CHAPTER 9

Perceptions of Environmental Hazards: Psychological Perspectives

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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 (Ricci, Sagan, & Whipple, 1984).

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 (Harris, 1980). 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.

Over the past 15 years, a small number of researchers have been 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.

This research attempts to aid policy makers by improving communication between them and the lay public, by directing educational efforts, and by predicting public responses to new technologies (e.g., genetic engineering), events (e.g., a good safety record, an accident), and new risk management strategies (e.g., 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 (Burton, Kates, & White, 1978). Sociological research (Freudenburg, 1988; Short, 1984) and anthropological studies (Douglas, 1966) have shown that perception and acceptance of risk have their roots in social and cultural factors. Short (1984) 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. In a similar vein, Douglas and Wildavsky (1982) 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 is the focus of this chapter, originated in empirical studies of probability assessment, utility assessment, and decision-making processes (Edwards, 1961). 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 (Kahneman, Slovic, & Tversky, 1982). 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. Unfortunately, experts' judgments appear to be prone to many of the same biases as those of laypersons, particularly when experts are forced to go

beyond the limits of available data and rely upon their intuitions (Henrion & Fischhoff, 1986; Kahneman, Slovic, & Tversky, 1982). 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 (Nisbett & Ross, 1980). 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 their perspectives and their actions (Tversky & Kahneman, 1981).

The Psychometric Paradigm

One broad strategy for studying perceived risk is to develop a taxonomy for hazards that can be used to understand and predict responses to their risks. A taxonomic scheme might explain, for example, people's extreme aversion to some hazards, their indifference to others, and the discrepancies between these reactions and experts' opinions. The most common approach to this goal has employed the *psychometric paradigm* (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978; Slovic, Fischhoff, & Lichtenstein, 1984), which uses psychophysical scaling and multivariate analysis techniques to produce quantitative representations 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, (iv) the number of deaths caused by the hazard in a disastrous year, and (v) the seriousness of each death from a particular hazard relative to a death due to other causes.

Numerous studies carried out within the psychometric paradigm have shown that perceived risk is quantifiable and predictable. Psychometric techniques seem well suited for identifying similarities and differences among groups with regard to risk perceptions and attitudes (see Table 9.1). They have also shown that the concept "risk" means different things to different people. When experts judge risk, their responses correlate highly with technical estimates of annual fatalities. Lay people can assess annual fatalities if they are asked to (and produce estimates somewhat like the technical estimates). However, their judgments of "risk" are 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.

Insert Table 9.1 about here

Another consistent result from psychometric studies 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 claim (1969) 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, further studies have shown that other (perceived) characteristics such as familiarity, control, catastrophic potential, equity, and level of knowledge also seem to influence the relationship between perceived risk, perceived benefit, and risk acceptance (Fischhoff et al., 1978; Slovic, Fischhoff, & Lichtenstein, 1980).

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

Factor-Analytic Representations

Psychometric studies have demonstrated that every hazard has a unique pattern of qualities that appears to be related to its perceived risk. Figure 9.1 shows the mean profiles across nine characteristic qualities of risk that emerged for nuclear power and medical x-rays in an early study (Fischhoff et al., 1978). Nuclear power was judged to have much higher risk than x-rays and to need much greater reduction in risk before it would become "safe enough." As the figure illustrates, nuclear power also had a much more negative profile across the various risk characteristics.

Insert Figure 9.1 about here

Many of the qualitative risk characteristics that make up a hazard's profile tend to be highly correlated with each other, across a wide range of hazards. For example, hazards rated as "voluntary" tend also to be rated as "controllable" and "well-known"; hazards that appeared

to threaten future generations tend also to be seen as having catastrophic potential, and so on. Investigation of these interrelationships by means of factor analysis has indicated that the broader domain of characteristics can be condensed to a small set of higher-order characteristics or factors. Figure 9.2 presents a spatial representation of hazards within a factor space which has been replicated across numerous groups of laypeople and experts judging large and diverse sets of hazards. The factors in this space reflect the degree to which a risk is understood and the degree to which it evokes a feeling of dread.

Insert Figure 2 about here

Research has shown that laypeople's risk perceptions and attitudes are closely related to the position of a hazard within the factor space. Most important is the factor "Dread Risk." The higher a hazard's score on this factor (i.e., the further to the right it appears in the space), the higher its perceived risk, the more people want to see its current risks reduced, and the more they want to see strict regulation employed to achieve the desired reduction in risk. In contrast, experts' perceptions of risk are not closely related to any of the various risk characteristics or factors derived from these characteristics. Instead, experts appear to see riskiness as synonymous with expected annual mortality (Slovic, Fischhoff, & Lichtenstein, 1979). As a result, many conflicts about risk may result from experts and laypeople having different definitions of the concept. In such cases, expert recitations of risk statistics will do little to change people's attitudes and perceptions.

The representation shown in Figure 9.2, while robust and informative, is by no means a universal cognitive representation 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 representations (Johnson & Tversky, 1984; Slovic, Fischhoff, & Lichtenstein, 1984). The utility of these models for understanding and predicting behavior remains to be determined.

Perceptions Have Impacts: The Social Amplification of Risk

Perceptions of risk play a key role in a process labeled social amplification of risk (Chapter 10 this book; Kasperson et al., 1988). Social amplification is triggered by the occurrence of an adverse event, which could be a major or minor accident, a discovery of pollution, an incident of sabotage, and so on. Risk amplification reflects the fact that the adverse impacts of such an event sometimes extend far beyond the direct damages to victims and property and may result in massive indirect impacts such as litigation against a company or loss of sales, increased regulation of an industry, and so on. In some cases, all companies within an industry are affected, regardless of which company was responsible for the mishap. Thus, the event can be thought of as a stone dropped in a pond. The ripples spread outward, encompassing first the directly affected victims, then the responsible company or agency, and, in the extreme, reaching other companies, agencies, or industries. Examples of events resulting in extreme higher-order impacts include the chemical manufacturing accident at Bhopal, India, the disastrous launch of the space shuttle Challenger, the nuclear-reactor accidents at Three Mile Island and Chernobyl, the adverse effects of the drug Thalidomide, the Exxon Valdez oil spill, and the adulteration of Tylenol capsules with cyanide. An important feature of social amplification is that the direct impacts need not be too large to trigger major indirect impacts.

The seven deaths due to the Tylenol tampering resulted in more than 125,000 stories in the print media alone and inflicted losses of more than one billion dollars upon the Johnson & Johnson Company, due to the damaged image of the product (Mitchell, 1989).

It appears likely that multiple mechanisms contribute to the social amplification of risk. First, extensive media coverage of an event can contribute to heightened perceptions of risk and amplified impacts (Burns et al., 1990). Second, a particular risk or risk event may enter into the agenda of social groups, or what Mazur (1981) terms the partisans, within the community or nation. The attack on the apple growth-regulator "Alar" by the Natural Resources Defense Council demonstrates the important impacts that special-interest groups can trigger (Moore, 1989).

