Perception of Risk

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as potent as carcinogens such as symphytine. If the other pyrrolizidine alkaloids in comfrey were as potent carcinogens as symphytine, the possible hazard of a daily cup of tea would be HERP = 0.6% and that of a daily nine tablets would be HERP = 7.3%.

104. *Agaricus bisporus* is the most commonly eaten mushroom in the United States with an estimated annual consumption of 340 million kilograms in 1984–85. Mushrooms contain various hydrazine compounds, some of which have been shown to cause tumors in mice. Raw mushrooms fed over a lifetime to male and female mice induced bone, forestomach, liver, and lung tumors [B. Toth and J. Erickson, *Cancer Res.* 46, 4007 (1986)]. The 15-g raw mushroom is given as wet weight. The TD_{50} value based on the above report is expressed as dry weight of mushrooms so as to be comparable to other values for TD_{50} in Table 1; 90% of a mushroom is assumed to be water. A second mushroom, *Gyromitra esculenta*, has been similarly studied and found to contain a mixture of carcinogenic hydrazines [B. Toth, *J. Environ. Sci. Health* C2, 51 (1984)]. These mushrooms are eaten in considerable quantities in several countries, though less frequently in the United States.

105. Safrole is the main component (up to 90%) of oil of sassafras, formerly used as the main flavor ingredient in root beer [J. B. Wilson, *J. Assoc. Off. Anal. Chem.* 42, 696 (1959); A. Y. Leung, *Encyclopedia of Common Natural Ingredients Used in Food, Drugs and Cosmetics* (Wiley, New York, 1980)]. In 1960, safrole and safrole-containing sassafras oils were banned from use in foods in the United States [*Fed. Regist.* 25, 12412 (1960)]. Safrole is also naturally present in the oils of sweet basil, cinnamon leaf, nutmeg, and pepper.

106. Diet cola available in a local market contains 7.9 mg of sodium saccharin per fluid ounce.

107. Metronidazole is considered to be the drug of choice for trichomonal and *Gardnerella* infections [AMA Division of Drugs, *AMA Drug Evaluations* (American Medical Association, Chicago, IL, ed. 5, 1983), pp. 1717 and 1802].

108. Isoniazid is used both prophylactically and as a treatment for active tuberculosis. The adult prophylactic dose (300 mg daily) is continued for 1 year [AMA Division of Drugs, *AMA Drug Evaluations* (American Medical Association, Chicago, IL, ed. 5, 1983), pp. 1766–1777].

109. D. M. Siegal, V. H. Frankos, M. A. Schneiderman, *Reg. Toxicol. Pharmacol.* 3, 365 (1983).

110. Supported by NCI Outstanding Investigator Grant CA39910 to B.N.A., NIEHS Center Grant ES01896, and NIEHS/DOE Interagency Agreement 222-Y01-ES-10066. We are indebted to numerous colleagues for criticisms, particularly W. Havender, R. Peto, J. Cairns, J. Miller, E. Miller, D. B. Clayson, J. McCann, and F. J. C. Roe.

Perception of Risk

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Studies of risk perception examine the judgments people make when they are asked to characterize and evaluate hazardous activities and technologies. This research aims to aid risk analysis and policy-making by (i) providing a basis for understanding and anticipating public responses to hazards and (ii) improving the communication of risk information among lay people, technical experts, and decision-makers. This work assumes that those who promote and regulate health and safety need to understand how people think about and respond to risk. Without such understanding, well-intended policies may be ineffective.

THE ABILITY TO SENSE AND AVOID HARMFUL ENVIRONMENTAL conditions is necessary for the survival of all living organisms. Survival is also aided by an ability to codify and learn from past experience. Humans have an additional capability that allows them to alter their environment as well as respond to it. This capacity both creates and reduces risk.

In recent decades, the profound development of chemical and nuclear technologies has been accompanied by the potential to cause catastrophic and long-lasting damage to the earth and the life forms that inhabit it. The mechanisms underlying these complex technologies are unfamiliar and incomprehensible to most citizens. Their most harmful consequences are rare and often delayed, hence difficult to assess by statistical analysis and not well suited to management by trial-and-error learning. The elusive and hard to manage qualities of today's hazards have forced the creation of a new intellectual discipline called risk assessment, designed to aid in identifying, characterizing, and quantifying risk (*1*).

