The Psychology of Risk: How Safe is Safe Enough?

Paul Slovic

Decision Research

and University of Oregon

Stanford

May 21, 2014

Some Questions Briefly Addressed:

1. How do people think about risk?

2. What factors determine the perception of risk and the acceptance of risk?

3. What are some of the social and economic implications of risk perceptions?

4. How do we value human lives in the face of risk ?

Lessons from Risk Perception Research

1. Risk is a complex and controversial concept.

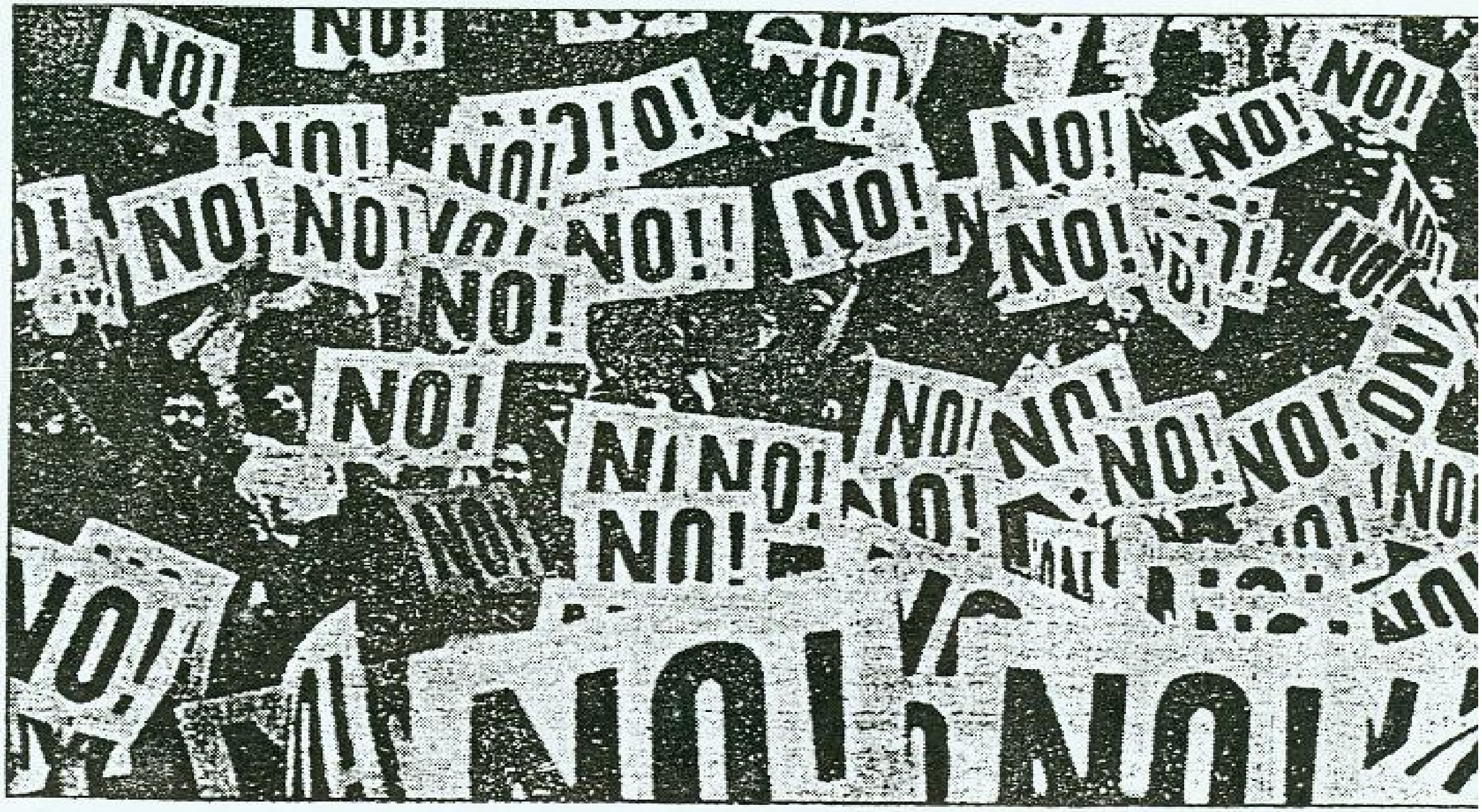
- Polarized views, controversy and overt conflict have become pervasive within risk assessment and risk management.

- Frustrated scientists and industrialists castigate the public for behaviors they judge to be based on irrationality or ignorance.

- Members of the the public feel similarly antagonistic toward industry and government.

- This dissatisfaction can be traced, in part, to a failure to appreciate the complex and socially determined nature of the concept “risk.”

6A ★ The Denver Post/Tuesday, February



NO, NO, A THOUSAND TIMES NO

Some of the 2,500 people attending a briefing in Naples, Maine, express their disapproval about the possibility of a high-level nuclear waste site being located at nearby Lake Region High School. Officials from the Department of Energy held the first scheduled public meeting Mond the controversial selection Maine as potential nuclear w

Yucca Mountain: 1982-2014 Still not approved

Risk Analysis

Risk Assessment

- Identification
- Quantification
- Characterization

Risk Management

- Decision making
- Acceptable risk
- How safe is safe enough?
- Communication
- Evaluation

Politics

- Risk perception
- Values
- Process issues: Who decides?
- Power
- Trust
- Conflict/Controversy

The Complexity of Risk

- Risk as Analysis
- Risk as Values
- Risk as Politics
- Risk as Feelings

What Is Risk?

- Risk does not exist “out there,” independent of our minds and cultures, waiting to be measured.