A third mechanism of amplification arises out of the interpretation of unfortunate events as clues or signals regarding the magnitude of the risk and the adequacy of the risk-management process (Burns et al., 1990; Slovic, 1987). The informativeness or signal potential of a mishap, and thus its potential social impact, appears to be systematically related to the perceived characteristics of the hazard. An accident that takes many lives may produce relatively little social disturbance (beyond that caused to the victims' families and friends) if it occurs as part of a familiar and well-understood system (e.g., a train wreck). However, a small accident in an unfamiliar system (or one perceived as poorly understood), such as a nuclear waste repository or a recombinant DNA laboratory, may have immense social consequences if it is perceived as a harbinger of future and possibly catastrophic mishaps.

The concept of accidents as signals helps explain our society's strong response to mishaps involving nuclear power and nuclear wastes. Because the risks associated with nuclear energy

are seen as poorly understood and catastrophic, accidents anywhere in the world may be seen as omens of disaster everywhere there are nuclear reactors and wastes, thus producing responses (e.g., increased regulation, public opposition) that carry large socioeconomic impacts.

Stigmatization

Substantial socioeconomic impacts may also result from the stigma associated with the perception of environmental contamination or risk. The word stigma was used by the ancient Greeks to refer to bodily marks or brands that were designed to signal infamy or disgrace—to show, for example, that the bearer was a slave or a criminal. As used today, the word denotes someone marked as deviant, flawed, limited, spoiled, or generally undesirable in the view of some observer (Goffman, 1963). When the stigmatizing characteristic is observed, the person is denigrated or avoided. Prime targets for stigmatization are members of minority groups, the aged, homosexuals, drug addicts, alcoholics, and persons afflicted with physical deformities or mental disabilities.

Jones et al. (1984) attempted to characterize the key dimensions of social stigma. The six dimensions or factors they proposed were as follows:

(1) *Concealability*. Is the condition hidden or obvious? To what extent is its visibility controllable?

(2) *Course*. What pattern of change over time is usually shown by the condition? What is its ultimate outcome?

(3) *Disruptiveness*. Does the condition block or hamper interaction and communication?

(4) *Aesthetic qualities*. To what extent does the mark make the possessor repellent, ugly, or upsetting?

(5) *Origin.* Under what circumstances did the condition originate? Was anyone responsible for it, and what was he or she trying to do?

(6) *Peril.* What kind of danger is posed by the mark and how imminent and serious is it?

Dimension 6, peril, is the key link between stigma and perceived risk, but other dimensions may also come into play in the stigmatization associated with hazards. It seems evident that stigmatization can be generalized from persons to products, technologies, and environments. For example, nuclear and chemical waste disposal sites may be perceived as repellent, ugly, and upsetting (Dimension 4) to the extent that they become visible (Dimension 1). Such waste sites may also be perceived as disruptive (Dimension 3). They are certainly perceived as dangerous (Dimension 6).

Stigmatization resulting from pollution by a toxic substance is described by Edelstein (1986), who analyzed a case in which a dairy's cows become contaminated with PCBs for a short period of time. Once this contamination became known (a visible mark) the reputation of the dairy was discredited and its products became undesirable, even though the level of PCBs was never sufficiently high to prohibit sale of those products. Edelstein showed, step by step, how this incident meets the various criteria of stigmatization put forth by Jones et al.

Although Edelstein's case of stigma involved dairy products, only a short leap is required to extend the concept to environments that have been contaminated by toxic substances (Edelstein, 1988). Times Beach, Missouri, and Love Canal, New York, come quickly to mind.

A dramatic example of stigmatization involving radiation occurred in September 1987, in Goiania, Brazil, where two men searching for scrap metal dismantled a cancer therapy device

in an abandoned clinic. In doing so, they sawed open a capsule containing 28 grams of cesium chloride. Children and workers nearby were attracted to the glowing material and began playing with it. Before the danger was realized, several hundred people became contaminated and four persons eventually died from acute radiation poisoning. Publicity about the incident led to stigmatization of the region and its residents (Petterson, 1988). Hotels in other parts of the country refused to allow Goiania residents to register; airline pilots refused to fly with Goiania residents on board; automobiles driven by Goianians were stoned; hotel occupancy in the region dropped 60% for six weeks following the incident and virtually all conventions were canceled during this period. The sale prices of clothing and other products manufactured in Goiania dropped by 40% after the first news reports and remained depressed for a period of 30-45 days, despite the fact that none of these items was ever shown to have been contaminated.

Empirical Studies of Environmental Risk Perception and Stigma

In recent years we have applied the concepts of perceived risk, social amplification of risk, and environmental stigma in an attempt to assess the potential economic impacts of the proposed national repository for disposing of high-level nuclear wastes.

In December 1987, the U.S. Congress amended the Nuclear Waste Policy Act and authorized the Department of Energy to determine whether Yucca Mountain, Nevada, is a geologically sound and technically feasible site for disposal of high-level nuclear waste. If the site passes a set of prescribed technical criteria, a repository will be constructed there to dispose of nuclear waste from the nation's commercial power plants.

Much effort has been, and will continue to be, devoted to characterizing the physical and biological risks associated with construction and operation of this unique facility, which must safely contain a large volume of highly radioactive material for a time period that is twice as long as recorded human history. Socioeconomic risks, though less studied, are also important. The remainder of this chapter describes a study in which my colleagues and I attempted to answer the following question pertaining to social impacts: What is the potential for a high-level nuclear waste repository at Yucca Mountain to have adverse economic effects on the city of Las Vegas and the State of Nevada during the period of constructing and filling the repository (approximately 40-60 years)?[1]

The economic impacts of concern to us included reduction in short-term visits to the city and state by vacationers or conventioneers, effects on long-term residents (moving out of the region, reduced in-migration of retirees), and reduced ability to attract new businesses. Assessment of these impacts is obviously important to citizens and officials of Nevada, who need to know what economic consequences to expect if Yucca Mountain is developed as the repository. Information about possible economic impacts may also be relevant to the final decision itself, regarding the acceptability of the Yucca Mountain site.

Empirical research on this topic faces some major obstacles, however. Changes in scientific knowledge and changes in public opinion are inherently difficult to forecast. For example, both scientific and public views about the risks of nuclear energy have changed dramatically since the "Atoms for Peace" program began in the 1950's. An obstacle to survey research is the fact that people may not really know how the repository will affect their future

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[1] Additional details of this research can be found in Slovic et al. (1991).

preferences and decisions or the decisions of their successors. As a result, asking people to project the repository's impacts on vacation decisions to be made many years hence may, in effect, be asking them to "tell more than they can know" (Nisbett & Wilson, 1977). Studies by Baker, Moss, West, and Weyant (1977) and West and Baker (1983) indicate that answers to questions about the impact of nuclear facilities on future behavior may not be trustworthy.

Despite these difficulties, there are theoretical reasons, based upon perception of risk, social amplification processes, and stigmatization, to expect that the repository may produce adverse economic impacts. In our studies we developed a method for assessing impacts that is not dependent on direct questioning of people. We then used this method to assess the potential impacts from a repository at Yucca Mountain.