Whereas technologically sophisticated analysts employ risk assessment to evaluate hazards, the majority of citizens rely on intuitive risk judgments, typically called "risk perceptions." For these people, experience with hazards tends to come from the news media, which rather thoroughly document mishaps and threats occurring throughout the world. The dominant perception for most Americans (and one that contrasts sharply with the views of professional risk assessors) is that they face more risk today than in the past and that future risks will be even greater than today's (*2*). Similar views appear to be held by citizens of many other industrialized nations. These perceptions and the opposition to technology that accompanies them have puzzled and frustrated industrialists and regulators and have led numerous observers to argue that the American public's apparent pursuit of a "zero-risk society" threatens the nation's political and economic stability. Wildavsky (*3*, p. 32) 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?

During the past decade, a small number of researchers has 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. The basic assumption underlying these efforts is that those who promote and regulate health and safety need to understand the ways in which people think about and respond to risk.

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If successful, this research should aid policy-makers by improving communication between them and the public, by directing educational efforts, and by predicting public responses to new technologies (for example, genetic engineering), events (for example, a good safety record or an accident), and new risk management strategies (for example, warning labels, regulations, substitute products).

Risk Perception Research

Important contributions to our current understanding of risk perception have come from geography, sociology, political science, anthropology, and psychology. Geographical research focused originally on understanding human behavior in the face of natural hazards, but it has since broadened to include technological hazards as well (*4*). Sociological (*5*) and anthropological studies (*6*) have shown that perception and acceptance of risk have their roots in social and cultural factors. Short (*5*) argues that response to hazards is mediated by social influences transmitted by friends, family, fellow workers, and respected public officials. In many cases, risk perceptions may form afterwards, as part of the ex post facto rationale for one's own behavior. Douglas and Wildavsky (*6*) assert that people, acting within social groups, downplay certain risks and emphasize others as a means of maintaining and controlling the group.

Psychological research on risk perception, which shall be my focus, originated in empirical studies of probability assessment, utility assessment, and decision-making processes (*7*). A major development in this area has been the discovery of a set of mental strategies, or heuristics, that people employ in order to make sense out of an uncertain world (*8*). Although these rules are valid in some circumstances, in others they lead to large and persistent biases, with serious implications for risk assessment. In particular, laboratory research on basic perceptions and cognitions has shown that difficulties in understanding probabilistic processes, biased media coverage, misleading personal experiences, and the anxieties generated by life's gambles cause uncertainty to be denied, risks to be misjudged (sometimes overestimated and sometimes underestimated), and judgments of fact to be held with unwarranted confidence. Experts' judgments appear to be prone to many of the same biases as those of the general public, particularly when experts are forced to go beyond the limits of available data and rely on intuition (*8, 9*).

Research further indicates that disagreements about risk should not be expected to evaporate in the presence of evidence. Strong initial views are resistant to change because they influence the way that subsequent information is interpreted. New evidence appears reliable and informative if it is consistent with one's initial beliefs; contrary evidence tends to be dismissed as unreliable, erroneous, or unrepresentative (*10*). When people lack strong prior opinions, the opposite situation exists—they are at the mercy of the problem formulation. Presenting the same information about risk in different ways (for example, mortality rates as opposed to survival rates) alters people's perspectives and actions (*11*).

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 opinions of experts. The most common approach to this goal has employed the psychometric paradigm (*12, 13*), 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 (i) the hazard's status on characteristics that have been hypothesized to account for risk perceptions and attitudes (for example, voluntariness, dread, knowledge, controllability), (ii) the benefits that each hazard provides to society, (iii) the number of deaths caused by the hazard in an average year, and (iv) the number of deaths caused by the hazard in a disastrous year.

In the rest of this article, I shall briefly review some of the results obtained from psychometric studies of risk perception and outline 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 (*14*) 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 trade-offs. Examining such data for several industries and activities,

Table 1. Ordering of perceived risk for 30 activities and technologies (*22*). The ordering is based on the geometric mean risk ratings within each group. Rank 1 represents the most risky activity or technology.

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 (nonnuclear)	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 and college football	23	26	21	27
Railroads	24	23	29	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

Starr concluded that (i) acceptability of risk from an activity is roughly proportional to the third power of the benefits for that activity, and (ii) the public will accept risks from voluntary activities (such as skiing) that are roughly 1000 times as great as it would tolerate from involuntary hazards (such as food preservatives) that provide the same level of benefits.

