Behavioral Decision Theory Perspectives on Protective Behavior

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Introduction

What determines whether people will protect themselves against the severe losses that might arise from some rare hazard?

What factors underlie the perception and acceptability of risks from technology?

The answers to questions such as these are vital for understanding how people cope with threats from accidents, diseases, and natural hazards and for helping them manage their lives more effectively in the face of such risks. The role that the study of judgment and decision processes can play in providing answers to these questions will be explored in this paper. Experiments studying insurance decisions, risk perception, and evaluation of technological risks will be described along with implications of this research for matters of public safety and health.

Overview

This paper is divided into five sections. It begins with a brief description of the leading normative theory of protective decision making, which proposes that a rational decision maker acts so as to maximize expected utility. The second section contrasts this idealized view with research on human intellectual limitations showing that people are, at best, "boundedly rational." In this section, we focus on the problems that occur when people seek to make sense out of a probabilistic environment and attempt to resolve the value conflicts arising from decisions about beneficial but hazardous activities. We point out the difficulties people have in thinking intuitively about risk and uncertainty. We argue that people's perceptions of the world are sometimes distorted and that their preferences can be unstable, vague, or inconsistent. The results of this research run counter to the traditional presumptions of knowledge and rationality that underlie economic approaches to decision making under risk.

The third section of this paper shows how some of the findings of the first section can be applied to two specific policy problems dealing with protective behavior: purchasing flood insurance and wearing seat belts. We argue that, to be effective, policies need to be based on knowledge regarding the determinants of people's protective behavior. Empirical research can play an important role in providing such knowledge.

The fourth section describes research on the perception of risk. This research explores what people mean when they say that an activity or a technology is "risky". We find that many attributes other than death rates determine judgments of riskiness. Such attributes include catastrophic potential, risk to future generations, and dread. In contrast with the first section, the tone of this section is optimistic. We find that laypeople have strong, consistent and reasonable views about risk. In fact, their model of what constitutes risk appears to be much richer than that held by most technical experts.

The final section is a discussion of the problems encountered in trying to inform people about risk. A common reaction of industry and government officials to evidence of ignorance, misinformation, or faulty thinking has been to call for educational programs to correct these shortcomings. Although we applaud such efforts and do believe that people are educable, our emphasis is on the obstacles educational programs must overcome in order to be effective.

A RATIONAL MODEL FOR PROTECTIVE DECISIONS

Decision theory provides a model, based on the maximization of expected utility, that serves as a normative or "rational" basis for protective decisions. It is rational in the sense of trying to prescribe a course of action that is consistent with the decision maker's own goals, expectations, and values.

In this model, decisions in the face of risk are typically represented by a payoff matrix, in which the rows correspond to alternative acts that the decision maker can select and the columns correspond to possible states of nature. In the cells of the payoff matrix are a set of consequences contingent upon the joint occurrence of a decision and a state of nature. A simple illustration for a traveler is given in Table 1.

Insert Table 1 about here

Since it is impossible to make a decision that will turn out best in any eventuality, decision theorists view choice alternatives as gambles and try to choose according to the "best bet." In 1738, Bernoulli defined the notion of best bet as one that maximizes the quantity

$$EU(A) = \sum_{i=1}^{n} P(E_i)\, U(X_i)$$

where EU(A) represents the expected utility of a course of action which has consequences $X_1, X_2, \ldots, X_n$ depending on events $E_1, E_2 \ldots,$

E_n, $P(E_i)$ represents the probability of the _i_th outcome of that action and $U(X_i)$ represents the subjective value or utility of that outcome. If we assume that the parenthesized values in the cells of Table 1 represent the traveler's utilities for the various consequences, and if the probability of sun and rain are taken to be 0.6 and 0.4, respectively, we can compute the expected utility for each action as follows:

$$EU(A_1) = 0.6(+1) + 0.4(+1) = 1.0$$

$$EU(A_2) = 0.6(+2) + 0.4(0) = 1.2$$

In this situation, leaving the umbrella has greater expected utility than taking it along. The same form of analysis can be applied to computing the expected utility of heeding a flood warning, getting vaccinated against the flu, or buying insurance.

A major advance in decision theory came when von Neumann and Morgenstern (1947) developed a formal justification for the expected utility criterion. They showed that, if an individual's preferences satisfied certain basic axioms of rational behavior, then his or her decisions could be described as the maximization of expected utility. Savage (1954) later generalized the theory to allow the $P(E_i)$ values to represent subjective or personal probabilities.

Maximization of expected utility commands respect as a guideline for wise behavior because it can be deduced from axiomatic principles that presumably would be accepted by any rational person. One such principle, that of _transitivity_, asserts that, if a decision maker prefers outcome A to outcome B and outcome B to outcome C, then he or she should prefer outcome A to outcome C. Any individuals who are deliberately and systematically intransitive can be turned into "money pumps." You can say to them: "I'll give you C. Now, for a penny, I'll take back C and give you B." Since they prefer B to C, they accept. Next you offer to replace B with A for another penny and again they accept. The cycle is completed by offering to replace A by C for another penny; the person accepts and is 3 cents poorer, back where they started, and ready for another round.

A second important tenet of rationality, known as the extended sure-thing principle, states that, if an outcome X_i is the same for two risky actions, then the value of X_i should be disregarded in choosing between the two options. Another way to state this principle is that outcomes that are not affected by your choice should not influence your decision.

These two principles, combined with several others of technical importance, imply a rather powerful conclusion--namely that the wise decision maker chooses that act whose expected utility is greatest. To do otherwise would violate one or more basic tenets of rationality.

Applied decision theory assumes that the rational decision maker wishes to select an action that is logically consistent with his basic preferences for outcomes and his feelings about the likelihoods of the events upon which those outcomes depend. Given this assumption, the practical problem becomes one of listing the alternatives and scaling the subjective values of outcomes and their likelihoods so that subjective expected utility can be calculated for each alternative. Another problem in application arises from the fact that the range of theoretically possible alternatives is often quite large. In addition to carrying an umbrella, the risk-taking traveler in our earlier example may have the options of carrying a raincoat, getting a ride, waiting for the rain to stop, and many others. Likewise, the outcomes are considerably more complex than in our simple example. For example, the consequences of building a dam are multiple, involving effects on flood potential, hydroelectric power, recreation, and local ecology. Some specific approaches that have been developed for dealing with the additional complexities of any real decision situation are discussed in the decision theory literature (see, e.g., Keeney & Raiffa, 1976).

CONFRONTING HUMAN LIMITATIONS

Bounded Rationality

The traditional view of human mental processes assumes that we are intellectually gifted creatures. Shakespeare referred to humans as "noble in reason, infinite in faculties...the beauty of the world, the paragon of animals." The rational model described above, with its presumption of well informed, utility maximizing decision makers, has echoed this theme. As economist Frank Knight put it, "We are so built that what seems reasonable to us is likely to be confirmed by experience or we could not live in the world at all" (1921, p. 227).

An important early critic of the economic model's descriptive adequacy was Herbert Simon, who drew upon psychological research to challenge traditional assumptions about the motivation, omniscience, and computational capacities of decision makers. As an alternative to utility maximization, Simon (1957) introduced the notion of "bounded rationality," which asserts that cognitive limitations force people to construct simplified models of the world in order to cope with it. To predict behavior "...we must understand the way in which this simplified model is constructed, and its construction will certainly be related to 'man's' psychological properties as a perceiving, thinking, and learning animal" (p. 198).