In order to avoid the problems of relying upon answers to hypothetical questions, our studies employed an indirect strategy, based on the notion of environmental imagery. Studies of environmental imagery appear to have the potential to provide a sound and defensible theoretical framework from which to understand and project possible impacts of a nuclear-waste repository on tourism and other important behaviors. Accordingly, the present studies were designed to demonstrate the concept of environmental imagery and show how it can be measured, assess the relationship between imagery and choice behavior, and describe economic impacts that might occur as a result of altered images and choices.

The concept of imagery is not new to the study of environment and behavior. Geographers, cognitive and environmental psychologists, marketing strategists, and consumer theorists have written at length about the importance of images in our environmental consciousness and our behavior (see, e.g., Boulding, 1956; Kearsley, 1985; McInnis & Price,

1987; Paivio, 1979; Saarinen & Sell, 1980; Weart, 1988). However, to our knowledge, no one has used a design such as ours to link imagery to the behaviors of concern here.

Our research was designed to test the following three propositions: (1) Images associated with environments have diverse positive and negative affective meanings that influence preferences (e.g., in this case, preferences for sites in which to vacation, retire, find a job, or start a new business); (2) A nuclear-waste repository evokes a wide variety of strongly negative images, consistent with extreme perceptions of risk and stigmatization; and (3) The repository at Yucca Mountain and the negative images it evokes will, over time, become increasingly salient in the images of Nevada and of Las Vegas. If these three propositions are true, it seems quite plausible that, as the imagery of Las Vegas and of Nevada becomes increasingly associated with the repository, the attractiveness of these places to tourists, job seekers, retirees, and business developers will decrease and their choices of Las Vegas and Nevada within sets of competing sites will decrease.

Support for these three propositions, therefore, would demonstrate the mechanism whereby the repository could produce adverse affects upon tourism, migration, and business development in Nevada and this demonstration would occur without having to ask people to make introspective judgments about their future behaviors.

Survey Design

In order to test the propositions described above, we first conducted three surveys of imagery and preference. Studies 1 and 2 surveyed representative samples of residents in Phoenix, Arizona. Study 1 elicited images for four cities and asked people to indicate their preferences among these cities as places to vacation, take a new job, or retire. Study 2 did the

same for four states. Study 3 surveyed a national sample of business executives, asking for their images of each of four cities and their preferences among these cities as places to open a new business or expand an existing business. All three surveys were conducted by telephone. Each survey had a sample size of about 400 persons.

The survey questions in Studies 1 and 2 were nearly identical. The *cities questionnaire* asked respondents to provide images for San Diego, Las Vegas, Denver, and Los Angeles. The *states questionnaire* elicited imagery for California, Nevada, Colorado, and New Mexico. These cities and states, in addition to Las Vegas and Nevada, were chosen for the study because they are important vacation destinations for residents of Phoenix.

The images were elicited using a version of the method of continued associations (Szalay & Deese, 1978), adapted for use in a telephone interview.[2] Image elicitation was always the first task in the survey. In the cities survey, the elicitation interview proceeded as follows:

> "My first question involves word association. For example, when I mention the word baseball, you might think of the World Series, Reggie Jackson, summertime, or even hot dogs. Today, I am interested in the first SIX thoughts or images that come to mind when you hear the name of a PLACE.
>
> Think about _____ for a minute. When you think about _____,
> [CITY] [CITY]
> what is the first thought or image that comes to mind?
>
> What is the next thought or image you have when I say _____?

[2] The study of associations has a long history in psychology, going back to Galton (1880), Wundt (1883), and Freud (1924). Szalay and Deese (1978) argue that word-association techniques are easy and efficient ways of determining the contents and representational systems of human minds without requiring those contents to be expressed in the full discursive structure of human language. In fact, they argue, we may reveal ourselves in associations in ways we find difficult to do if we were required to spell out the full propositions behind these associations through answers to questions.

[CITY]

_____. Your next thought or image?
[CITY]

What is another thought or image you have about _____?"
[CITY]

This continued until six associations were produced or the respondent drew a blank. Then the procedure was repeated for the next city. The order of the cities was rotated across respondents. The procedure was identical for the states and business location surveys.

Following the elicitation of images, respondents were asked to rate each image they gave on a scale ranging from very positive (+2), somewhat positive (+1), neutral (0), somewhat negative (-1), or very negative (-2).

Respondents in Studies 1 and 2 were then asked to rank the cities/states according to their preference for a vacation site (long weekend vacation for cities; week or longer vacation for states). Subsequent questions asked for a preference ranking among these cities or states as retirement sites or places to move to assuming equally attractive job offers in each place, much in the same manner as vacation preferences were elicited.

Next, up to six images were elicited to the stimulus "underground nuclear waste storage facility" and the stimulus "nuclear test site."

The survey also asked "in which state has the federal government proposed to build an underground facility for storing radioactive wastes?" and "in which state is the nuclear test site located?"[3]

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[3] The nation's nuclear weapons test site is located in Nye County, Nevada, adjacent to the proposed repository site at Yucca Mountain.

The survey of corporate decision makers first elicited images for each of four cities—Phoenix, Las Vegas, Denver, and Albuquerque—and then asked the respondents to evaluate these images on the -2 to +2 rating scale, as in the other surveys. These individuals were then asked to rank these cities in order of preference as a location for opening or expanding a business, assuming that market conditions and cost conditions were about equal.

Results: Cities Survey

Images. In response to "Las Vegas," images associated with gambling, casinos, hotels, bright lights and entertainment were dominant, followed by imagery pertaining to the climate and physical landscape, money, crime, and immorality. Imagery related to nuclear waste and the nuclear test site was very infrequent (only 2 images out of more than 1500 responses). Table 9.2 presents the hierarchy of images elicited by the phrase "underground nuclear waste storage facility." This imagery was overwhelmingly negative. The most frequent associations by far were dangerousness and death and their synonyms, followed by pollution, negative concepts, and radiation. Although we did not ask people to score these images, it seems likely that most of them would have been judged "very negative," a -2 on our five-point scale. Although some images pertaining to "necessity" came at the 17th position, they were very few in number (17) and included the phrase "necessary evil" given by two respondents. The words "Nevada" and "Las Vegas" were weakly associated with the repository, which was not surprising, given the low level of awareness of where the site is proposed to be located.[4]

[4] Only 19.6% of the cities sample knew that Nevada had been selected as the leading candidate for an underground facility for disposing of radioactive wastes and 46.8% knew that the nuclear weapons test site is in Nevada.

Insert Table 9.2 about here

Images of the nuclear test site were similarly negative and exhibited considerable overlap in content with the images of a nuclear-waste storage facility. Major test-site images included radiation, death, danger, cancer, destruction, and Nevada. More people associated Nevada with the test site (82 mentions) than with the repository.

Predicting preferences from images. To predict preferences among cities from images, we developed a scoring rule, the summation model, which simply sums the ratings for all the images a respondent produced for each city. A person's preferences among cities are hypothesized to be predictable from these sums.

An example, illustrating the application of the summation model to the data of one respondent, is given in Table 9.3. For this respondent, the rank order of summation scores exactly matched the preference order for vacation sites.