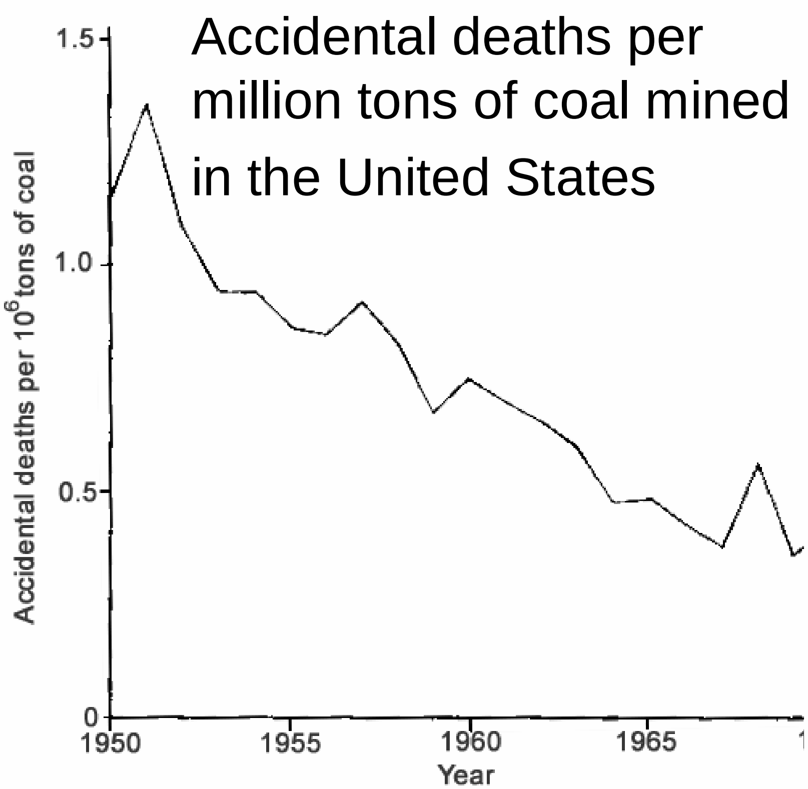
- Human beings have invented the concept <u>risk</u> to help them understand and cope with dangers and uncertainties of life.

- There is no such thing as “real risk” or “objective risk.” The nuclear engineer’s probabilistic risk estimate for a nuclear accident or the toxicologist’s quantitative estimate of a carcinogenic risk are both based on theoretical models, whose structure is subjective and assumption-laden, and whose inputs are dependent on judgment.

One way in which subjectivity permeates risk assessment is its dependence on judgments in every stage of the process, from the initial structuring of a risk problem to deciding which endpoints or consequences to include in the analysis, identifying and estimating exposures, choosing dose-response relationships, and so on.

Choosing a Measure of Risk

- Is coal mining getting safer? It depends on which measure you choose.



Each way of summarizing deaths embodies its own set of values

- Counting fatalities gives equal weight to:
  - young and old
  - painful and nonpainful
  - voluntary and involuntary
  - fair (beneficial) and unfair (no benefit)

The Multidimensional Nature of Risk

- The public has a broad conception of risk, qualitative and complex, that incorporates considerations such as uncertainty, dread, catastrophic potential, controllability, equity, risk to future generations, and so forth, into the risk equation.

Values Underlie Risk

- There are legitimate, value-laden issues underlying these multiple dimensions of risk, and these dimensions need to be considered in risk-policy decisions.

- For example, is risk from cancer (a dread disease) worse than risk from auto accidents (not dreaded)? Is a risk imposed on a child more serious than a known risk accepted voluntarily by an adult? Are the deaths of 50 passengers in separate automobile accidents equivalent to the deaths of 50 passengers in one airplane crash?

- Defining risk is an exercise of power! Whoever controls the definition of risk controls the rational solution to the problem at hand.

- If you define risk one way, then one option will rise to the top as the most cost-effective or the safest or the best. If you define it another way, perhaps incorporating qualitative characteristics and other contextual factors, you will likely get a different ordering of your action solutions.

Risk Perception

Can discern the [illegible] the key one. Not the rate per exposure hour.

Social Benefit versus Technological Risk

What is our society willing to pay for safety?

P.1237 uses concept of acceptable risk [illegible] life is safe enough

Chauncey Starr

The evaluation of technical approaches to solving societal problems customarily involves consideration of the relationship between potential technical performance and the required investment of societal resources. Although such performance-versus-cost relationships are clearly useful for choosing between alternative solutions, they do not by themselves determine how much technology a society can justifiably purchase. This latter determination requires, additionally, knowledge of the relationship between social benefit and justified social cost. The two relationships may then be used jointly to determine the optimum investment of societal resources in a technological approach to a social need.

Technological analyses for disclosing the relationship between expected performance and monetary costs are a traditional part of all engineering planning and design. The inclusion in such studies of *all* societal costs (indirect as well as direct) is less customary, and obviously makes the analysis more difficult and less definitive. Analyses of social value as a function of technical performance are not only uncommon but are rarely quantitative. Yet we know that implicit in every nonarbitrary national decision on the use of technology is a trade-off of societal benefits and societal costs.

In this article I offer an approach for establishing a quantitative measure of benefit relative to cost for an important element in our spectrum of social values—specifically, for accidental deaths arising from technological developments in public use. The analysis is based on two assumptions. The first is that historical national accident records are adequate for revealing consistent patterns of fatalities in the public use of technology. (That this may not always be so is evidenced by the paucity of data relating to the effects of environmental pollution.) The second assumption is that such historically revealed social preferences and costs are sufficiently enduring to permit their use for predictive purposes.

~~In the absence~~ of economic or sociological theory which might give better results, this empirical approach provides some interesting insights into accepted social values relative to personal risk. Because this methodology is based on historical data, it does not serve to distinguish what is "best" for society from what is "traditionally acceptable."

thus it assumes trad. acceptable is good enough.