During the past twenty years, the skeleton theory of bounded rationality has been fleshed out. We have learned much about human cognitive limitations and their implications for behavior--particularly with regard to decisions made in the face of uncertainty and risk. Numerous studies show that people (including experts) have great difficulty judging probabilities, making predictions, and otherwise attempting to cope with uncertainty. Frequently these difficulties can be traced to the use of judgmental heuristics, which serve as general strategies for simplifying complex tasks. These heuristics are valid in many circumstances, but in others they lead to large and persistent biases with serious implications for decision making. Much of this work has been summarized by Kahneman, Slovic and Tversky (1982), Nisbett and Ross (1980), Slovic, Fischhoff and Lichtenstein (1977), and Tversky and Kahneman (1974). In the remainder of this section we shall discuss two general manifestations of bounded rationality that are particularly relevant to regulation of risk. These topics are judgmental biases and unstable preferences.

Judgmental Biases in Risk Perception

If people are to respond optimally to the risks they face, they must have reasonably accurate perceptions of the magnitude of those risks. Yet the formal education of most laypeople rarely includes any serious instruction in how to assess risks. Their subsequent learning is typically restricted to unsystematic personal experience and news media reports. It should not be surprising that people often are misinformed, rely on suboptimal risk assessment strategies, and fail to understand the limits of their own knowledge.

Availability. One inferential strategy that has special relevance for risk perception is the availability heuristic (Tversky & Kahneman, 1973). People using this heuristic judge an event as likely or frequent if instances of it are easy to imagine or recall. Because frequently occurring events are generally easier to imagine or recall than are rare events, availability is often an appropriate cue. However, availability is also affected by factors unrelated to frequency of occurrence. For example, a recent disaster or a vivid film could seriously bias risk judgments.

Availability bias is illustrated by several studies in which people judged the frequency of 41 causes of death (Lichtenstein, Slovic, Fischhoff, Layman, & Combs, 1978). In one study, these people were first told the annual death toll in the United States for one cause (50,000 deaths from motor vehicles accidents) and then asked to estimate the frequency of the other 40 causes. Figure 1 compares the judged number of deaths per year with the number reported in public health statistics. If the frequency judgments equalled the statistical rates, all data points would fall on the identity line. Although more likely hazards generally evoked higher estimates, the points were scattered about a curved line that lay sometimes above and sometimes below the line representing accurate judgment. In general, rare causes of death were overestimated and common causes of death were underestimated. In addition to this general bias, sizable specific biases are evident in Figure 1. For example, accidents were judged to cause as many deaths as diseases, whereas diseases actually take about 15 times as many lives. Homicides were incorrectly judged as more frequent than diabetes and stomach cancer deaths. Pregnancies, births, and abortions were judged to take about as many lives as diabetes, though diabetes actually causes about 80 times more deaths. In keeping with availability considerations, causes of death that were overestimated (relative to the curved line) tended to be dramatic and sensational (accidents, natural disasters, fires, homicides), whereas underestimated causes tended to be unspectacular events that claim one victim at a time and are common in nonfatal form (e.g., smallpox vaccinations, stroke, diabetes, emphysema).

Insert Figure 1 about here

The availability heuristic highlights the vital role of experience as a determinant of perceived risk. If one's experiences are misleading, one's perceptions are likely to be inaccurate. Unfortunately, much of the information to which people are exposed provides a distorted picture of the world of hazards. One result of this is that people tend to view themselves as personally immune to certain kinds of hazards. Research shows that the great majority of individuals believe themselves to be better than average drivers (Svenson, 1981), more likely than average to live past 80 years old (Weinstein, 1980), less likely than average to be harmed by products that they use (Rethans, 1979), and so on. Although such perceptions are obviously unrealistic, the risks may look very small from the perspective of each individual's experience. Consider automobile driving: despite driving too fast, following too closely, etc., poor drivers make trip after trip without mishap. This personal experience demonstrates to them their exceptional skill and safety. Moreover, their indirect experience via the news media shows that when accidents happen, they happen to others. Given such misleading experiences, people may feel quite justified in refusing to take protective actions such as wearing seat belts (Slovic, Fischhoff & Lichtenstein, 1978).

In some situations, failure to appreciate the limits of available data may lull people into complacency. For example, we asked people to evaluate the completeness of a fault tree showing the problems that could cause a car not to start when the ignition key was turned (Fischhoff, Slovic, & Lichtenstein, 1978). Respondents' judgments of completeness were about the same when looking at the full tree as when looking at a tree in which half of the causes of starting failure were deleted. In keeping with the availability heuristic, what was out of sight was also out of mind. The only antidote to availability-induced biases is to recognize the limitations in the samples of information received from the world and produced by one's own mind. Doing so requires a knowledge of the world and of mental processes that few people can be expected to have. Even scientists often have difficulty identifying systematic biases in their data.

<u>Overconfidence</u>. A particularly pernicious aspect of heuristics is that people typically have too much confidence in judgments based upon

them. In another follow-up to the study on causes of death, people were asked to indicate the odds that they were correct in choosing the more frequent of two lethal events (Fischhoff, Slovic, & Lichtenstein, 1977). Odds of 100 : 1 or greater were given often (25% of the time). However, about one out of every eight answers associated with such extreme confidence was wrong (fewer than 1 in 100 would have been wrong had the odds been appropriate). At odds of 10,000 : 1, people were wrong about 10% of the time. The psychological basis for this unwarranted certainty seems to be an insensitivity to the tenuousness of the assumptions upon which one's judgments are based. For example, extreme confidence in the incorrect assertion that homicides are more frequent than suicides may occur because people fail to appreciate that the greater ease of recalling instances of homicides is an imperfect basis for inference.

Overconfidence manifests itself in other ways as well. A typical task in estimating uncertain quantities such as failure rates is to set upper and lower bounds so that there is a certain fixed probability that the true value lies between them. Experiments with diverse groups of people making many different kinds of judgments have found that true values tend to lie outside of the confidence boundaries much too often. Results with 98% bounds are typical. Rather than 2% of the true values falling outside such bounds, 20-50% usually do so (Lichtenstein, Fischhoff & Phillips, 1982). Thus people think that they can estimate uncertain quantities with much greater precision than they actually can.

Unfortunately, once experts are forced to go beyond their data and rely on judgment, they may be as prone to overconfidence as laypeople. Fischhoff, Slovic, and Lichtenstein (1978) repeated their fault-tree study with professional automobile mechanics (averaging about 15 years of experience) and found them to be about as insensitive as laypersons to deletions from the tree. Hynes and Vanmarcke (1976) asked seven "internationally known" geotechnical engineers to predict the height of an embankment that would cause a clay foundation to fail and to specify confidence bounds around this estimate that were wide enough to have a 50% chance of enclosing the true failure height. None of the bounds specified by those individuals actually enclosed the true failure height.

Unstable Preferences: Difficulties in Evaluating Risk

The process of evaluation is the heart of decision making. Evaluating the (good and bad) outcomes associated with hazardous activities might seem to be relatively straightforward. Certainly people know what they like and dislike. Research has, however, shown the assessment of values to be as troublesome as the assessment of facts. Evidence is mounting in support of the view that our values are often not clearly apparent, even to ourselves; that methods for measuring values are intrusive and biased; and that the structure of any decision problem is psychologically unstable, leading to inconsistencies in choice.