Insert Table 9.3 about here

When ranks generated by the summation model were compared to the actual ranks generated by the respondents when they stated their preferences, the model did quite well, correctly predicting 55% of the number 1 ranked vacation cities and 56% of the fourth ranked cities, with somewhat less accuracy in predicting intermediate ranks (if the model lacked predictive validity, we would expect a 25% hit rate by chance). The exact rank order of four

cities generated by the summation model matched the exact rank order of the respondent 26.4% of the time (perfect matching of ranks would be expected by chance only 4.2% of the time).

A second set of tests was conducted with the summation model. Each of the four cities was paired with every other cities—making six pairs in all. For every respondent and every pair, the image score for city B was subtracted from the image score of city A. The resulting 2,346 A-B scores across all respondents were ordered from extreme negative to extreme positive and this distribution was partitioned into five subsets, as equal in size as possible (419 to 511 comparisons in each subset). Finally, within each subset, the percentage of respondents who ranked city A more favorably than city B as a vacation site was calculated. For the pairs where the mean A-B difference was most negative (mean = -6.2), A was preferred as a vacation site for only 27.4%. For those in which the mean difference was most in favor of A (mean = +11.4), 90.7% of the preferences favored A. Figure 9.3 illustrates the performance of the summation model across *all pairs* of cities. The choice proportions for *specific pairs* of cities (e.g., Las Vegas vs. Denver) were found to be quite similar to the combined plot. The data show that imagery and preference for vacation cities are strongly related. If city B has a more positive set of images than city A (as indicated by simply summing the affect ratings across images produced for each city), then city B is more likely to be preferred as a vacation site. If city A has more positive imagery, then city A is more likely to be preferred as a vacation site.

Insert Figure 9.3 about here

Predicting job and retirement preferences. The summation model was applied in similar fashion to the prediction of job preferences and retirement preferences for the cities survey. The

hit rates were similar to those reported earlier for vacation preferences and the functional relationships relating job and retirement preferences to image scores were almost identical to the relationship shown in Figure 9.3.

Results: States Survey

As in the cities survey, more people (41.0%) knew the location of the nuclear weapons test site than knew the location being considered for the repository (24.5%). The summation model was found to be about as accurate in predicting vacation, job, and retirement preferences among states as it was for predicting preferences among cities.

Imagery associated with "a nuclear waste storage facility" and the "nuclear test site" was extremely negative for respondents in the states survey and was almost identical to the imagery obtained in the cities survey. Whereas few people in the cities survey expressed nuclear-related imagery in response to Las Vegas, about 10% of respondents in the states survey produced nuclear imagery in response to Nevada. Such images included the terms nuclear testing, nuclear bomb, nukes, explosions, and radiation. The mean image score for Nevada for these persons was 0.18. The mean image score for persons who did not associate Nevada with things nuclear was 2.56 (a statistically significant difference; $p < .001$). As expected, persons with nuclear imagery assigned lower (poorer) preference rankings to Nevada than did persons without such images (see Table 9.4). These findings are important because they suggest that Nevada has already undergone some stigmatization as a nuclear place.

Insert Table 9.4 about here

Results: Corporate Decision Makers Survey

Parallel analyses were carried out with the images and preferences of the corporate decision makers. The summation model correctly predicted 47% of the first-choice locations for siting a new business and the functional relationship between image scores and preferences for pairs of cities looked much like the relationship for vacation preferences in Figure 9.3.

In summary, three separate surveys totaling more than 1200 respondents demonstrated that a simple summation model applied to sets of images did a good job of predicting expressed preferences for cities and states in which to vacation, take a new job, retire, or site a business. The slopes of the best-fitting lines relating preferences among pairs of cities/states to differences in image values were quite steep, indicating that a change in one or two images could imply a substantial shift in preference probability.

Effects of Repository Knowledge and Test-Site Knowledge

Additional analyses were conducted using the states survey data to determine the impact of knowledge about the state being considered for the nuclear waste repository and knowledge about the state in which the nuclear-test site is located upon images and preferences for Nevada as a vacation site. These two types of knowledge were found to be related. Persons who knew that the repository was being considered for Nevada were somewhat more likely to know that the test site is in Nevada (71%) as compared to those who lacked knowledge of the repository (55%). Similar results were obtained in the cities survey, where the corresponding values were 70% and 41%.

Additional analyses showed that the presence of a nuclear image in one's image set for Nevada was determined more by knowledge of the test-site location than by knowledge of the

repository location. Nuclear imagery was produced by 15% of those persons who knew the test-site location compared to 2% of those who did not know the location. Corresponding figures associated with knowledge and lack of knowledge of the proposed repository were 12% and 9%.

Summarizing the results from these analyses, we see that the proposed Yucca Mountain repository has not yet infiltrated people's images of Nevada and has not yet had much effect on their stated vacation preferences. The test site, which has been a feature of Nevada for many years, has had a stronger influence on images and preferences. Knowledge that the weapons test site is in Nevada appears to have led to an increase in nuclear-related imagery for Nevada and nuclear imagery is associated with decreased preference for Nevada as a vacation site.

Imagery and Vacation Behavior

The previous analyses demonstrated that images could predict expressed preferences for vacation sites. Can image scores also predict actual vacation trips? To address this question we attempted to resurvey the 802 respondents from our 1988 Phoenix surveys some 16-18 months later (October - December 1989). We were successful in re-interviewing about 130 persons in each of the two samples (cities survey and states survey) studied earlier. Again, we elicited word associations to each of the same four cities or four states and asked for positive/negative ratings of each image produced. In addition, we asked the respondents to indicate in which of these cities (or states) they had vacationed since the previous survey was conducted.

The predictive capability of the word-association image scores was tested by means of logistic regression analysis using a person's 1988 image score for a state or city to estimate the probability that that person would vacation in a place during the subsequent 16-18 months (until the date of the repeat survey). The estimated probabilities for both cities and states are

presented in Figures 9.4 and 9.5. These data show that the affective qualities of a person's images of a place were clearly related to the probability that the person would subsequently vacation there, with the relationship being stronger for states than for cities.

Insert Figures 9.4 and 9.5 about here

Discussion

The results of this study supported the three propositions that the research aimed to test: Images of cities and states, derived from a word-association technique, exhibited positive and negative affective meanings that were highly predictive of preferences for vacation sites, job and retirement locations, and business sites (Proposition 1). The concept of a nuclear-waste storage facility evoked extreme negative imagery (Proposition 2). The nuclear-weapons test site, which has been around far longer than the Yucca Mountain nuclear-waste project, has led to a modest amount of nuclear imagery becoming associated with the state of Nevada. This provides indirect evidence for Proposition 3, which asserts that nuclear-waste related images will also become associated with Nevada and Las Vegas if the Yucca Mountain Project proceeds. Nuclear imagery, when present in a person's associative responses, was found to be linked with much lower preference for Nevada as a vacation site. the verification of these propositions implies that the repository also has the potential to cause an increase in nuclear imagery which, in turn, will produce adverse impacts on tourism and other economically important activities in Nevada.[5]

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[5] A parallel study by Easterling and Kunreuther (1990) has found that repository imagery reduces the attractiveness of Las Vegas for convention planners and convention attendees and thus has the potential to affect the city's convention industry.

