making the set of hazards more or less specific (e.g., partitioning nuclear power into radioactive waste transport, uranium mining, nuclear reactor accidents) has had little effect on the factor structure or its relationship to risk perceptions (Slovic, Fischhoff, & Lichtenstein, 1985).

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Insert Figure 1 about here  
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Research has shown that laypeople's risk perceptions and attitudes are closely related to the position of a hazard within the factor space. Most important is the factor "Dread Risk." The higher a hazard's score on this factor (i.e., the further to the right it



appears in the space), the higher its perceived risk, the more people want to see its current risks reduced, and the more they want to see strict regulation employed to achieve the desired reduction in risk (Figure 2). In contrast, experts' perceptions of risk are not closely related to any of the various risk characteristics or factors derived from these characteristics (Slovic, Fischhoff, & Lichtenstein, 1985). Instead, experts appear to see riskiness as synonymous with expected annual mortality (Slovic, Fischhoff, & Lichtenstein, 1979). As a result, some conflicts over "risk" may result from experts and laypeople having different definitions of the concept.

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Insert Figure 2 about here  
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#### Accidents as Signals

Risk analyses typically model the impacts of unfortunate events (e.g., an accident, a discovery of pollution, sabotage, product tampering, etc.) in terms of direct harm to victims--deaths, injuries, and damages. The impacts of an unfortunate event, however, sometimes extend far beyond these direct harmful effects, and may include indirect costs to the responsible government agency or private company that far exceed direct costs. In some cases, all companies in an industry are affected, regardless of which company was responsible for the mishap. In extreme cases, the indirect costs of a mishap may even extend past industry boundaries, affecting companies, industries, and agencies whose business is minimally related to the initial event. Thus, an unfortunate event can be thought of as a stone dropped in a

pond. The ripples spread outward, encompassing first the directly affected victims, then the responsible company or agency, and, in the extreme, reaching other companies, agencies, and industries.

Some events make only small ripples; others make big ones. Early theories equated the magnitude of impact to the number of people killed or injured, or to the amount of property damaged. Unfortunately, things aren't this simple. The accident at the Three Mile Island (TMI) nuclear reactor in 1979 provides a dramatic demonstration that factors besides injury, death, and property damage impose serious costs. Despite the fact that not a single person died at TMI, and few if any latent cancer fatalities are expected, no other accident in our history has produced such costly societal impacts. The accident at TMI devastated the utility that owned and operated the plant. It also imposed enormous costs (estimated at 500 billion dollars by one source) on the nuclear industry and on society, through stricter regulation, reduced operation of reactors worldwide, greater public opposition to nuclear power, reliance on more expensive energy sources, and increased costs of reactor construction and operation. It may even have led to a more hostile view of other large scale, modern technologies, such as chemical manufacturing and genetic engineering. The point is that traditional economic and risk analyses tend to neglect these higher-order impacts, hence they greatly underestimate the costs associated with certain kinds of mishaps.

An important concept that has emerged from psychometric research is that the seriousness and higher-order impacts of an unfortunate event are determined, in part, by what that event signals or portends

(Slovic, Lichtenstein, & Fischhoff, 1984). The informativeness or signal potential of an event, and thus its potential social impact, appears to be systematically related to the characteristics of the hazard and the location of the event within the factor space (see Figure 3). An accident that takes many lives may produce relatively little social disturbance (beyond that caused the victims' families and friends) if it occurs as part of a familiar and well-understood system (e.g., a train wreck). However, a small accident in an unfamiliar system (or one perceived as poorly understood), such as a nuclear reactor or a recombinant DNA laboratory, may have immense social consequences if it is perceived as a harbinger of further and possibly catastrophic mishaps.

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Insert Figure 3 about here  
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The concept of accidents as signals was eloquently expressed in an editorial addressing the tragic accident at Bhopal, India: "What truly grips us in these accounts [of disaster] is not so much the numbers as the spectacle of suddenly vanishing competence, of men utterly routed by technology, of fail-safe systems failing with a logic as inexorable as it was once--indeed, right up until that very moment--unforseeable. And the spectacle haunts us because it seems to carry allegorical import, like the whispery omen of a hovering future" (The New Yorker; February 18, 1985).

One implication of the signal concept is that effort and expense beyond that indicated by a cost/benefit analysis might be warranted to

reduce the possibility of "high-signal accidents." Unfortunate events involving hazards in the upper-right quadrant of Figure 1 appear particularly likely to have the potential to produce large ripples. As a result, risk analysis of these hazards needs to be sensitive to these possible higher-order impacts.

#### Placing Risks in Perspective

A consequence of the public's concerns and their opposition to risky technologies has been an increase in attempts to inform and educate people about risk. Risk perception research has a number of implications for such educational efforts (Slovic, in press).