Labile values. When one is considering simple, familiar events with which people have direct experience, it may be reasonable to assume that they have well-articulated preferences. But that may not be so in the case of the novel, unfamiliar consequences potentially associated with outcomes of events such as surgery, automobile accidents, carbon-dioxide-induced climatic changes, nuclear meltdowns, or genetic engineering. In these and other circumstances, our values may be incoherent, not sufficiently thought out (Fischhoff, Slovic & Lichtenstein, 1980a, b). When we think about risk management policies, for example, we may be unfamiliar with the terms involved (e.g., social discount rates, minuscule probabilities, megadeaths). We may have contradictory values (e.g., a strong aversion to catastrophic losses of life but an awareness that we are no more moved by a plane crash with 500 fatalities than one with 300). We may occupy different roles in life (parents, workers, children) each of which produces clear-cut but inconsistent values. We may vacillate between incompatible but strongly held positions (e.g., freedom of speech is inviolate, but it should be denied authoritarian movements). We may not even know how to begin thinking about some issues (e.g., the appropriate tradeoffs between the outcomes of surgery for cancer vs. the very different outcomes from radiation therapy). Our views may change so much over time (say, as we near the hour of decision or of experiencing the consequences) that we are disoriented as to what we really think.

Competent decision analysts may tell us what primary, secondary, and tertiary consequences to expect, but not what these consequences really entail. To some extent we are all prisoners of our past experiences, unable to imagine drastic changes in our world or health or relationships.

Unstable decision frames. In addition to the uncertainties that sometimes surround our values, perceptions of the basic structure of a decision problem are also unstable. The acts or options available, the possible outcomes or consequences of those acts, and the contingencies or conditional probabilities relating outcomes to acts make up what Tversky and Kahneman (1981) have called the "decision frame." Much as changes in vantage point induce alternative perspectives on a visual scene, the same decision problem can be subject to many alternative frames (see Figure 2). Which frame is adopted is determined in part by the external formulation of the problem and in part by the structure spontaneously imposed by the decision maker. Tversky and Kahneman have demonstrated that normatively inconsequential changes in the framing of decision problems significantly affect preferences. These effects are noteworthy because they are sizable (often complete reversals of preference), because they violate important consistency and coherence requirements of economic theories of choice, and because they influence not only behavior, but how the consequences of behavior are experienced.

Insert Figure 2 about here

Tversky and Kahneman (1981) have presented numerous illustrations of framing effects, one of which involves the following pair of problems, given to separate groups of respondents.

1. Problem 1. Imagine that the U.S. is preparing for the outbreak of an unusual disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the consequences of the programs are as follows: If Program A is adopted, 200 people will be saved. If Program B is adopted, there is 1/3 probability that 600 people will be saved, and 2/3 probability that no people will be saved. Which

of the two programs would you favor?

2. Problem 2. (Same cover story as Problem 1.) If Program C is adopted, 400 people will die. If Program D is adopted, there is 1/3 probability that nobody will die, and 2/3 probability that 600 people will die. Which of the two programs would you favor?

The preference patterns tend to be quite different in the two problems. In a study of college students, 72% of the respondents chose Program A over Program B and 78% chose Program D over Program C. Another study, surveying physicians, obtained very similar results. On closer examination, we can see that the two problems are essentially identical. The only difference between them is that the outcomes are described by the number of lives saved in Problem 1 and the number of lives lost in Problem 2.

One important class of framing effects deals with a phenomenon that Tversky and Kahneman (1981) have called "pseudocertainty." It involves altering the representations of protective actions so as to vary the apparent certainty with which they prevent harm. For example, an insurance policy that covers fire but not flood could be presented either as full protection against the specific risk of fire or as a reduction in the overall probability of property loss. Because outcomes that are merely probable are undervalued in comparison with outcomes that are obtained with certainty, Tversky and Kahneman hypothesized that the above insurance policy should appear more attractive in the first context (pseudocertainty), which offers unconditional protection against a restricted set of problems. We have tested this conjecture in the context of one particular kind of protection, vaccination. Two forms of a "vaccination questionnaire" were created. Form I (probabilistic protection) described a disease expected to afflict 20% of the population and asked people whether they would volunteer to receive a vaccine that protects half of the people receiving it. According to Form II (pseudocertainty), there were two mutually exclusive and equiprobable strains of the disease, each likely to afflict 10% of the population; the vaccination was said to give complete protection against one strain and no protection against the other.

The participants in this study were college students, half of whom received each form. After reading the description, they rated the likelihood that they would get vaccinated in such a situation. Although both forms indicated that vaccination reduced one's overall risk from 20% to 10%, we expected that vaccination would appear more attractive to those who received Form II (pseudocertainty) than to those who received Form I (probabilistic protection). The results confirmed this prediction: 57% of those who received Form II indicated they would get vaccinated compared with 40% of those who received Form I.

The pseudocertainty effect highlights the contrast between the reduction and the elimination of risk. As Tversky and Kahneman have indicated, this distinction is difficult to justify on any normative grounds. Moreover, manipulations of certainty would seem to have important implications for the design and description of other forms of protection (e.g., medical treatments, insurance, flood- and earthquake-proofing activities).

STUDIES OF PROTECTIVE BEHAVIOR

In this section we shall describe studies of two kinds of protective behavior, insurance purchases and the use of seat belts. This research, which was designed to provide basic knowledge relevant for regulatory decisions, illustrates the complex interplay between cognitive limitatins and public policy.

National Flood Insurance Program

Although few residents of flood and earthquake areas voluntarily insure themselves against the consequences of such disasters, many turn to the federal government for aid after suffering losses. Policy makers have argued that both the government and the property owners at risk would be better off financially under a federal insurance program. Such a program would shift the burden of disasters from the general taxpayer to individuals living in hazardous areas and would thus promote wiser decisions regarding the use of flood plains (Kunreuther et al., 1978).

Without a firm understanding of how people perceive and react to risks, however, there is no way of knowing what sort of disaster insurance program would be most effective. For example, the National Flood Insurance Program took the seemingly reasonable step of lowering the cost of insurance in order to stimulate purchases. However, despite heavily subsidized rates, relatively few policies were bought (Kunreuther, 1974).

An integrated program of laboratory experiments and field surveys by Kunreuther, Ginsberg, Miller, Sagi, Slovic, Borkan, & Katz (1978) and Slovic, Fischhoff, Lichtenstein, Corrigan, & Combs (1977) was designed to determine the critical factors influencing the voluntary purchase of insurance against natural hazards such as floods or earthquakes. Analysis of the survey data revealed widespread ignorance and misinformation regarding the availability and terms of insurance and the probabilities of damage from a future disaster. The laboratory experiments showed that people preferred to insure against relatively high-probability, low-loss hazards and tended to reject insurance in situations where the probability of loss was low and the potential losses were high. These results suggest that people's natural predispositions run counter to economic theory (e.g., Friedman & Savage, 1948), which assumes that individuals are risk averse and should desire a mechanism that protects them from rare catastrophic losses.

When asked about their insurance decisions, subjects in both the laboratory and survey studies indicated a disinclination to worry about low-probability hazards. Such a strategy is understandable. Given the limitations on their time, energy, and attentional capacities, people have a finite reservoir of concern. Unless they ignored many low-probability threats they would become so burdened that productive life would become impossible. Another insight gleaned from the experiments and the survey is that people think of insurance as an investment. Receiving payments for claims seems to be viewed as a return on the premium--one which is received more often with more probable losses. The popularity of low-deductible insurance plans (Fuchs, 1976; Pashigian, Schkade & Menefee, 1966) provides confirmation from outside the laboratory that people prefer to insure against relatively probable events with small consequences.