The merits and deficiencies of Starr's approach have been debated at length (*15*). 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.* (*12*) 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 (*16–24*).

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 (Table 1). They have also shown that the

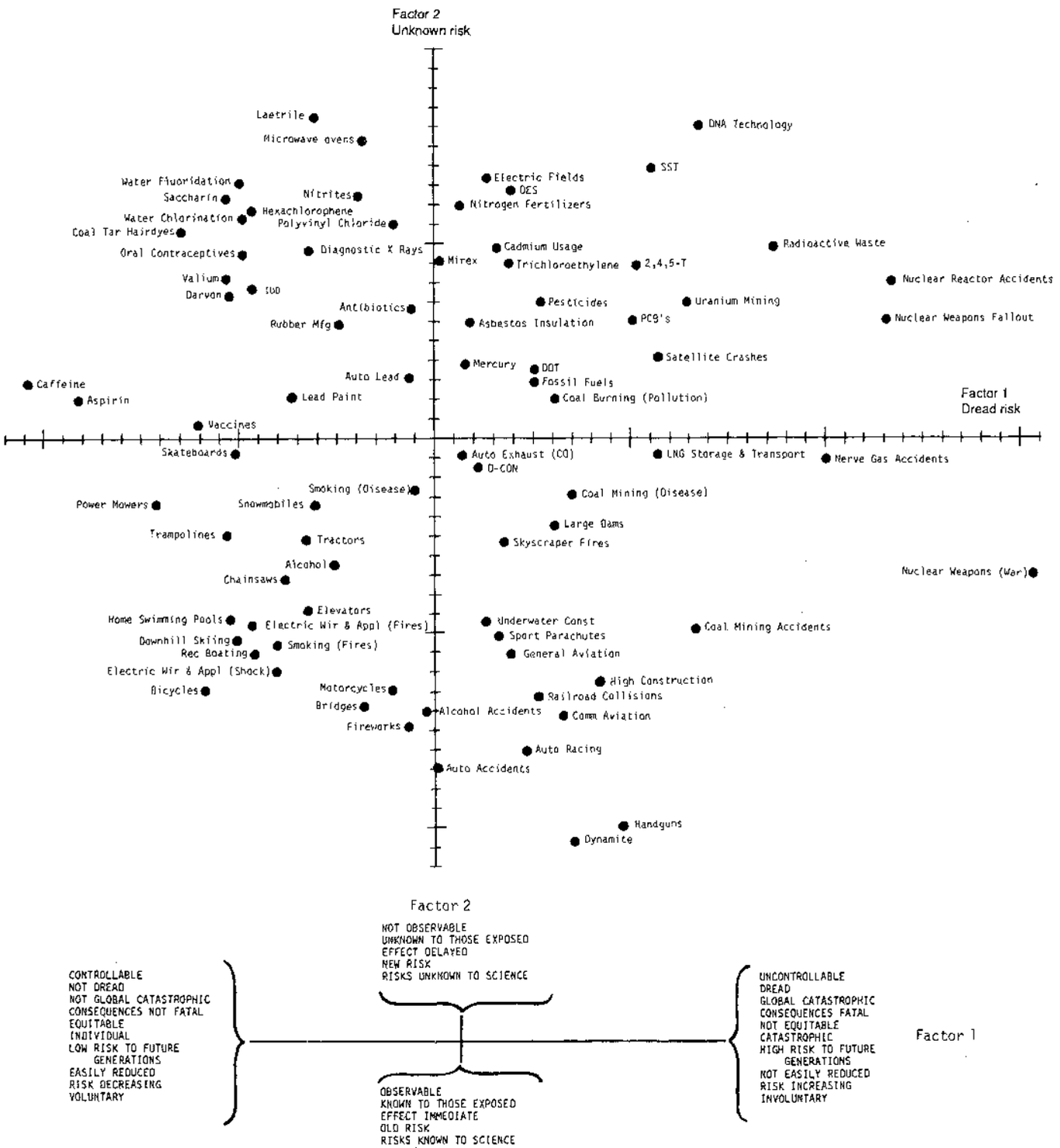

Fig. 1. Location of 81 hazards on factors 1 and 2 derived from the relationships among 18 risk characteristics. Each factor is made up of a combination of characteristics, as indicated by the lower diagram (*25*).