Maximum Benefit at Minimum Cost

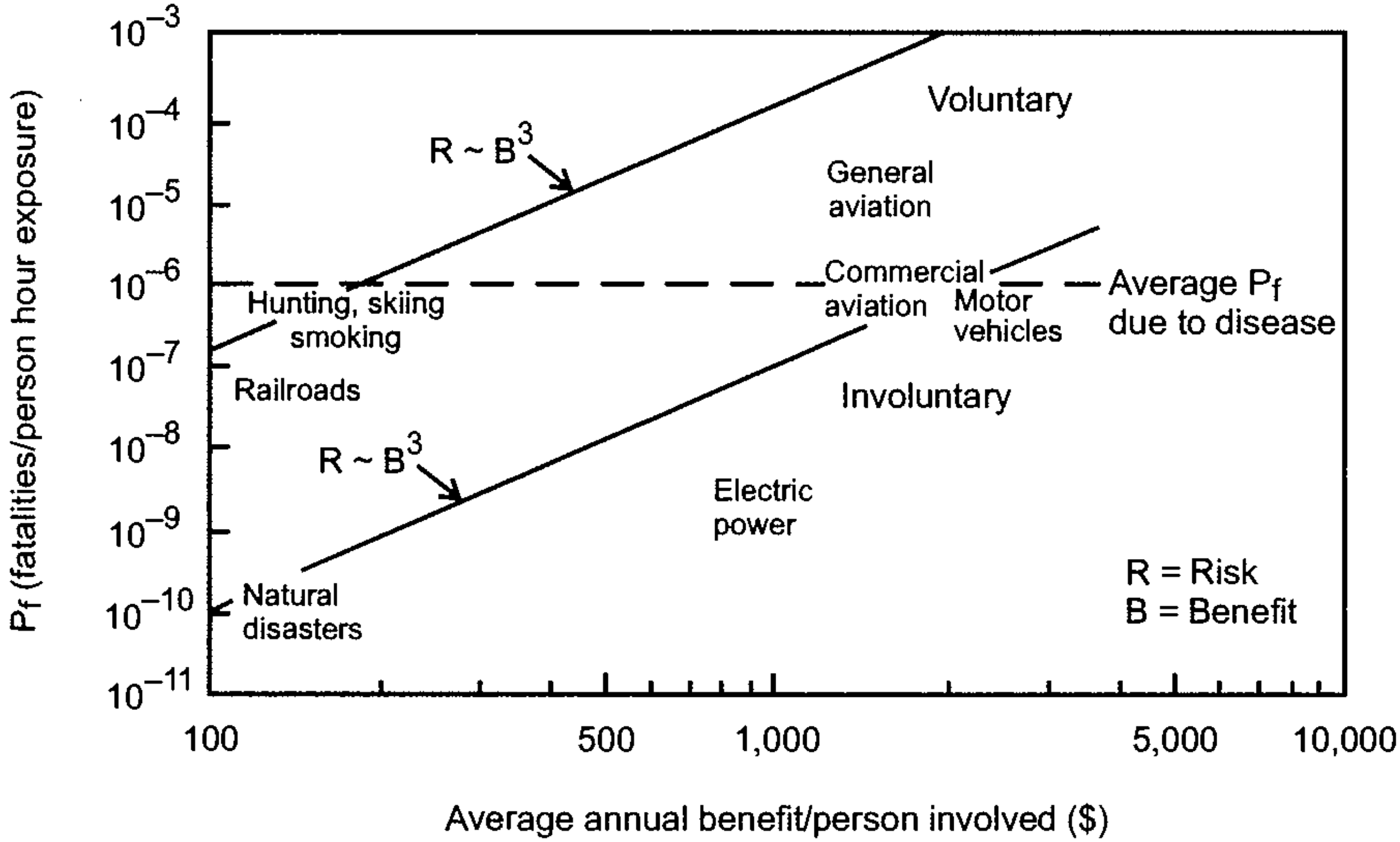
The broad societal benefits of advances in technology exceed the associated costs sufficiently to make technological growth inexorable. Shef's socioeconomic study (*1*) has indicated that technological growth has been generally exponential in this century, doubling every 20 years in nations having advanced technology. Such technological growth has apparently stimulated a parallel growth in socioeconomic benefits and a slower associated growth in social costs.

The conventional socioeconomic benefits—health, education, income—are presumably indicative of an improvement in the "quality of life." The cost of this socioeconomic progress shows up in all the negative indicators of our society—urban and environmental problems, technological unemployment, poor physical and mental health, and so on. If we understood quantitatively the causal relationships between specific technological developments and societal values, both positive and negative, we might deliberately guide and regulate technological developments so as to achieve maximum social benefit at minimum social cost. Unfortunately, we have not as yet developed such a predictive system analysis. As a result, our society historically has arrived at acceptable balances of technological benefit and social cost empirically—by trial, error, and subsequent corrective steps.

In advanced societies today, this historical empirical approach creates an increasingly critical situation, for two basic reasons. The first is the well-known difficulty in changing a technical subsystem of our society once it has been woven into the economic, political, and cultural structures. For example, many of our environmental-pollution problems have known engineering

The author is dean of the School of Engineering and Applied Science, University of California, Los Angeles. This article is adapted from a paper presented at the Symposium on Human Ecology held at Airlie House, Warrenton, Virginia, in November 1968.