One surprising survey result was that homeowners' lack of interest in disaster insurance did not seem to be due to expectations that the federal government would bail them out in an emergency. The majority of individuals interviewed said they anticipated no aid at all from the government in the event of a disaster. Most appeared not to have considered how they would recover from flood or earthquake damage.

If insurance is to be marketed on a voluntary basis, consumers' attitudes and information-processing limitations must be taken into account. Policy makers and insurance providers must find ways to communicate the risks and arouse concern for the hazards. One method found to work in the laboratory experiments is to increase the perceived probability of disaster by lengthening the individual's time horizon. For example, considering the risk of experiencing a 100-year flood at least once during a 25-year period, instead of considering the risk in one year, raises the probability from .01 to .22 and may thus cast flood insurance in a more favorable light. Another step would have insurance agents play an active role in educating homeowners about the proper use of insurance as a protective mechanism and providing information about the availability of insurance, rate schedules, deductible values, etc. If such actions are not effective, then it may be necessary to institute some form of mandatory coverage. Recognizing the difficulty of inducing voluntary coverage, the National Flood Insurance Program now requires insurance as a condition for obtaining federal funds for building in flood-prone areas.

Seat Belts

Another form of protection that people do not often use is the automobile seat belt. Promotional efforts to get motorists to wear seat belts have failed dismally (Robertson, 1976). Despite expensive advertising campaigns and buzzer systems, fewer than 20% of motorists "buckle up for safety." Policy makers have criticized the public for failing to appreciate the risks of driving and the benefits of seat belts. However, results from risk perception research provide an alternative perspective that seems at once more respectful of drivers' reasoning and more likely to increase seat belt use.

As noted above, people's insurance decisions reflect a disinclination to worry about very small probabilities. Reluctance to wear seat belts might, therefore, be due to the extremely small probability of incurring a fatal accident on a single automobile trip. Because a fatal accident occurs only about once in every 3.5 million person-trips and a disabling injury only once in about every 100,000 person-trips, refusing to buckle up one's seat belt may seem quite reasonable. It may look less reasonable, however, if one frames the problem within a multiple-trip perspective. This is, of course, the perspective of traffic safety planners, who see the thousands of lives that might be saved annually if belts were used regularly. For the individual, during 50 years of auto travel (about 40,000 trips), the probability of being killed is .01 and the probability of experiencing at least one disabling injury is .33. In laboratory experiments, we found that people induced to consider this lifetime perspective responded more favorably toward the use of seat belts (and air bags) than did people asked to consider a trip-by-trip perspective (Slovic, Fischhoff & Lichtenstein, 1978). More recent studies suggest that television and radio messages based on this lifetime-cumulative-risk theme can increase actual seat belt use (Schwalm & Slovic, 1982).

UNDERSTANDING PERCEIVED RISK

If it is to aid hazard management, a theory of perceived risk must explain people's extreme aversion to some hazards, their indifference to others, and the discrepancies between these reactions and experts' recommendations. Why, for example, do some people react vigorously against the location of a liquid natural gas terminal in their vicinity, despite the assurances of experts that it is safe? Why, on the other hand, do people living below great dams generally show little concern for experts' warnings? Over the past few years researchers have been attempting to answer such questions as these by examining the opinions that people express when they are asked, in a variety of ways, to characterize and evaluate hazardous activities and technologies. The goals of this descriptive research are (a) to develop a taxonomy of risk characteristics that can be used to understand and predict societal responses to hazards and (b) to develop methods for assessing public opinions about risk in a way that could be useful for policy decisions.

The Psychometric Paradigm

Psychometric scaling methods and multivariate analysis techniques have been used to produce quantitative representations of risk attitudes and perceptions (Brown & Green, 1980; Fischhoff, Slovic, Lichtenstein, Layman, & Combs, 1978; Gardner, Tiemann, Gould, DeLuca, Doob, & Stolwijk, 1982; Green, 1980a, b; Green & Brown, 1980; Johnson & Tversky, in press; Renn, 1981; Slovic, Fischhoff & Lichtenstein, 1979, 1980a, in press; Vlek & Stallen, 1981; von Winterfeldt, John & Borcherding, 1982). Researchers employing the psychometric paradigm have typically asked people to judge the current and desired riskiness (or safety) of diverse sets of hazardous activities, substances, and technologies, and to indicate their desires for risk reduction and regulation of these hazards. These global judgments have then been related to judgments about:

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

Among the generalizations that have been drawn from the results of psychometric studies are the following:

1. 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, for example, Table 2).

Insert Table 2 about here

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2. "Risk" means different things to different people. When experts judge risk, their responses correlate highly with technical estimates of annual fatalities (Figure 3, top). Laypeople can assess annual fatalities if they are asked to (and produce estimates somewhat similar to 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, are not closely related to their own (or experts') estimates of annual fatalities (see Figure 3, bottom).

Insert Figure 3 about here

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3. Even when groups disagree about the overall riskiness of specific hazards, they show remarkable agreement when rating those hazards on characteristics of risk such as knowledge, controllability, dread, catastrophic potential, etc.

4. Many of these risk characteristics are highly correlated with each other, across a wide domain of hazards. For example, voluntary hazards tend also to be controllable and well known, hazards that threaten future generations tend also to be seen as having catastrophic potential. Analysis of these interrelationships shows that the broader domain of characteristics can be condensed to three higher-order characteristics or factors. These factors reflect the degree to which a risk is understood, the degree to which it evokes a feeling of dread, and the number of people exposed to the risk (see Figure 4). This factor structure has been found to be similar across groups of

laypersons and experts judging large and diverse sets of hazards. Making the set of hazards more specific (e.g., partitioning nuclear power into radioactive waste transport, uranium mining, nuclear reactor accidents, etc.) appears to have little effect on the factor structure or its relationship to risk perceptions (Slovic, Fischhoff & Lichtenstein, in press).[2]

Insert Figure 4 about here

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5. Many of the various characteristics, particularly those associated with the factor "Dread Risk," correlate highly with laypersons' perceptions of risk. The higher an activity's score on the dread factor, the higher its perceived risk, the more people want its risks reduced, and the more they want to see strict regulation employed to achieve the desired reductions in risk (see Figure 5). The factor labeled "Unknown Risk" tends not to correlate highly with risk perception. Factor 3, Exposure, is moderately related to lay perceptions of risk. In contrast, experts' perceptions of risk are <u>not</u> related to any of these risk characteristics or factors derived from them. As noted above, experts' risk perceptions seem determined by annual fatalities.

Insert Figure 5 about here

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6. The perceived seriousness of an accident is systematically related to its "signal potential," the degree to which that accident

serves as a warning signal, providing information about the probability that similar or more destructive mishaps might occur. Signal potential and perceived seriousness are systematically related to both Dread Risk and Unknown Risk factors (see Figure 6).

Insert Figure 6 about here

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7. In agreement with hypotheses originally put forth by Starr (1969), people's acceptance of risk appears related to their perception of benefit. All other things being equal, greater perceived benefit is associated with a greater acceptance of risk. Moreover, acceptability depends upon various qualitative aspects of risk, including its voluntariness, familiarity, catastrophic potential and perceived uncertainty. In sharp contrast to Starr's views, however, our respondents did not believe that society has managed hazards so well that optimal tradeoffs among these characteristics have already been achieved.