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 related more to other hazard characteristics (for example, catastrophic potential, threat to future generations) and, as a result, tend to differ from their own (and experts') estimates of annual fatalities.

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 perceptions of current risks and benefits. However, studies of expressed preferences do seem to support Starr's argument 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 (perceived) characteristics such as familiarity, control, catastrophic potential, equity, and level of knowledge also seem to influence the relation between perceived risk, perceived benefit, and risk acceptance (*12, 22*).

Various models have been advanced to represent the relation 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 correlated with each other, across a wide range of hazards. For example, hazards judged to be "voluntary" tend also to be judged as "controllable"; hazards whose adverse effects are delayed tend to be seen as posing risks that are not well known, and so on. Investigation of these relations 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 Fig. 1 has been replicated across groups of lay people and experts judging large and diverse sets of hazards. Factor 1, labeled "dread risk," is defined at its high (right-hand) end by perceived lack of control, dread, catastrophic potential, fatal consequences, and the inequitable distribution of risks and benefits. Nuclear weapons and nuclear power score highest on the characteristics that make up this factor. Factor 2, labeled "unknown risk," is defined at its high end by hazards judged to be unobservable, unknown, new, and delayed in their manifestation of harm. Chemical technologies score particularly high on this factor. 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 (for example, partitioning nuclear power into radioactive waste, uranium mining, and nuclear reactor accidents) has had little effect on the factor structure or its relation to risk perceptions (*25*).

Research has shown that lay people's risk perceptions and attitudes are closely related to the position of a hazard within this type of factor space. Most important is the horizontal factor "dread risk." The higher a hazard's score on this factor (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 (Fig. 2). In contrast, experts' perceptions of risk are not closely related to any of the various risk characteristics or factors derived from these characteristics (*25*). Instead, as noted earlier, experts appear to see riskiness as synonymous with expected annual mortality (*26*). As a result, conflicts over "risk" may result from experts and lay people having different definitions of the concept.

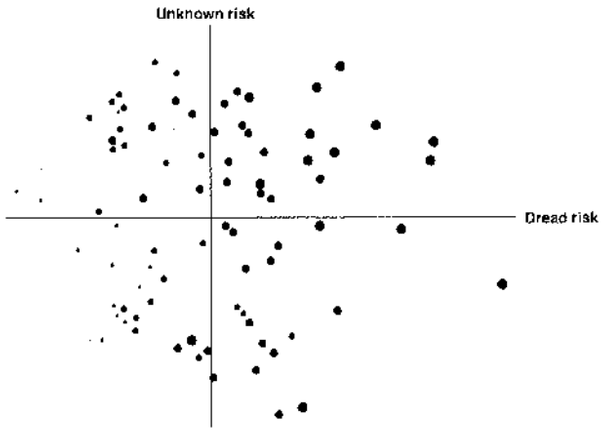

Fig. 2. Attitudes toward regulation of the hazards in Fig. 1. The larger the point, the greater the desire for strict regulation to reduce risk (*25*).

The representation shown in Fig. 1, while robust and informative, is by no means a universal cognitive mapping of the domain of hazards. Other psychometric methods (such as multidimensional scaling analysis of hazard similarity judgments), applied to quite different sets of hazards, produce different spatial models (*13, 18*). The utility of these models for understanding and predicting behavior remains to be determined.

Accidents as Signals

Risk analyses typically model the impacts of an unfortunate event (such as an accident, a discovery of pollution, sabotage, product tampering) in terms of direct harm to victims—deaths, injuries, and damages. The impacts of such events, however, sometimes extend far beyond these direct harms and may include significant indirect costs (both monetary and nonmonetary) 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 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 analogous to 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 larger ones. The challenge is to discover characteristics associated with an event and the way that it is managed that can predict the breadth and seriousness of those impacts (Fig. 3). Early theories equated the magnitude of impact to the number of people killed or injured, or to the amount of property damaged. However, 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, 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 (*27*) on the nuclear industry and on society, through stricter regulation (resulting in increased construction and operation costs), reduced