One frequently advocated approach to broadening people's perspectives is to present quantitative risk estimates for a variety of hazards, expressed in some unidimensional index of death or disability, such as risk per hour of exposure (Sowby, 1965), annual probability of death (Wilson, 1979), or reduction in life expectancy (Cohen & Lee, 1979; Reissland & Harries, 1979). Even though such comparisons have no logically necessary implications for acceptability of risk (Fischhoff, Lichtenstein, Slovic, Derby, & Keeney, 1981), one might still hope that they would help improve people's intuitions about the magnitude of risks. Risk perception research suggests, however, that these comparisons may not be very satisfactory even for this purpose. People's perceptions and attitudes are determined not only by the sort of unidimensional statistics used in such tables but also by the variety of quantitative and qualitative characteristics reflected in Figure 1. To many people, statements such as "the annual risk from living near a nuclear power plant is equivalent to the risk of riding

an extra three miles in an automobile" give inadequate consideration to the important differences in the nature of the risks from these two technologies.

In short, "riskiness" means more to people than "expected number of fatalities." Attempts to characterize, compare, and regulate risks must be sensitive to this broader conception of risk. Fischhoff, Watson, and Hope (1984) have made a start in this direction by demonstrating how one might construct a more adequate measure of risk. They show that variations in the scope of one's definition of risk can greatly change the assessment of risk from various energy technologies.

The concept of accidents as signals indicates that, when informed about a particular hazard, people may "read between the lines," generalizing beyond the immediate problem to other related and possibly more ominous hazards. In response to information provided by EPA about the small degree of carcinogenicity associated with exposure to the pesticide ethylene dibromide (EDB), one newspaper editor wrote:

"The cumulative effect--the 'body burden count' as scientists call it--is especially worrisome considering the number of other pesticides and carcinogens humans are exposed to." (The Sunday Star-Bulletin and Advertiser, Honolulu, Feb. 5, 1984)

On the same topic, another editor wrote:

"Let's hope there are no cousins of EDB waiting to ambush us in the months ahead." (San Francisco Examiner, Feb. 10, 1984)

As a result of this broad (and legitimate) perspective, communications from risk managers pertaining to the risk and control of a single hazard, no matter how carefully presented, may fail to alleviate people's fears, frustrations, and anger. However, if people trust the ability of the risk manager to handle the risk problem, these broader concerns will probably not surface.

Whereas psychometric research implies that risk debates are not merely about risk statistics, some sociological and anthropological research implies that some of these debates may not even be about risk (Douglas & Wildavsky, 1982; Short, 1984). Risk concerns may provide a rationale for actions taken on other grounds or they may be a surrogate for other social or ideological concerns. When this is the case, communication about risk is simply irrelevant to the discussion. Hidden agendas need to be brought to the surface for open discussion, if possible (Edwards & von Winterfeldt, 1984).

Perhaps the most important message from the research done to date is that there is wisdom as well as error in public attitudes and perceptions. Laypeople sometimes lack certain information about hazards. However, their basic conceptualization of risk is much richer than that of the experts and reflects legitimate concerns that are typically omitted from expert risk assessments. As a result, risk communication efforts are destined to fail unless they are structured as a two-way process. Each side, expert and public, has something valid to contribute. Each side must respect the insights and intelligence of the other.

## References

- Brown, R. A., & Green, C. H. (1980). Precepts of safety assessments. Journal of the Operational Research Society, 11, 563-571.
- Cohen, B., & Lee, I. (1979). A catalog of risks. Health Physics, 36, 707-722.
- Douglas, M., & Wildavsky, A. (1982). Risk and culture. Berkeley and Los Angeles: University of California Press.
- Edwards, W., & von Winterfeldt, D. (1984). Public values in risk communication. Unpublished manuscript. Los Angeles, CA: Institute for Systems and Safety Management, University of Southern California.
- Fischhoff, B., Lichtenstein, S., Slovic, P., Derby, S. L., & Keeney, R. L. (1981). Acceptable Risk. New York: Cambridge University Press.
- Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S., & Combs, B. (1978). How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. Policy Sciences, 8, 127-152.
- Fischhoff, B., Watson, S., & Hope, C. (1984). Defining risk. Policy Sciences, 17, 123-139.
- Gardner, G. T., Tiemann, A. R., Gould, L. C., DeLuca, D. R., Doob, L. W., & Stolwijk, J. A. J. (1982). Risk and benefit perceptions, acceptability judgments, and self-reported actions toward nuclear power. Journal of Social Psychology, 116, 179-197.
- Green, C. H. (1980). Risk: Attitudes and beliefs. In D. V. Canter (Ed.), Behavior in fires. Chichester: Wiley.