These findings provide a partial answer to the question that motivated the inquiry. The mechanisms of perceived risk, social amplification, and stigma are observable in the record of past experience with nuclear and other types of hazards. In the context of the Yucca Mountain Repository, these mechanisms appear to have the potential to cause substantial losses to each of the various economic sectors at risk. It would be unwise and unfair for development of the nation's high-level nuclear waste repository to proceed without taking these potential economic impacts into consideration.

Although this research has clarified the mechanisms by which adverse economic impacts can be generated, predicting the precise magnitude and duration of those impacts is impossible. The uncertainties involved in repository development make it inevitable that the actual impacts—physical, biological, social, and economic—will differ from the best of impact projections.

In sum, this analysis indicates that the development of the Yucca Mountain Repository will, in effect, force Nevadans to gamble with their future economy. The nature of that gamble cannot be specified precisely, but it appears to include credible possibilities (with unknown probabilities) of substantial losses to the visitor economy, the migrant economy, and the business economy. Because of the uncertainty inherent in projecting these impacts, reasonable people may differ greatly in their estimates. Actions may or may not appear warranted, based upon assessment of these special impacts. But the important implication of this study is that the possibility of such impacts cannot be ignored.

Broader Implications

The research described in this chapter has implications for social-impact analysis that transcend the conflicts and concerns surrounding the proposed Yucca Mountain repository. The processes of social amplification and stigma appear relevant also to the analysis of impacts from any major facility that produces, uses, transports, or disposes of hazardous materials. The numerous proposed sites for disposal of low-level radioactive wastes and the many sites being considered for chemical-waste incinerators and landfills will face similar problems of perceived risk and its impacts, though probably to a lesser degree than the problems posed for Nevadans by a Yucca Mountain repository. The study of socioeconomic impacts at Yucca Mountain has demonstrated that the so-called "standard effects" of large engineering projects on local employment, housing, and transportation have the potential to be dwarfed by the "special effects" of risk perception and stigma. However, just as physical or technical risks can be mitigated by proper safety design and management, effects of perceived risk may be mitigated by means of management processes that instill and maintain trust and that work to protect the economic base of those individuals and communities whom the project puts at risk.

Acknowledgement

This paper draws heavily upon two previous papers:

Slovic, P. (1987). Perception of risk. *Science*, *236*, 280-285; and

Slovic, P., Layman, M., Kraus, N., Flynn, J., Chalmers, J., & Gesell, G. (1991). Perceived risk, stigma, and potential economic impacts of a high-level nuclear waste repository in Nevada. *Risk Analysis*, *11*, 683-696.

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Table 9.1

Ordering of perceived risks 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. Source: Slovic, Fischhoff, and Lichtenstein (1980).

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 and 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

Table 9.2

Hierarchy of images associated with an "underground nuclear waste storage facility." Source: Slovic et al. (1991).

	Category	Frequency	Images Included in Category
1.	Dangerous	179	dangerous, danger, hazardous, toxic, unsafe, harmful, disaster
2.	Death	107	death, sickness, dying, destruction
3.	Negative	99	negative, wrong, bad, unpleasant, terrible, gross, undesirable, awful, dislike, ugly, horrible
4.	Pollution	97	pollution, contamination, leakage, spills, Love Canal
5.	War	62	war, bombs, nuclear war, holocaust
6.	Radiation	59	radiation, nuclear, radioactive, glowing
7.	Scary	55	scary, frightening, concern, worried, fear, horror
8.	Somewhere Else	49	wouldn't want to live near one, not where I live, far away as possible.
9.	Unnecessary	44	unnecessary, bad idea, waste of land
10.	Problems	39	problems, trouble
11.	Desert	37	desert, barren, desolate
12.	Non-Nevada Locations	35	Utah, Arizona, Denver
13.	Storage Location	32	caverns, underground salt mine
14.	Government/Industry	23	government, politics, big business

Table 9.3

Images, ratings, and summation scores for respondent 132. Source: Slovic et al. (1991).

Sample Subject	Image Number	Image Rating	
SAN DIEGO	1	2	very nice
SAN DIEGO	2	2	good beaches
SAN DIEGO	3	2	zoo
SAN DIEGO	4	1	busy freeway
SAN DIEGO	5	1	easy to find way
SAN DIEGO	6	2	pretty town
		Sum = 10	
LAS VEGAS	1	-2	rowdy town
LAS VEGAS	2	-1	busy town
LAS VEGAS	3	-1	casinos
LAS VEGAS	4	-1	bright lights
LAS VEGAS	5	-2	too much gambling
LAS VEGAS	6	0	out of the way
		Sum = -7	
DENVER	1	2	high
DENVER	2	0	crowded
DENVER	3	2	cool
DENVER	4	1	pretty
DENVER	5	-2	busy airport
DENVER	6	-2	busy streets
		Sum = 1	
LOS ANGELES	1	-2	smoggy
LOS ANGELES	2	-2	crowded
LOS ANGELES	3	-2	dirty
LOS ANGELES	4	-1	foggy
LOS ANGELES	5	0	sunny
LOS ANGELES	6	-2	drug place
		Sum = -9	

Note: Based on these summation scores, this person's predicted preference order for a vacation site would be: San Diego, Las Vegas, Denver, and Los Angeles.

Table 9.4

Preference for Nevada as a vacation site among respondents who do and do not exhibit nuclear imagery. Source: Slovic et al. (1991).

	Nevada Preference Rank				
	1	2	3	4	Mean Rank
Nuclear Imagery Present (N = 39)	3	3	46	49	3.41
Nuclear Imagery Absent (N = 354)	6	16	51	27	2.98

Note: Cell entries are percentages within each row.

Figure Captions

Figure 9.1. Profiles for nuclear power and x-rays across nine risk characteristics. Source: Fischhoff et al. (1978).

Figure 9.2. Location of 81 hazards on Factors 1 and 2 derived from the interrelationships among 15 risk characteristics. Each factor is made up of a combination of characteristics, as indicated by the lower diagram. Source: Slovic (1987).

Figure 9.3. Proportion of times (P) City A was ranked higher than City B in the respondent's preference rankings for vacation sites as a function of mean image score differences (City A-City B). All possible pairs of cities are included in this analysis. Source: Slovic et al. (1991).

Figure 9.4. Probability of vacationing in a particular city after June, 1988, as a function of image scores elicited prior to that date (Phoenix survey). Upper row of numbers indicates the number of people with that image score who vacationed in the city; lower row is the number who did not vacation in the city; * marks the proportion who vacationed. The curve is the best-fit logistic function to these proportions. Source: Slovic et al. (1991).

Figure 9.5. Probability of vacationing in a particular state after June, 1988 as a function of image scores elicited prior to that date (Phoenix survey). Upper row of numbers indicates the number of people with that image score who vacationed in the state; lower row is the number who did not vacation in the state; * marks the proportion who vacationed. The curve is the best-fit logistic function to these proportions. Source: Slovic et al. (1991).