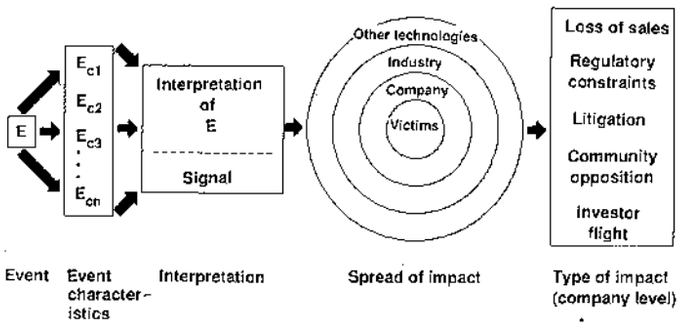

Fig. 3. A model of impact for unfortunate events.

operation of reactors worldwide, greater public opposition to nuclear power, and reliance on more expensive energy sources. It may even have led to a more hostile view of other complex 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 events.

Although the TMI accident is extreme, it is by no means unique. Other recent events resulting in enormous higher order impacts include the chemical manufacturing accident at Bhopal, India, the pollution of Love Canal, New York, and Times Beach, Missouri, the disastrous launch of the space shuttle Challenger, and the meltdown of the nuclear reactor at Chernobyl. Following these extreme events are a myriad of mishaps varying in the breadth and size of their impacts.

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 (*28*). 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 described earlier (Fig. 4). An accident that takes many lives may produce relatively little social disturbance (beyond that experienced by the victims' families and friends) if it occurs as part of a familiar and well-understood system (such as 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.

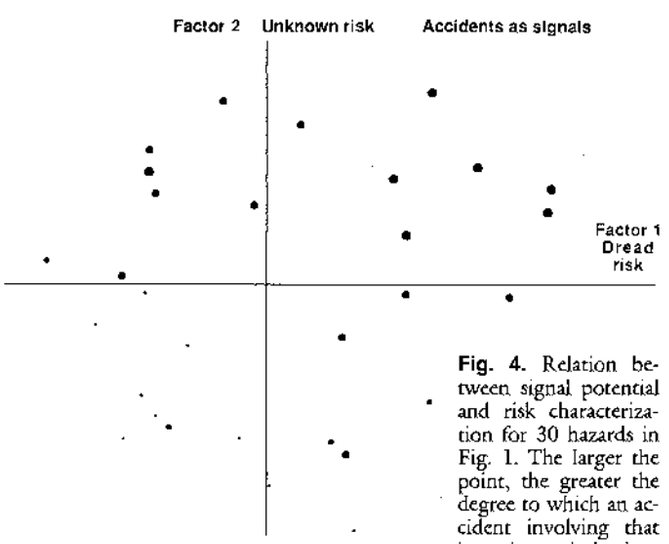

Fig. 4. Relation between signal potential and risk characterization for 30 hazards in Fig. 1. The larger the point, the greater the degree to which an accident involving that hazard was judged to "serve as a warning signal for society, providing new information about the probability that similar or even more destructive mishaps might occur within this type of activity." Media attention and the higher order costs of a mishap are likely to be correlated with signal potential (*28*).

The concept of accidents as signals was eloquently expressed in an editorial addressing the tragic accident at Bhopal (*29*).

> What truly grips us in these accounts 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—unforeseeable. And the spectacle haunts us because it seems to carry allegorical import, like the whispery omen of a hovering future.

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 Fig. 1 appear particularly likely to have the potential to produce large ripples. As a result, risk analyses involving these hazards need to be made sensitive to these possible higher order impacts. Doing so would likely bring greater protection to potential victims as well as to companies and industries.

Analysis of Single Hazard Domains

Psychometric analyses have also been applied to judgments of diverse hazard scenarios within a single technological domain, such as railroad transport (*30*) or automobiles (*31*). Kraus (*30*) had people evaluate the riskiness of 49 railroad hazard scenarios that varied with respect to type of train, type of cargo, location of the accident, and the nature and cause of the accident (for example, a high-speed train carrying passengers through a mountain tunnel derails due to a mechanical system failure). The results showed that these railroad hazards were highly differentiated, much like the hazards in Fig. 1. The highest signal potential (and thus the highest potential for large ripple effects) was associated with accidents involving trains carrying hazardous chemicals.