Implications of Risk Perception Research

In the results of the psychometric studies, we have the beginnings of a perceptual/psychological classification system for hazards. Ultimately, we need not only a better psychological taxonomy but one that also reflects physical, biological, and social/managerial elements of hazards. Such a taxonomy would be a potent device for understanding and guiding social regulation of risk. We are far from this goal, though a start towards an expanded taxonomy has been made (Hohenemser, Kates & Slovic, 1983). For the present, more modest insights and applications must suffice.

Forecasting public response. Despite the lack of a complete understanding of public attitudes and perceptions, we have attempted to use the results from risk perception studies to explain and forecast reactions to specific technologies. Nuclear power has been the principle object of such analysis because of the obvious role of social factors governing this important technology. Weinberg (1976), reflecting on the future of nuclear power, observed that, "...the public perception and acceptance of nuclear energy...has emerged as the most critical question." The reasonableness of these perceptions has been the topic of an extensive public debate, filled with charges and countercharges. For example, one industry source has argued that public reaction to Three Mile Island has cost "...as much as $500 billion...and is one measure of the price being paid as a consequence of fear arising out of an accident that according to the most thorough estimates may not have physiologically hurt even one member of the public (EPRI Journal, 1980; p. 30)."

Risk perception research offers some promise of clarifying the concerns of opponents of nuclear power (Fischhoff, Slovic & Lichtenstein, 1983; Slovic, Fischhoff & Lichtenstein, 1981b; Slovic, Lichtenstein & Fischhoff, 1979). In particular, psychometric studies show that these people judge its benefits as quite low and its risks as unacceptably great. On the benefit side, most opponents do not see nuclear power as a vital link in meeting basic energy needs; rather, they view it as a supplement to other sources of energy which are themselves adequate. On the risk side, nuclear power occupies a unique position in the factor space, reflecting people's views that its risks are unknown, dread, uncontrollable, inequitable, catastrophic, and likely to affect future generations (see Figure 4). Opponents recognize that few people have died to date as a result of nuclear power. However, they do have great concern over the potential for catastrophic accidents. Nuclear hazards are particularly memorable and imaginable, yet hardly amenable to empirical verification. These special qualities blur the distinction between the possible and the probable and produce an immense gap between the views of most technical experts and a significant portion of the public. Because much of the opposition to nuclear power can be understood in terms of basic psychological principles of perception and cognition or to deep-seated differences in values, this opposition is not likely to be reduced by information campaigns that focus on safety. What might improve the industry's status is convincing information about its benefits, perhaps in conjunction with energy shortages. A superb safety record might, over time, reduce opposition, but because nuclear risks are perceived to be unknown and potentially catastrophic, even small accidents will be judged as quite serious (see Figure 6), will be highly publicized, and will have immense social costs. This fact has direct implications for the setting of safety standards (Slovic, Fischhoff & Lichtenstein, 1980c).

This type of research may also forecast the response to technologies that have yet to catch the public's eye. For example, our studies indicate that recombinant DNA technology shares several of the characteristics that make nuclear power so hard to manage (Slovic, Fischhoff & Lichtenstein, in press). If it somehow seizes public attention, this new technology could face some of the same problems and opposition now confronting the nuclear industry.

INFORMING PEOPLE ABOUT RISK

One consequence of the growing concern about hazards has been pressure on the promoters and regulators of hazardous enterprises to inform citizens, patients, and workers about the risks they face from their daily activities, their medical treatments, and their jobs (see Cohen's chapter, this book). Attempts to implement information programs depend upon a variety of political, economic and legal forces (e.g., Gibson, 1985; Sales, 1982). The success of such efforts depends, in part, upon how clearly the information can be presented (Fischhoff, 1985; Slovic, Fischhoff & Lichtenstein, 1980a, 1981).

One thing that past research demonstrates clearly is the difficulty of creating effective risk-information programs. Doing an adequate job means finding cogent ways of presenting complex technical material that is often clouded by uncertainty. Reactions to the material may be distorted by the listeners' preconceptions (and possibly the presenter's misrepresentations) of the hazard and its consequences. Difficulties in putting risks into perspective or resolving the conflicts posed by life's gambles may cause risk information to frighten and frustrate people, rather than aid their decision making.

If an individual has formed strong initial impressions about a hazard, results from cognitive social psychology suggest that those beliefs may structure the way that subsequent evidence is interpreted.

New evidence will appear reliable and informative if it is consistent with one's initial belief; contrary evidence may be dismissed as unreliable, erroneous, or unrepresentative. As a result, strongly held views will be extraordinarily difficult to change by informational presentations (Nisbett & Ross, 1980).

When people lack strong prior opinions about a hazard, the opposite situation exists--they are at the mercy of the way that the information is presented. Subtle changes in the way that risks are expressed can have a major impact on perceptions and decisions. One dramatic recent example of this comes from a study by McNeil, Pauker, Sox, and Tversky (1982), who asked people to imagine that they had lung cancer and had to choose between two therapies, surgery or radiation. The two therapies were described in some detail. Then, some subjects were presented with the cumulative probabilities of surviving for varying lengths of time after the treatment. Other subjects received the same cumulative probabilities framed in terms of dying rather than surviving (e.g., instead of being told that 68% of those having surgery will have survived after one year, they were told that 32% will have died). Framing the statistics in terms of dying dropped the percentage of subjects choosing radiation therapy over surgery from 44% to 18%. The effect was as strong for physicians as for laypersons.

Numerous other examples of "framing effects" have been demonstrated by Tversky and Kahneman (1981). Some of these effects can be explained in terms of the nonlinear probability and value functions proposed by Kahneman and Tversky (1979) in their theory of risky choice. Others can be explained in terms of other information-processing considerations such as compatibility effects, anchoring processes, and choice heuristics (Slovic, Fischhoff, & Lichtenstein, 1982). Whatever the causes, the fact that subtle differences in how risks are presented can have such marked effects suggests that those responsible for information programs have considerable ability to manipulate perceptions and behavior. Indeed, since these effects are not widely known, people may inadvertently be manipulating their own perceptions by casual decisions that they make about how to organize their knowledge.

Behavioral research can make a number of contributions toward the process of informing people about risk. Research can alert people to potential biases so that the parties involved can defend their own interests. It can also assess the feasibility of informational programs by determining how well people can be informed. Fortunately, despite the difficulties that have been discovered, there is evidence showing that properly designed information programs can be beneficial. Research indicates that people can understand some aspects of risk quite well and they do learn from experience. In situations where misperception of risks is widespread, people's errors can often be traced to inadequate information and biased experiences, which educational programs may be able to counter. A final contribution of research is in determining how interested people are in having the information at all. Despite occasional claims to the contrary by creators of risk, people seem to want information (Fischhoff, 1983; Slovic, Fischhoff & Lichtenstein, 1980a), even when the nature of that information is threatening (Weinstein, 1979; 1985).

Comparing Risks

One common approach to deepening people's perspectives is presenting quantified risk estimates for a variety of hazards. These presentations typically involve elaborate tables and even 'catalogues of risks' in which diverse indices of death or disability are displayed for a broad spectrum of life's hazards. Some of these provide extensive data on risks per hour of exposure, showing, for example, that an hour of riding a motorcycle is as risky as an hour of being 75 years old. One analyst developed lists of activities, each of which is estimated to increase one's chances of death (in any year) by 1 in 10^6. Other analysts have ranked hazards in terms of their expected reduction in life expectancy. Those who compile such data typically assume that they will be useful for decision making.