10 September, 1969



Source: taken from Starr, 1969

Figure 5.1 *Revealed risk-benefit relationships*

Lessons from Risk Perception Research

2. Every hazard is uniquely understood and evaluated in terms of its characteristic qualities.

Studies of Perceived Risk

"Risk" is left undefined

Rate the risk to society as a whole on a 0 – 100 scale

Motor vehicles - - - - - - - - - - - - - - - -

0 100

Pesticides - - - - - - - - - - - - - - - -

0 100

Drugs/Medicines - - - - - - - - - - - - - - - -

etc. 0 100

up to 90 items

Experts vs. Laypersons
Perceptions of Risk

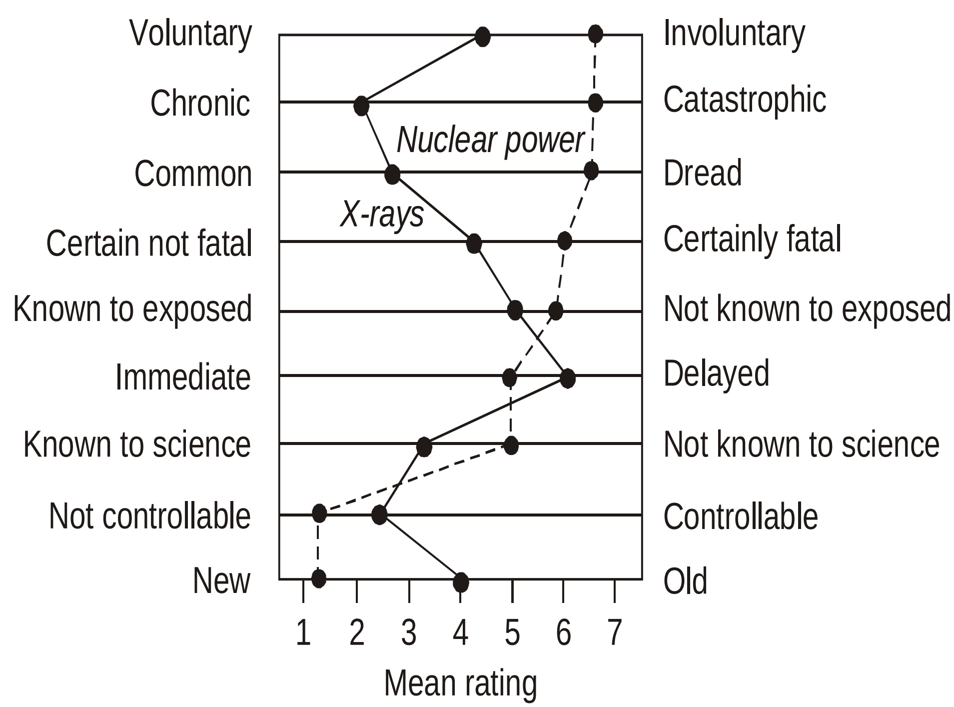
Rank Order		
1977 Laypersons		Experts
1	Nuclear power	20
2	Motor vehicles	1
3	Handguns	4
4	Smoking	2
17	Electric power (non-nuclear)	9
22	X-rays	7
30	Vaccinations	25