A study by Slovic, MacGregor, and Kraus (*31*) examined perceptions of risk and signal value for 40 structural defects in automobiles. Multivariate analysis of these defects, rated in terms of various characteristics of risk, produced a two-factor space. As in earlier studies with diverse hazards, the position of a defect in this space predicted judgments of riskiness and signal value quite well. One defect stood out much as nuclear hazards do in Fig. 1. It was a fuel tank rupture upon impact, creating the possibility of fire and burn injuries. This, of course, is similar to the notorious design problem that plagued Ford Pinto and that Ford allegedly declined to correct because a cost-benefit analysis indicated that the correction costs greatly exceeded the expected benefits from increased safety (*32*). Had Ford done a psychometric study, the analysis might have highlighted this particular defect as one whose seriousness and higher order costs (lawsuits, damaged company reputation) were likely to be greatly underestimated by cost-benefit analysis.

Forecasting Public Acceptance

Results from studies of the perception of risk have been used to explain and forecast acceptance and opposition for specific technologies (*33*). Nuclear power has been a frequent topic of such analyses because of the dramatic opposition it has engendered in the face of experts' assurances of its safety. Research shows that people judge the benefits from nuclear power to be quite small and the risks to be unacceptably great. Nuclear power risks occupy extreme positions in

psychometric factor spaces, reflecting people's views that these risks are unknown, dread, uncontrollable, inequitable, catastrophic, and likely to affect future generations (Fig. 1). Opponents of nuclear power recognize that few people have died thus far as a result of this technology. However, long before Chernobyl, they expressed great concern over the potential for catastrophic accidents.

These public perceptions have evoked harsh reactions from experts. One noted psychiatrist wrote that "the irrational fear of nuclear plants is based on a mistaken assessment of the risks" (*34*, p. 8). A nuclear physicist and leading advocate of nuclear power contended that " . . . the public has been driven insane over fear of radiation [from nuclear power]. I use the word 'insane' purposefully since one of its definitions is loss of contact with reality. The public's understanding of radiation dangers has virtually lost all contact with the actual dangers as understood by scientists" (*35*, p. 31).

Risk perception research paints a different picture, demonstrating that people's deep anxieties are linked to the reality of extensive unfavorable media coverage and to a strong association between nuclear power and the proliferation and use of nuclear weapons. Attempts to "educate" or reassure the public and bring their perceptions in line with those of industry experts appear unlikely to succeed because the low probability of serious reactor accidents makes empirical demonstrations of safety difficult to achieve. Because nuclear risks are perceived as unknown and potentially catastrophic, even small accidents will be highly publicized and may produce large ripple effects (Fig. 4).

Psychometric research may be able to forecast the response to technologies that have yet to arouse strong and persistent public opposition. For example, DNA technologies seem to evoke several of the perceptions that make nuclear power so hard to manage. In the aftermath of an accident, this technology could face some of the same problems and opposition now confronting the nuclear industry.

Placing Risks in Perspective

A consequence of the public's concerns and its 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 (*36*).

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, annual probability of death, or reduction in life expectancy. Even though such comparisons have no logically necessary implications for acceptability of risk (*15*), one might still hope that they would help improve people's intuitions about the magnitude of risks. Risk perception research suggests, however, that these sorts of 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 Fig. 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 3 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 (*37*) have made a start in this direction by demonstrating how one might construct a more comprehensive 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.

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 (*5*, *6*). 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 discussion (*38*).

Perhaps the most important message from this research is that there is wisdom as well as error in public attitudes and perceptions. Lay people 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 and risk management 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 AND NOTES