The research on perceived risk described earlier implies that comparisons such as these will not, by themselves, be adequate guides to personal or public decision policies. Risk perceptions and risk-taking behaviors appear to be determined not only by accident probabilities, annual mortality rates or the mean losses of life expectancy, but also by numerous other characteristics of hazards such as uncertainty, controllability, catastrophic potential, equity and threat to future generations. Within the perceptual space defined by these and other characteristics, each hazard is unique. To many persons, 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' appear ludicrous because they fail to give adequate consideration to the important differences in the nature of the risks from these two technologies. However, comparisons within the same hazard domain, may be useful. For example, one may gain some perspective on the amount of radiation absorbed from a medical X ray by comparing it to radiation received in a trans-continental flight or from living in Denver for a year. Unfortunately, we need considerably more research to determine how best to compare risks and how to present risk statistics.

Recognizing the Difficulties

The development of programs to inform patients, workers and consumers about risk is an admirable goal. However, as the discussion above indicates, it is important to recognize the difficulties confronting such programs. Since every decision about the content and format of an information statement is likely to influence perception and behavior (and ultimately product viability, jobs, electricity costs, compliance with medical treatments, and other important consequences), extreme care must be taken to select knowledgeable and trustworthy designers and program coordinators. Finally, it is important to recognize that informing people, whether by warning labels, package inserts or extensive media presentations, is but part of the larger problem of helping them to cope with the risks and uncertainties of modern life. We believe that much of the responsibility lies with the schools, whose curricula should include material designed to teach people that the world in which they live is probabilistic, not deterministic, and to help them learn judgment and decision strategies for dealing with that world. These strategies are as necessary for navigating in a world of uncertain information as geometry and trigonometry are to nagivating among physical objects.

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Table 1. Example of a payoff matrix

			State of nature	
			sun (E_1)	rain (E_2)
Alternatives	A_1	carry umbrella	(+1) stay dry carrying umbrella	(+1) stay dry carrying umbrella
	A_2	leave umbrella	(+2) dry and unburdened	(0) wet and unburdened

Table 2

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.

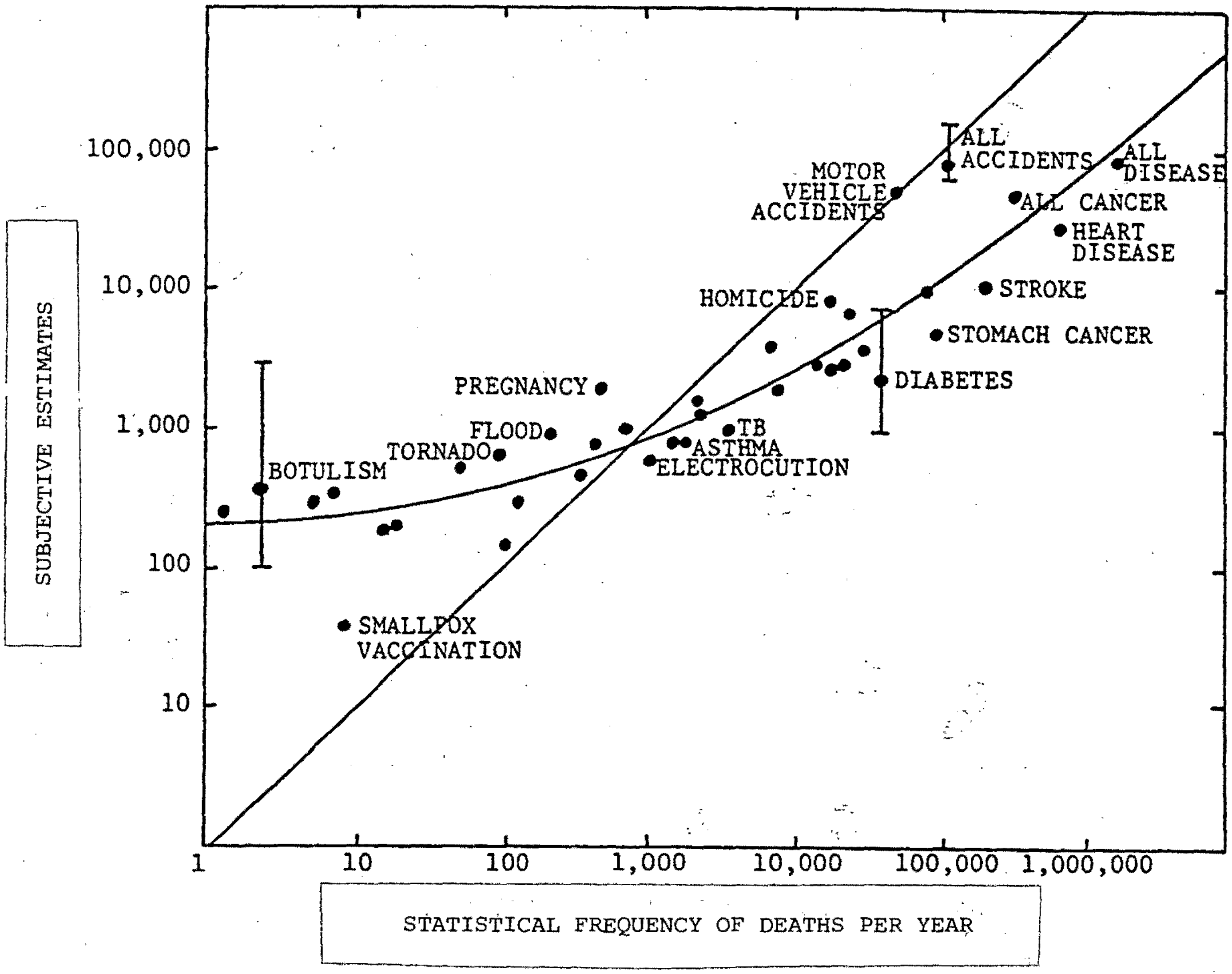

Figure 1. Relation between judged and statistical frequencies for 41 causes of death.

Source: Lichtenstein <u>et al</u>. (1978).

A civil defense committee in a large metropolitan area met recently to discuss contingency plans in the event of various emergencies. One emergency threat under discussion posed two options, both involving some loss of life.

Option A: Carries with it a .5 probability of containing the threat with a loss of 40 lives and a .5 probability of losing 60 lives. It is like taking the gamble:

.5 lose 40 lives
.5 lose 60 lives

Option B: Would result in the loss of 50 lives:

lose 50 lives

The options can be presented under three different frames:

I. This is a choice between a 50-50 gamble (lose 40 or lose 60 lives) and a sure thing (the loss of 50 lives).

II. Whatever is done at least 40 lives will be lost. This is a choice between a gamble with a 50-50 chance of either losing no additional lives or losing 20 additional lives (A) and the sure loss of 10 additional lives (B).

III. Option B produces a loss of 50 lives. Taking Option A would mean accepting a gamble with a .5 chance to save 10 lives and a .5 chance to lose 10 additional lives.

Figure 2. Decision framing: Three perspectives on a civil defense problem.

Source: Fischhoff, 1983 (a).