Risk is Multidimensional

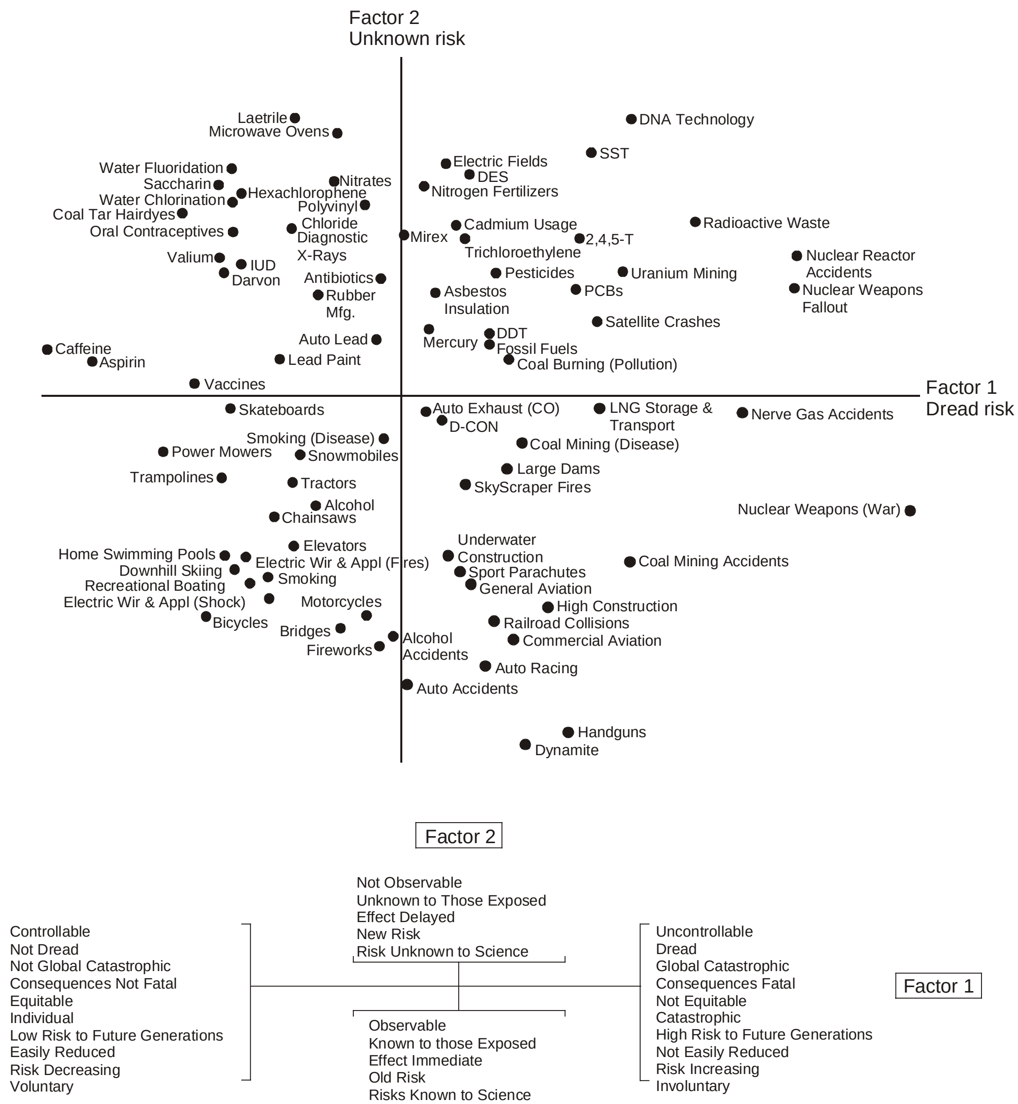
Qualitative Risk Concerns

- Voluntary – Involuntary
- Chronic – Catastrophic
- Common – Dread
- Certainly not fatal – Certainly fatal
- Known to exposed – Not known to exposed
- Immediate – Delayed
- Known to science – Not known to science
- Not Controllable – Controllable
- New – Old
- Equitable – Not equitable

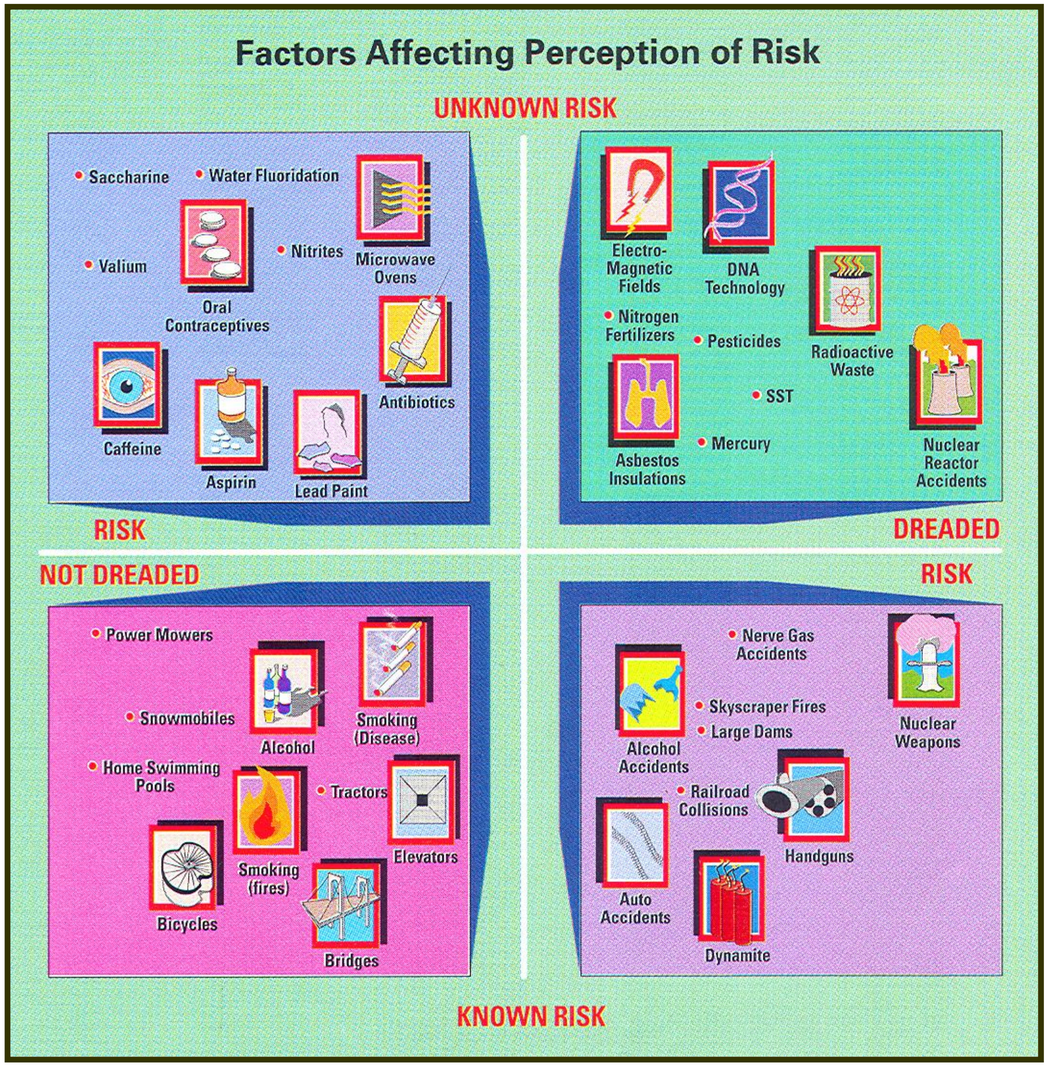
Every hazard has a unique risk profile



40,000 judgments synthesized into one figure



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 et al. (1985).


Factors Affecting Perception of Risk
UNKNOWN RISK
Saccharine
Water Fluoridation
Valium
Oral Contraceptives
Nitrites
Microwave Ovens
Caffeine
Aspirin
Lead Paint
Antibiotics
Electro-Magnetic Fields
DNA Technology
Nitrogen Fertilizers
Pesticides
Radioactive Waste
SST
Asbestos Insulations
Mercury
Nuclear Reactor Accidents
RISK
DREADED
NOT DREADED
RISK
Power Mowers
Snowmobiles
Alcohol
Smoking (Disease)
Home Swimming Pools
Tractors
Elevators
Smoking (fires)
Bicycles
Bridges
Nerve Gas Accidents
Alcohol Accidents
Skyscraper Fires
Large Dams
Nuclear Weapons
Railroad Collisions
Handguns
Auto Accidents
Dynamite
KNOWN RISK

Acceptance of Risk Tends to Be Reduced If:

- exposure to the hazard is involuntary
- the risk is not under one’s control
- the risk evokes feelings of dread
- the outcomes are catastrophic
- the benefits of an activity are not fairly or equitably distributed among those who bear the risks.