- Green, C. H., & Brown, R. A. (1980). Through a glass darkly: Perceiving perceived risks to health and safety (Research paper). Scotland: School of Architecture, Duncan of Jordanstone College of Art/University of Dundee.
- Johnson, E. J., & Tversky, A. (1984). Representations of perceptions of risks. Journal of Experimental Psychology: General, 113, 55-70.
- Lindell, M. K., & Earle, T. C. (1983). How close is close enough? Public perceptions of the risks of industrial facilities. Risk Analysis, 3, 245-254.
- MacGill, S. M. (1983). Exploring the similarities of different risks. Environment and Planning B: Planning and Design, 10, 303-329.
- Reissland, J., & Harries, V. (1979). A scale for measuring risks. New Scientist, 83, 809-811.
- Renn, O. (1981). Man, technology and risk: A study on intuitive risk assessment and attitudes towards nuclear power (Report Jul-Spez 115, Jülich, June). Federal Republic of Germany: Nuclear Research Center.
- Short, J. F., Jr. (1984). The social fabric at risk: Toward the social transformation of risk analysis. American Sociologist Review, 49, 711-725.
- Slovic, P. (in press). Informing and educating the public about risk. Risk Analysis.



- Slovic, P., Fischhoff, B., & Lichtenstein, S. (1980). Facts and fears: Understanding perceived risk. In R. Schwing & W. A. Albers, Jr. (Eds), Societal risk assessment: How safe is safe enough? New York: Plenum.
- Slovic, P., Fischhoff, B., & Lichtenstein, S. (1981). Perceived risk: Psychological factors and social implications. In F. Warner & D. H. Slater (Eds.), The assessment and perception of risk. London: The Royal Society.
- Slovic, P., Fischhoff, B., & Lichtenstein, S. (1984). Behavioral decision theory perspectives on risk and safety. Acta Psychologica, 56, 183-203.
- Slovic, P., Fischhoff, B., & Lichtenstein, S. (1985). Characterizing perceived risk. In R. W. Kates, C. Hohenemser, & J. X. Kasperson (Eds.), Perilous progress: Managing the hazards of technology (pp. 91-125). Boulder, CO: Westview.
- Slovic, P., Lichtenstein, S., & Fischhoff, B. (1984). Modeling the societal impact of fatal accidents. Management Science, 30, 464-474.
- Sowby, F. D. (1965). Radiation and other risks. Health Physics, 11, 879-887.
- Starr, C. (1969). Social benefit versus technological risk. Science, 165, 1232-1238.
- Vlek, C. A. J., & Stallen, P. J. (1981). Judging risk and benefit in the small and in the large. Organizational Behavior and Human Performance, 28, 235-271.

von Winterfeldt, D., John, R. S., & Borcharding, K. (1981). Cognitive components of risk ratings. Risk Analysis, 1, 277-288.

Wildavsky, A. (1979). No risk is the highest risk of all. American Scientist, 67, 32-37.

Wilson, R. (1979). Analyzing the daily risks of life. Technology Review, 81(4), 40-46.

Table 1

## Ordering of Perceived Risk for 30 Activities and Technologies

(The ordering is based on the geometric mean risk ratings within each group.  
Rank 1 represents the most risky activity or technology.)

	League of Women Voters	College Students	Active Club Members	experts
Nuclear power	1	1	8	20
Motor vehicles	2	5	3	1
Handguns	3	2	1	4
Smoking	4	3	4	2
Motorcycles	5	6	2	6
Alcoholic beverages	6	7	5	3
General (private) aviation	7	15	11	12
Police work	8	8	7	17
Pesticides	9	4	15	8
Surgery	10	11	9	5
Fire fighting	11	10	6	18
Large construction	12	14	13	13
Hunting	13	18	10	23
Spray cans	14	13	23	26
Mountain climbing	15	22	12	29
Bicycles	16	24	14	15
Commercial aviation	17	16	18	16
Electric power (non-nuclear)	18	19	19	9
Swimming	19	30	17	10
Contraceptives	20	9	22	11
Skiing	21	25	16	30
X rays	22	17	24	7
High school & college football	23	26	21	27
Railroads	24	23	20	19
Food preservatives	25	12	28	14
Food coloring	26	20	30	21
Power mowers	27	28	25	28
Prescription antibiotics	28	21	26	24
Home appliances	29	27	27	22
Vaccinations	30	29	29	25

Source: Slovic, Fischhoff, and Lichtenstein, 1981.

### Figure Captions

Figure 1. Location of 81 hazards on Factors 1 and 2 derived from the interrelationships among 18 risk characteristics. Each factor is made up of a combination of characteristics, as indicated by the lower diagram. Source: Slovic, Fischhoff, and Lichtenstein, 1985.

Figure 2. Attitudes towards regulation of the hazards in Figure 1. The larger the point, the greater the desire for strict regulation to reduce risk. Source: Slovic, Fischhoff, and Lichtenstein, 1985.

Figure 3. Relation between signal potential and risk characterization for 30 hazards in Figure 1. The larger the point, the greater the degree to which an accident involving that hazard was judged to "serve as a warning signal for society, providing new information about the probability that similar or even more destructive mishaps might occur within this type of activity." The higher-order costs of a mishap are likely to be correlated with signal potential. Source: Slovic, Lichtenstein, and Fischhoff, 1984.

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