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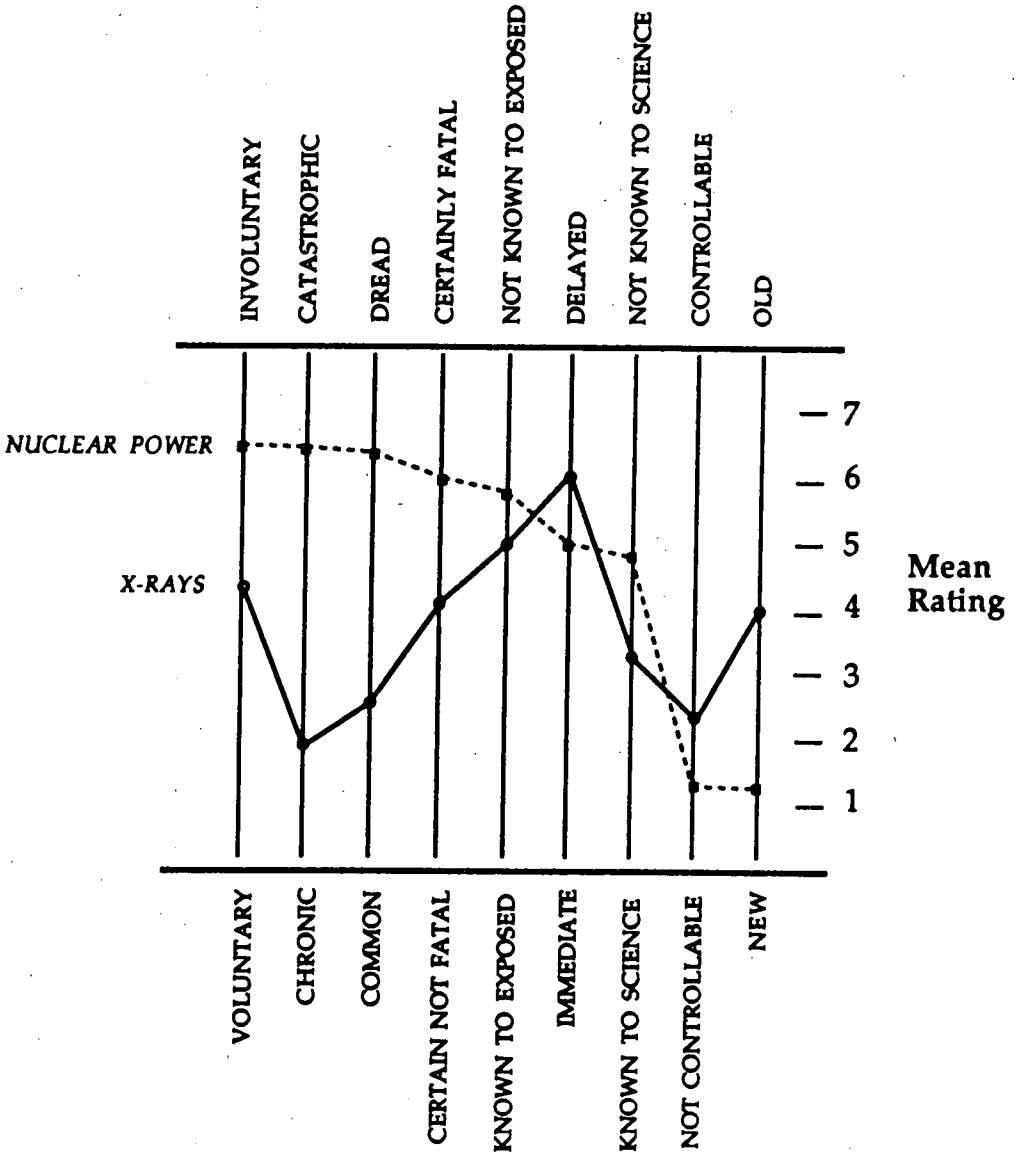
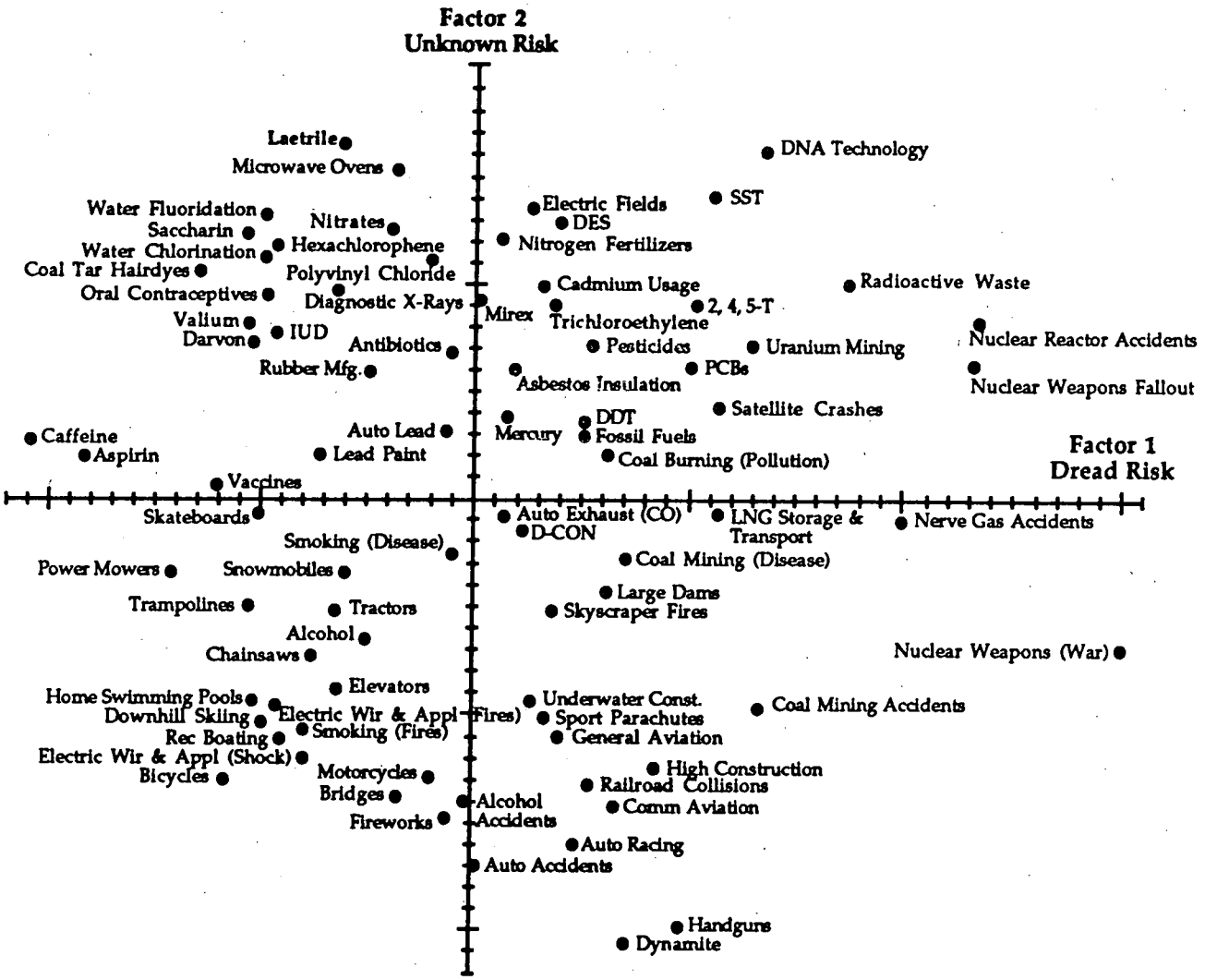