Acceptance of Risk Tends to Be Reduced If:

- the risk is posed by human failure as opposed to natural causes
- the potential harms are genetic and/or delayed in time
- the risk is perceived as not well known to science or to those who might be harmed

3. Lessons from risk perception research

Perceptions Have Impacts!

The Social Amplification of Risk

Individual risk perceptions and cognitions, interaction with social and institutional forces, can trigger massive social and economic impacts even when direct harm from an accident or mishap is small.

Due to ripple effects.

Risk Events Are Signals

1. The perceived seriousness of a mishap, the media coverage it gets, and the long-range costs to the responsible company, industry, or agency are determined by the mishap's **signal value**

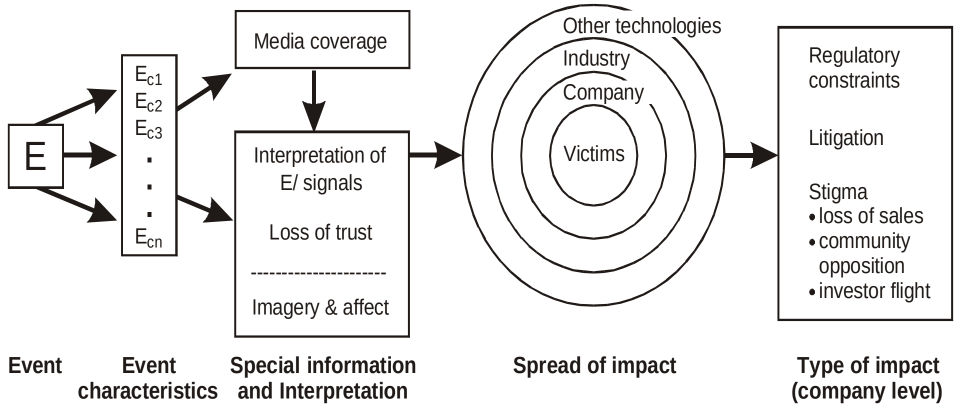
2. Signal value reflects perception that the event provides new information about the likelihood of similar or more destructive future mishaps

3. High signal events: Three Mile island, Bhopal, Chernobyl, the 9/11 attacks

   "What truly grips us in these accounts [of disaster] is not so much the numbers as the spectre of suddenly vanishing competence, of men utterly routed by technology, of fail-safe systems failing . . . And the spectre haunts us because it seems to carry allegorical import, like the whispery omen of a hovering future."

   The New Yorker, February 18, 1985

The Social Amplification of Risk



A preliminary model of social amplification of risk and stigma impacts. Development of the model will require knowledge of how the characteristics (E_c) associated with a hazard event interact to determine the media coverage and the interpretation or message drawn from that event. The nature of the media coverage and the interpretation is presumed to determine the type and magnitude of ripple effects.

Source: Kasperson et al. (1988).

Risk Perceptions → Stigma → Economic Losses ($)

Stigmatization Affects

- Technologies: nuclear, chemical, bioengineering
- Places: Chernobyl, Love Canal
- Products: Tylenol, Alar

♦ *Perrier*	– $80 million loss
♦ *Alar*	– $100 million loss
♦ *Tylenol*	– $1.4 billion loss
♦ *Three Mile Island*	– $10 billion loss

12 The Impact of External Parties on Brand-Name Capital: The 1982 Tylenol® Poisonings and Subsequent Cases[1]

Mark L. Mitchell

An examination of the 1982 Tylenol® poisonings reveals stock market losses to Johnson & Johnson that far exceed direct costs and losses shared with other pain-reliever producers; this evidence provides support for the Klein and Leffler (1981) theory of brand names as quality-assuring mechanisms. Of the subsequent cases, only the 1986 Tylenol® poisonings were associated with significant stock market losses. Prior to the 1982 and 1986 Tylenol® poisonings, Tylenol® was the number one pain reliever whereas the other pain relievers that were poisoned had a much lower level of brand-name capital to lose.

I. Introduction

On September 30, 1982 Johnson & Johnson announced that three people had been killed as the result of ingesting cyanide-laced Tylenol® capsules.[2] Four more Tylenol-related deaths were reported within the next two days. Culminating in 125,000 stories in the print media alone, the poisonings were an event without precedent in American business ("Crisis Public Relations," 1982). The Tylenol® brand received over $1 billion in adverse publicity.[3] As a result, many analysts claimed the brand was dead. But the company president, James Burke, ignoring the advice of government officials and even some of his close associates, decided to spend millions to revive Tylenol®. Burke's decision will be studied in business schools for years to come. The general opinion today is

Public Response to Crises: Models, Methods and Ripple Effects

William J. Burns: Decision Research, CSUSM

with J.A. Giesecke, A. Barret, E. Bayrak, A. Rose, P. Slovic, M. Suher

April 2, 2013

Study of the economic impacts of a dirty bomb scenario

Based on the social amplification of risk

An Event as it is Occurring.

Dirty Bomb Rocks Financial District of Los Angeles!

180 Dead and Hundreds Potentially Exposed to Radiation as Mayor Requests Downtown to Seek Shelter for Hours

(An approximately 500 word scenario description followed together with an audio recording of the LA mayor-dramatization.)

The Aftermath of the Event: One Month Later

Radiation Levels Throughout Los Angeles Pose Little Threat says Panel of Health Officials!