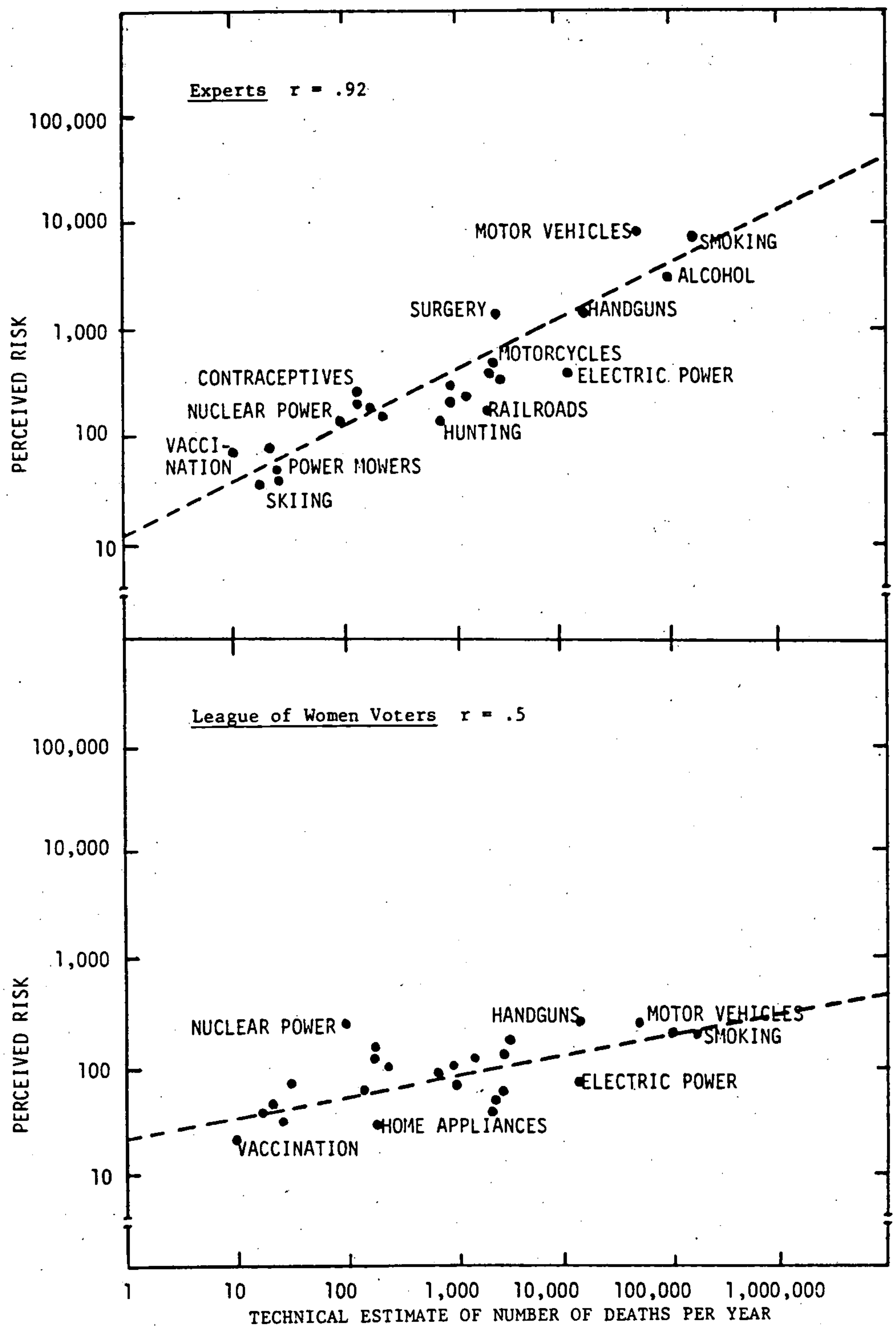

Figure 3. Judgments of perceived risk for experts (top) and laypeople (bottom) plotted against the best technical estimates of annual fatalities for 25 technologies and activities. Each point represents the average responses of the participants. The dashed lines are the straight lines that best fit the points. The experts' risk judgments are seen to be more closely associated with annual fatality rates than are the lay judgments.

Source: Slovic, Fischhoff and Lichtenstein, 1979.

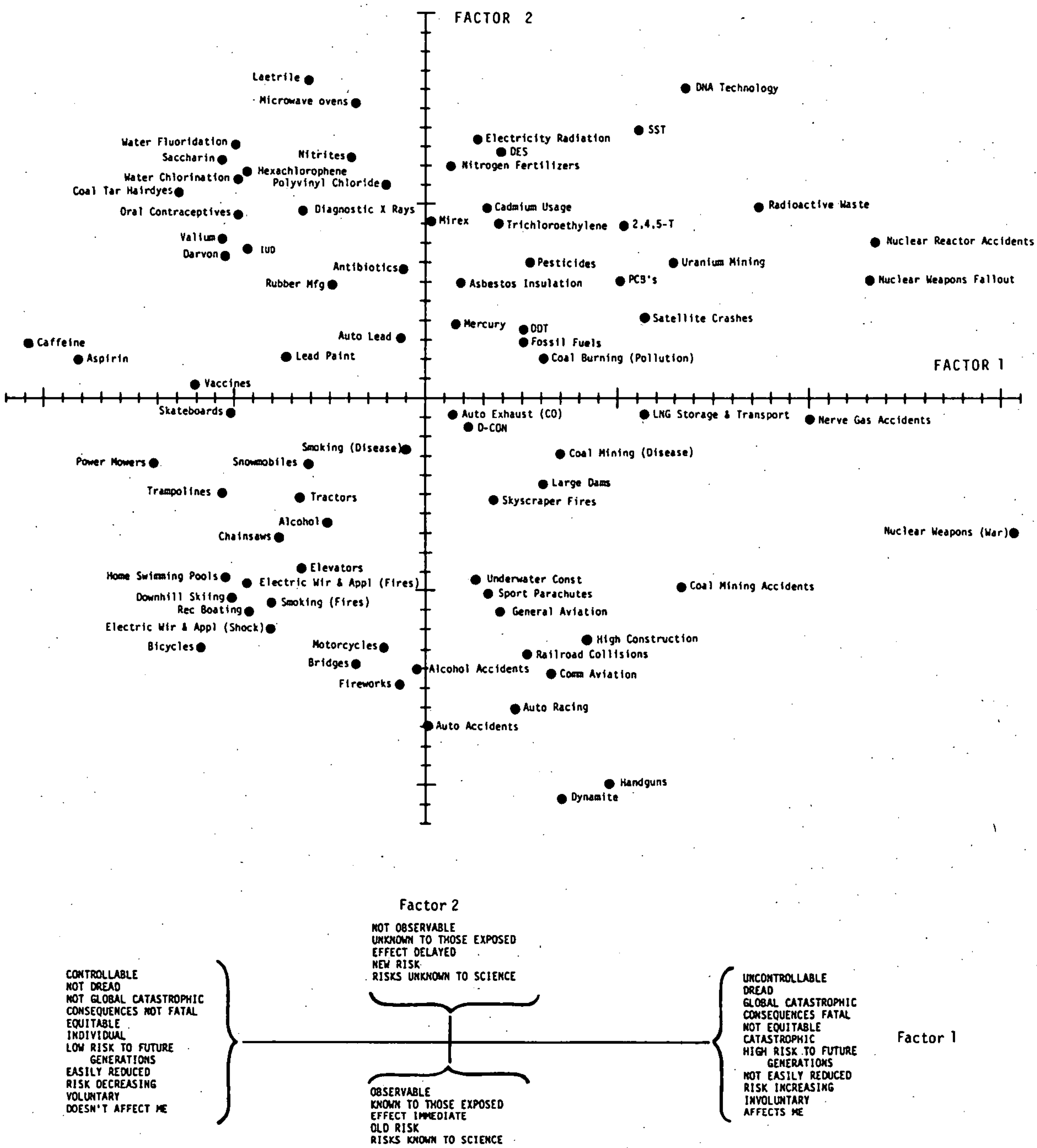

Figure 4. Hazard locations on Factors 1 and 2 of the three-dimensional structure derived from the interrelationships among 18 risk characteristics. Factor 3 (not shown) reflects the number of people exposed to the hazard and the degree of one's personal exposure. The diagram beneath the figure illustrates the characteristics that comprise the two factors.