1. For a comprehensive bibliography on risk assessment, see V. Covello and M. Abernathy, in *Technological Risk Assessment*, P. F. Ricci, L. A. Sagan, C. G. Whipple, Eds. (Nijhoff, The Hague, 1984), pp. 283–363.
2. "Risk in a complex society," report of a public opinion poll conducted by L. Harris for the Marsh and McClennan Company, New York (1980).
3. A. Wildavsky, *Am. Sci.* **67**, 32 (1979).
4. I. Burton, R. W. Kates, G. F. White, *The Environment as Hazard* (Oxford Univ. Press, Oxford, 1978).
5. J. F. Short, Jr., *Am. Sociol. Rev.* **49**, 711 (1984).
6. M. Douglas and A. Wildavsky, *Risk and Culture* (Univ. of California Press, Berkeley, 1982).
7. W. Edwards, *Annu. Rev. Psychol.* **12**, 473 (1961).
8. D. Kahneman, P. Slovic, A. Tversky, Eds. *Judgment Under Uncertainty: Heuristics and Biases* (Cambridge Univ. Press, New York, 1982).
9. M. Henrion and B. Fischhoff, *Am. J. Phys.*, in press.
10. R. Nisbett and L. Ross, *Human Inference: Strategies and Shortcomings of Social Judgment* (Prentice-Hall, Englewood Cliffs, NJ, 1980).
11. A. Tversky and D. Kahneman, *Science* **211**, 453 (1981).
12. B. Fischhoff *et al.*, *Policy Sci.* **8**, 127 (1978).
13. P. Slovic, B. Fischhoff, S. Lichtenstein, *Acta. Psychol.* **56**, 183 (1984).
14. C. Starr, *Science* **165**, 1232 (1969).
15. B. Fischhoff, S. Lichtenstein, P. Slovic, S. L. Derby, R. L. Keeney, *Acceptable Risk* (Cambridge Univ. Press, New York, 1981).
16. G. T. Gardner *et al.*, *J. Soc. Psychol.* **116**, 179 (1982).
17. D. R. DeLuca, J. A. J. Stolwijk, W. Horowitz, in *Risk Evaluation and Management*, V. T. Covello, J. Menkes, J. L. Mumpower, Eds. (Plenum, New York, 1986), pp. 25–67.
18. E. J. Johnson and A. Tversky, *J. Exp. Psych. Gen.* **113**, 55 (1984).
19. M. K. Lindell and T. C. Earle, *Risk Anal.* **3**, 245 (1983).
20. H. J. Otway and M. Fishbein, *The Determinants of Attitude Formation: An Application to Nuclear Power* (RM-76-80 Technical Report, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1976).
21. O. Renn and E. Swaton, *Env. Int.* **10**, 557 (1984).
22. P. Slovic, B. Fischhoff, S. Lichtenstein, in *Societal Risk Assessment: How Safe is Safe Enough?*, R. Schwing and W. A. Albers, Jr., Eds. (Plenum, New York, 1980), pp. 181–216.
23. C. A. J. Vlek and P. J. Stallen, *Organ. Behav. Hum. Perf.* **28**, 235 (1981).
24. D. von Winterfeldt, R. S. John, K. Borcherding, *Risk Anal.* **1**, 277 (1981).
25. P. Slovic, B. Fischhoff, S. Lichtenstein, in *Perilous Progress: Managing the Hazards of Technology*, R. W. Kates, C. Hohenemser, J. X. Kasperson, Eds. (Westview, Boulder, CO, 1985), pp. 91–125.
26. P. Slovic, B. Fischhoff, S. Lichtenstein, *Environment* **21** (no. 3), 14 (1979).
27. Estimated at $500 billion [see *Electr. Power Res. Inst. J.* **5** (no. 5), 24 (1980)].
28. P. Slovic, S. Lichtenstein, B. Fischhoff, *Manage. Sci.* **30**, 464 (1984).
29. The Talk of the Town, *New Yorker* **60** (no. 53), 29 (1985).
30. N. Kraus, thesis, University of Pittsburgh (1985).
31. P. Slovic, D. MacGregor, N. Kraus, *Accident Anal. Prev.*, in press.
32. *Grimshaw* vs. *Ford Motor Co.*, Superior Court, No. 19776, Orange County, CA, 6 February 1978.
33. P. Slovic, B. Fischhoff, S. Lichtenstein, in *Advances in Environmental Psychology*, A. Baum and J. E. Singer, Eds. (Erlbaum, Hillsdale, NJ, 1981), vol. 3, pp. 157–169.
34. R. L. Dupont, *Bus. Week*, 7 September 1981, pp. 8–9.
35. B. L. Cohen, *Before It's Too Late: A Scientist's Case for Nuclear Energy* (Plenum, New York, 1983).
36. P. Slovic, *Risk Anal.* **6**, 403 (1986).
37. B. Fischhoff, S. Watson, C. Hope, *Policy Sci.* **17**, 123 (1984).
38. W. Edwards and D. von Winterfeldt, *Risk Anal.*, in press.

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