Today the Mayor Received a Reassuring Report from a Team of Radiation Experts Regarding Long-term Health Risks. The Downtown to Re-Open.

(An approximately 200 word scenario description followed together with an audio recording of the LA mayor-dramatization.)

Measures Used for Economic Estimates

Consumption & Wage Premiums
(*Reports of Postponement & Required Incentives*)

Specialty Food Items

Vacation

Professional Services

Electronic Products

Jobs

Required Rates of Return
(*Property Values Near Hazardous Sites*)

Economic Activity in Financial District

3 Day vs. 30 Day Shutdown

RDD Impacts to Los Angeles GDP (CGE Estimates)

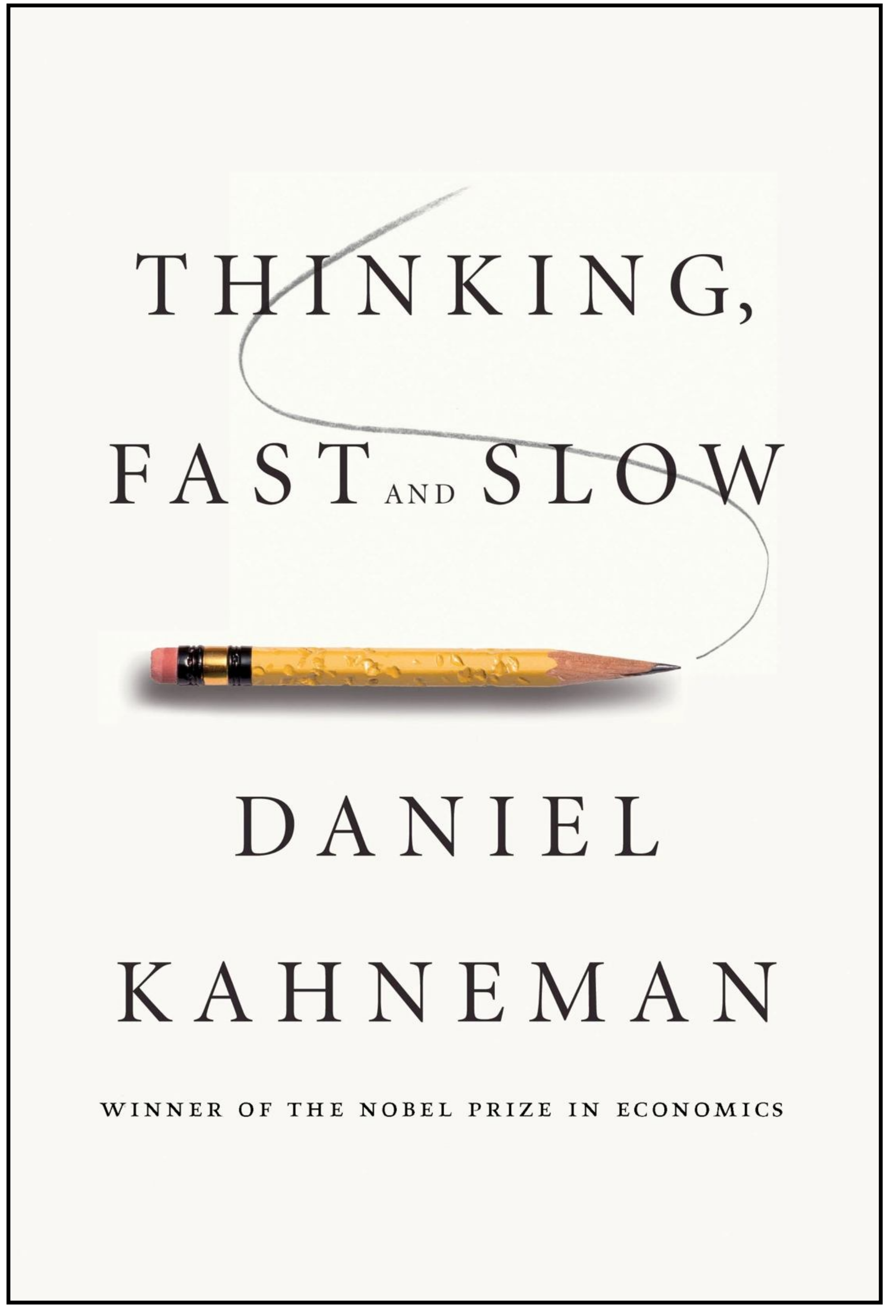
Impact	Category	
(1) Short-run	**Direct business interruption** (BI). (GDP loss, $m.) (a)	-$817
(2) Short-run	**Indirect business interruption** (BI). (GDP loss, $m.)	-$214
(3) Short-run	Other resource loss. (GDP loss, $m.) (*casualties, property*)	-$27
(4) Short-run	**Behavioral effects**. (GDP loss, $m.)	-$889
(5) Short-run	**Total short-run**. (GDP loss, $m.)	-$1,947
(6) Long-run	**One-Year Behavioral**. (GDP loss, $m.)	-$2,628
(7) Long-run	**Total Ten-Year Behavioral**. (GDP loss, $m.) (b)	**-$15,808**
(8) Total (1)+(2)+(3)+(7)	**Total Costs** (Resource Loss/Behavioral Effects-GDP loss $m)	**-$16,866**
(9) **Ratio** = (7)/[(1)+(2)+(3)]	**Total Ten-Year Behavioral/Ordinary Loss**	**14.9**

Implications of ripple effect model

- Prevention is important — not just mitigation — even at great cost
- Do more than the law requires
  - e.g., tamper-resistant packaging
  - airport security
  - remote siting of hazardous facilities
  - dedicated trains for hazardous material