Source: Slovic, Fischhoff, and Lichtenstein, in press.

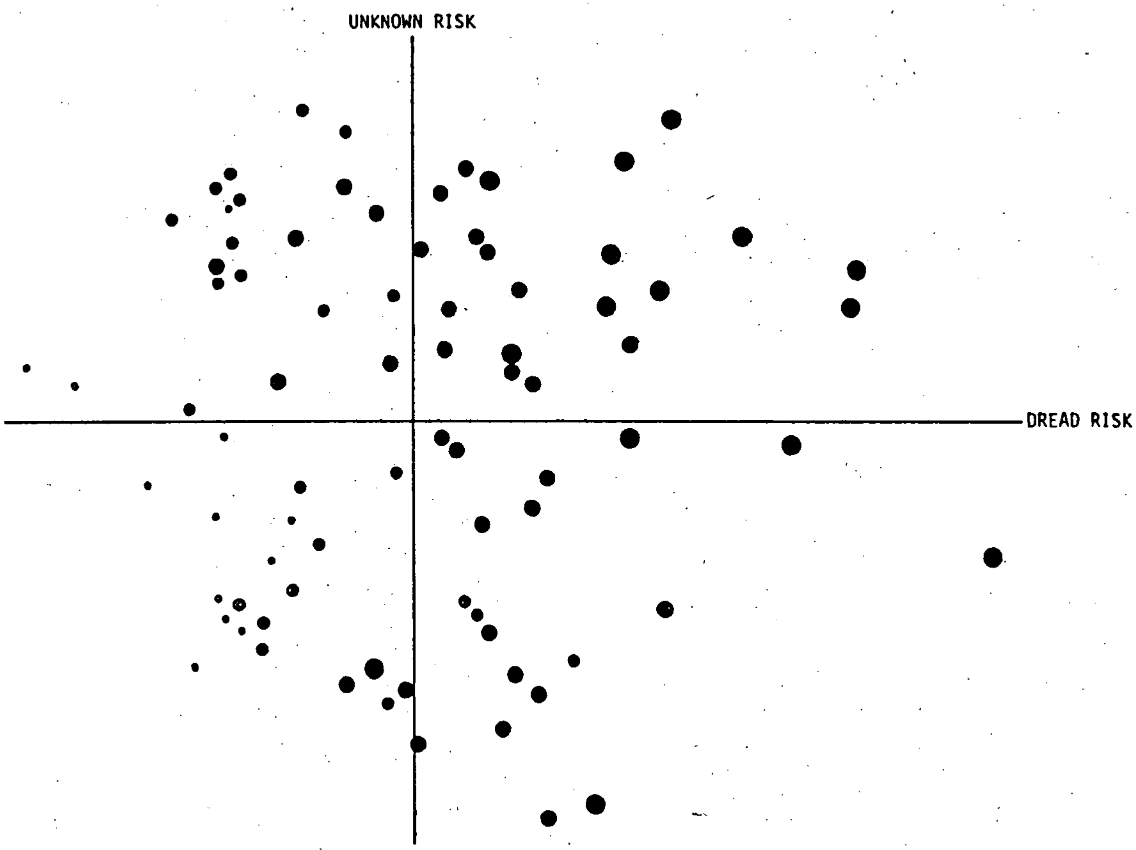

Figure 5. Attitudes towards regulation of the hazards in Figure 4. The larger the point, the greater the desire for strict regulation to reduce risk.

Source: Slovic, Lichtenstein and Fischhoff, in press.

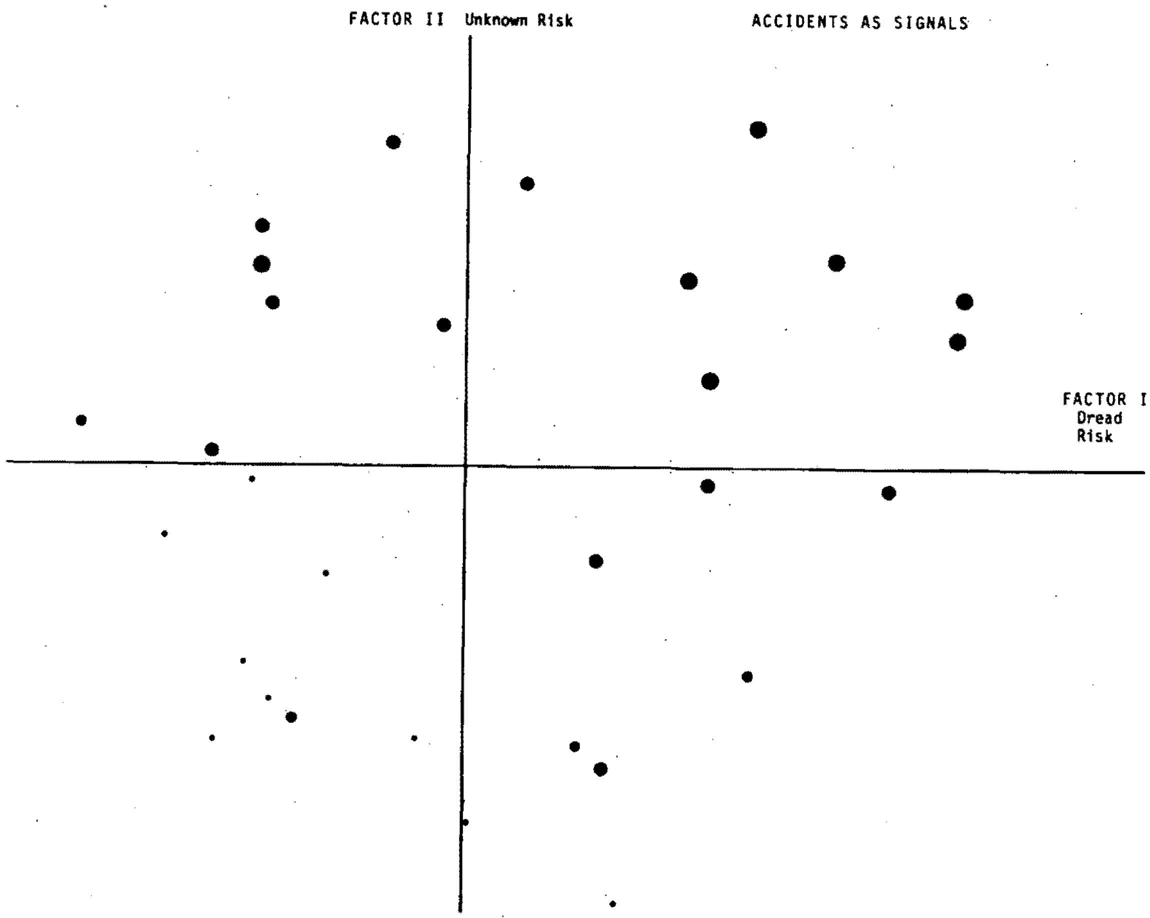

Figure 6. Relation between signal potential and risk characterization for 30 hazards in Figure 4. The larger the point, the greater the degree to which an accident involving the hazard was judged to "serve as a warning signal for society, providing new information about the probability that similar or even more destructive mishaps might occure within this type of activity."

Source: Slovic, Lichtenstein & Fischhoff, 1984.