INVOLUNTARY
CATASTROPHIC
DREAD
CERTAINLY FATAL
NOT KNOWN TO EXPOSED
DELAYED
NOT KNOWN TO SCIENCE
CONTROLLABLE
OLD
NUCLEAR POWER
X-RAYS
7
6
5
4
3
2
1
Mean Rating
VOLUNTARY
CHRONIC
COMMON
CERTAIN NOT FATAL
KNOWN TO EXPOSED
IMMEDIATE
KNOWN TO SCIENCE
NOT CONTROLLABLE
NEW

Figure 9.1


Factor 2
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Factor 1
Dread Risk
Laetrile
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Water Fluoridation
Saccharin
Water Chlorination
Coal Tar Hairdyes
Oral Contraceptives
Valium
Darvon
Nitrates
Hexachlorophene
Polyvinyl Chloride
Diagnostic X-Rays
IUD
Antibiotics
Rubber Mfg.
Caffeine
Aspirin
Vaccines
Skateboards
Auto Lead
Lead Paint
Smoking (Disease)
Power Mowers
Snowmobiles
Trampolines
Tractors
Alcohol
Chainsaws
Elevators
Home Swimming Pools
Downhill Skiing
Rec Boating
Electric Wir & Appl (Shock)
Bicycles
Electric Wir & Appl
Smoking (Fires)
Motorcycles
Bridges
Fireworks
Alcohol Accidents
Auto Accidents
Handguns
Dynamite
Auto Racing
Fires)
Underwater Const.
Sport Parachutes
General Aviation
High Construction
Railroad Collisions
Comm Aviation
Electric Fields
DES
Nitrogen Fertilizers
Cadmium Usage
Mirex
Trichloroethylene
Pesticides
Asbestos Insulation
Mercury
DDT
Fossil Fuels
Auto Exhaust (CO)
D-CON
Large Dams
Skyscraper Fires
DNA Technology
SST
2, 4, 5-T
PCBs
Satellite Crashes
Coal Burning (Pollution)
LNG Storage & Transport
Coal Mining (Disease)
Radioactive Waste
Uranium Mining
Nerve Gas Accidents
Nuclear Weapons (War)
Coal Mining Accidents
Nuclear Reactor Accidents
Nuclear Weapons Fallout

Figure 9.2

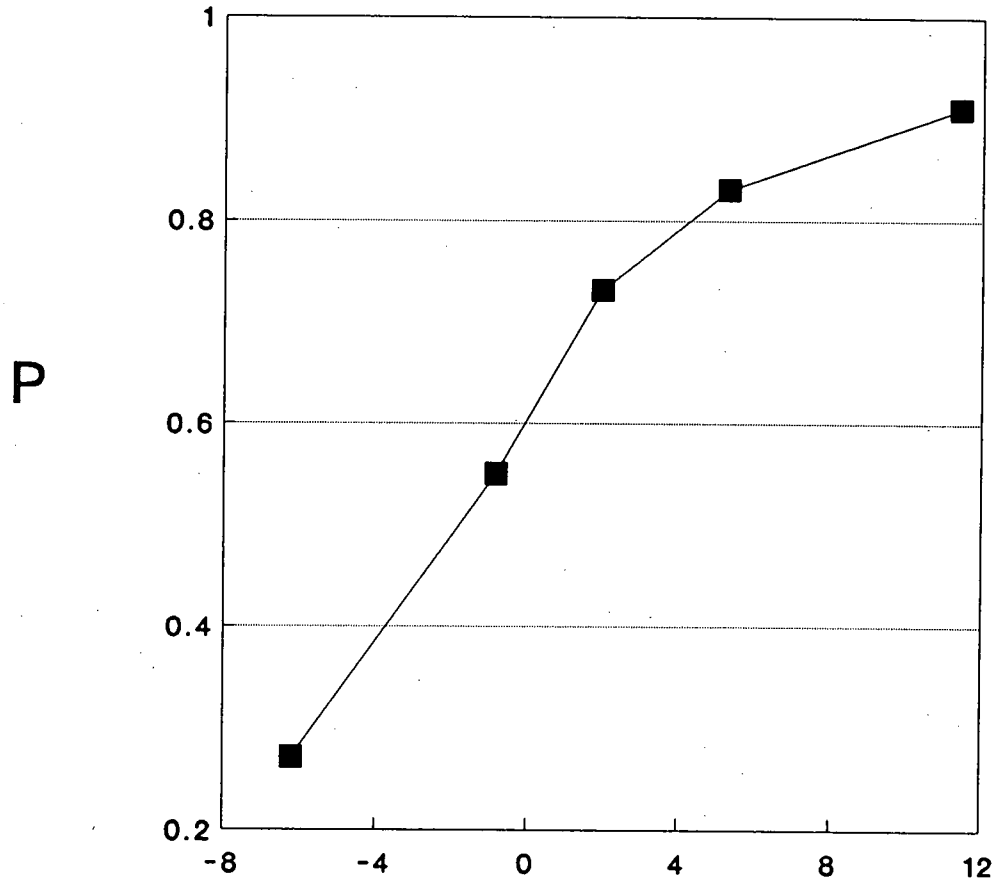
P
1
0.8
0.6
0.4
0.2
-8
-4
0
4
8
12
IMAGE SCORE DIFFERENCE
Vacations - Cities Survey

Figure 9.3

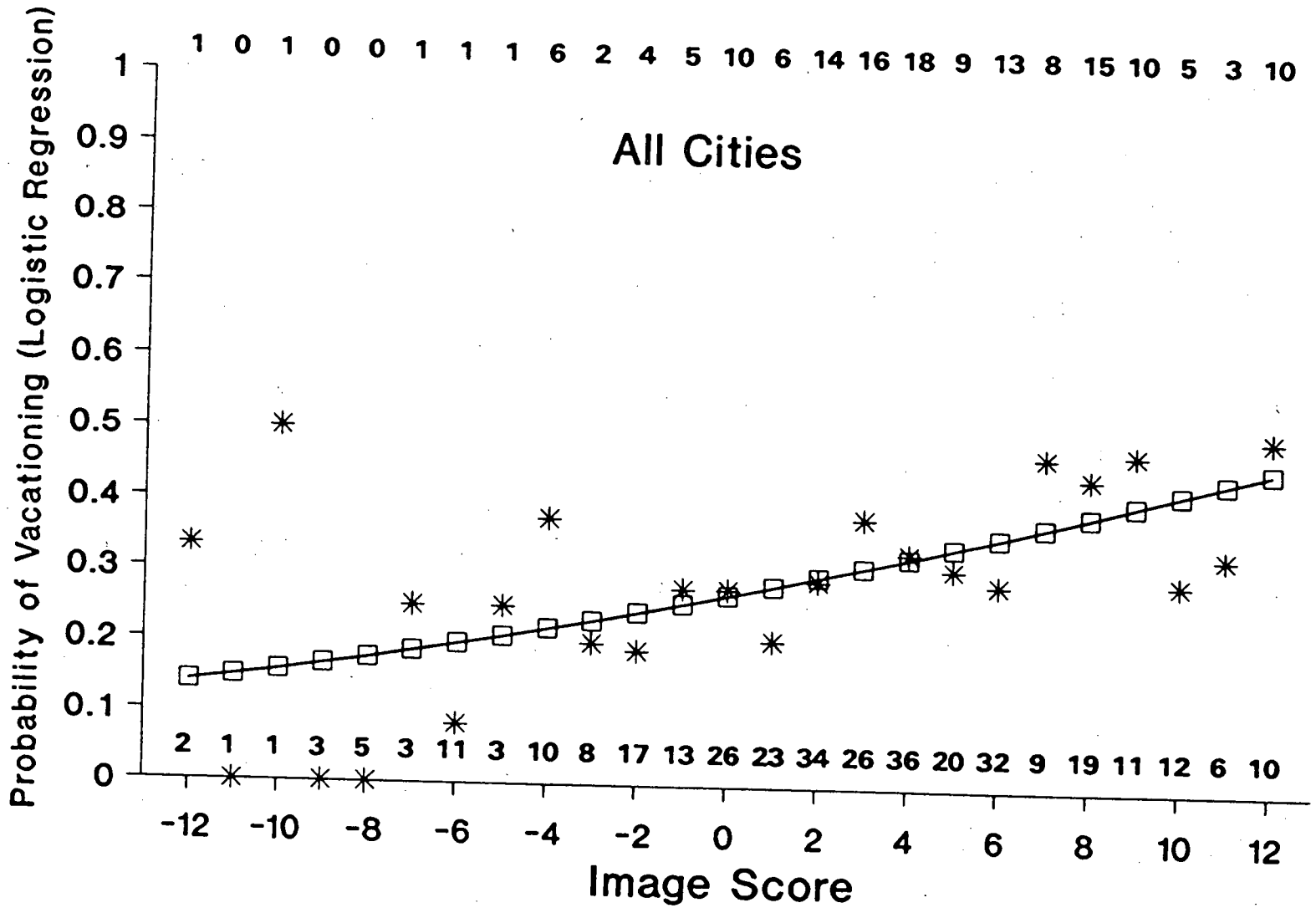
All Cities
Probability of Vacationing (Logistic Regression)
Image Score
1 0 1 0 0 1 1 1 6 2 4 5 10 6 14 16 18 9 13 8 15 10 5 3 10
2 1 1 3 5 3 11 3 10 8 17 13 26 23 34 26 36 20 32 9 19 11 12 6 10
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12

Figure 9.4

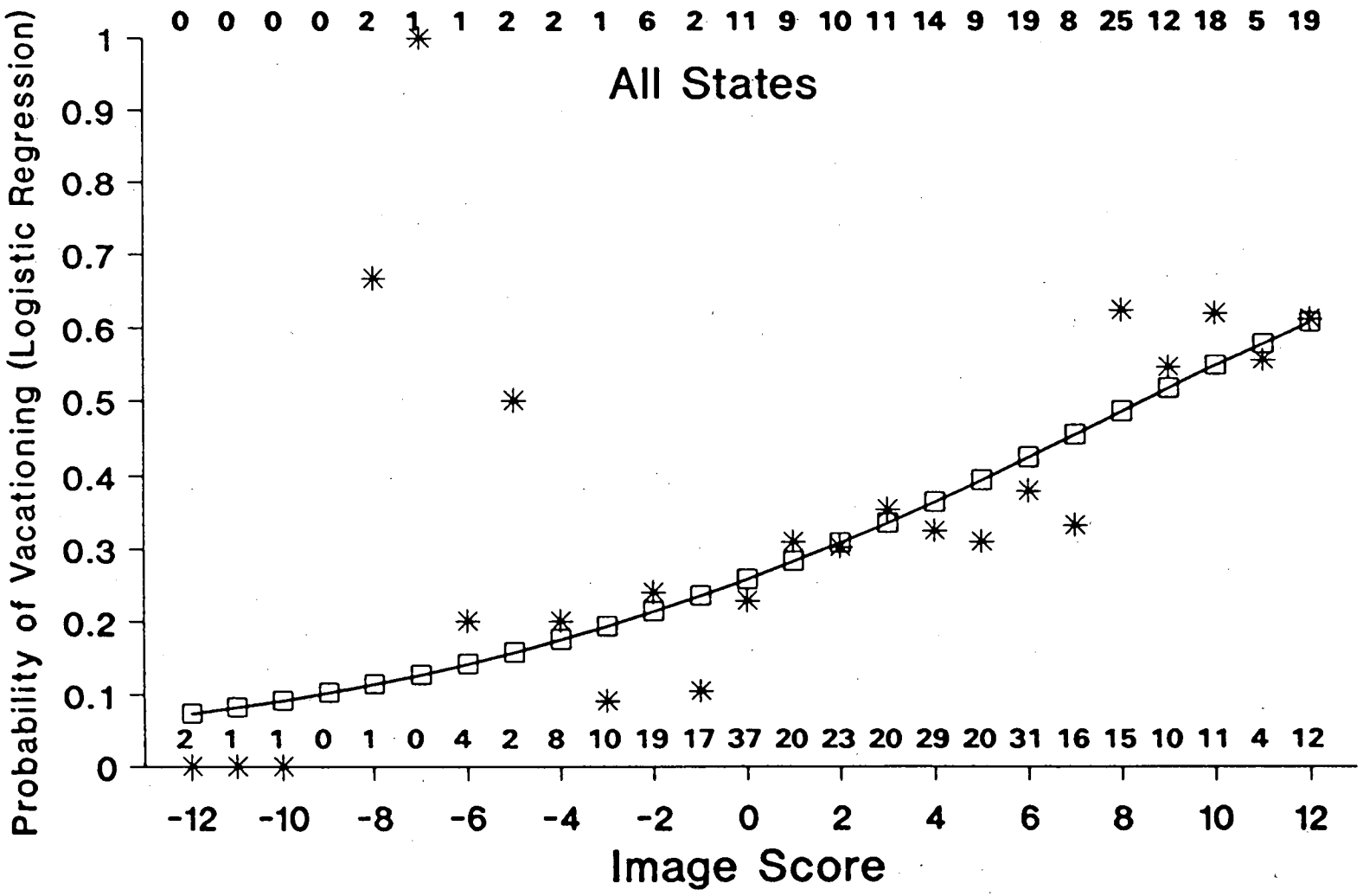
0 0 0 0 2 1 1 2 2 1 6 2 11 9 10 11 14 9 19 8 25 12 18 5 19
All States
Probability of Vacationing (Logistic Regression)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2 1 1 0 1 0 4 2 8 10 19 17 37 20 23 20 29 20 31 16 15 10 11 4 12
-12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12
Image Score

Figure 9.5