Lessons From Risk-Perception Research

- Risk primarily resides in us as a “gut feeling.”
- Relying on feelings is natural and rational but sometimes problematic


THINKING,
FAST AND SLOW
DANIEL
KAHNEMAN
WINNER OF THE NOBEL PRIZE IN ECONOMICS

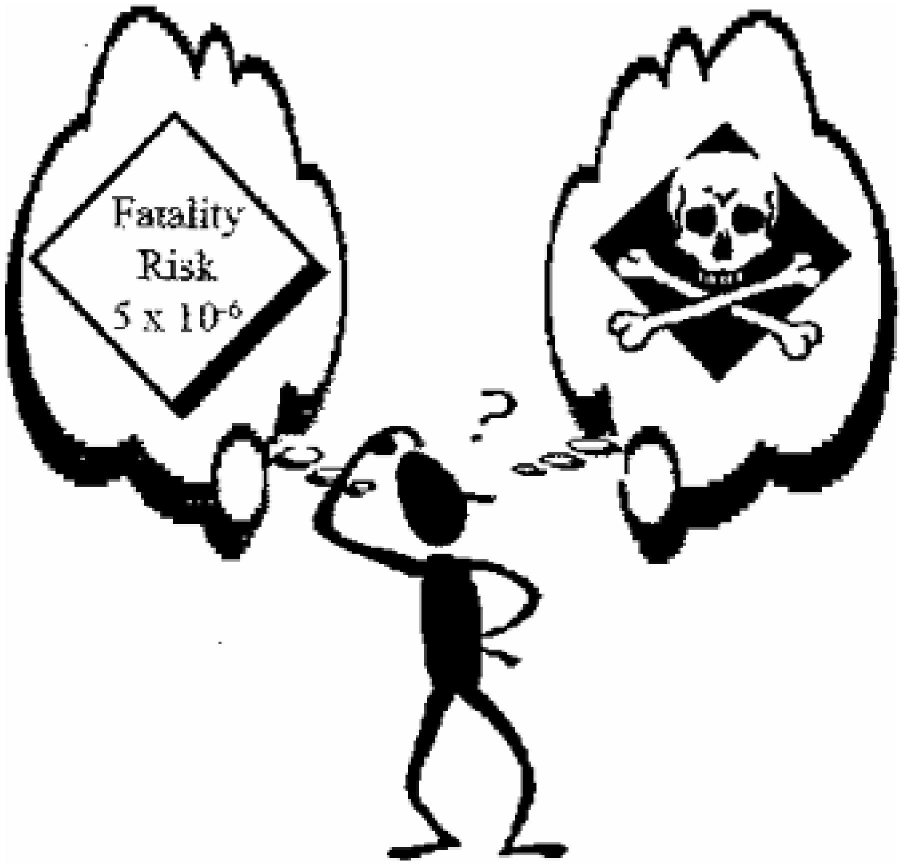
Two Modes of Thinking

Fast	Slow
Experiential (System 1)	Analytical (System 2)
Intuitive	Deliberative
Images,associations	Logical
Feelings	Reasoned
Stories/narratives	Uses symbols,numbers
Often non-conscious	Conscious appraisals
	Slowly constructs feelings

Risk As Analysis vs. Risk as Feelings

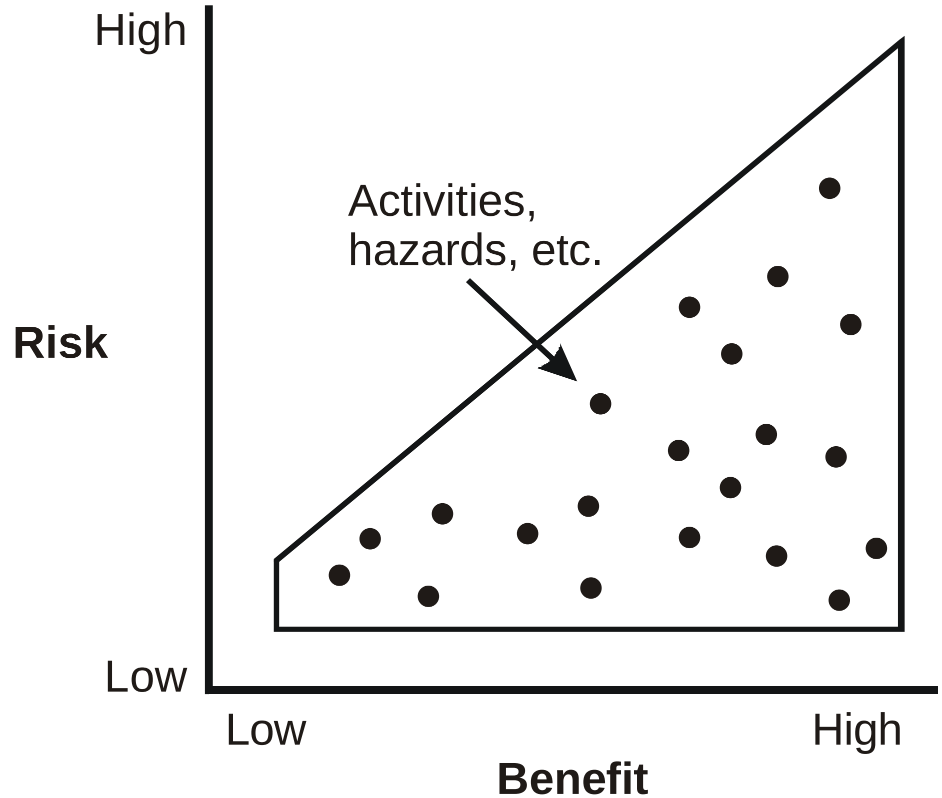
Analytic/
Deliberative

Experiential/
Affective



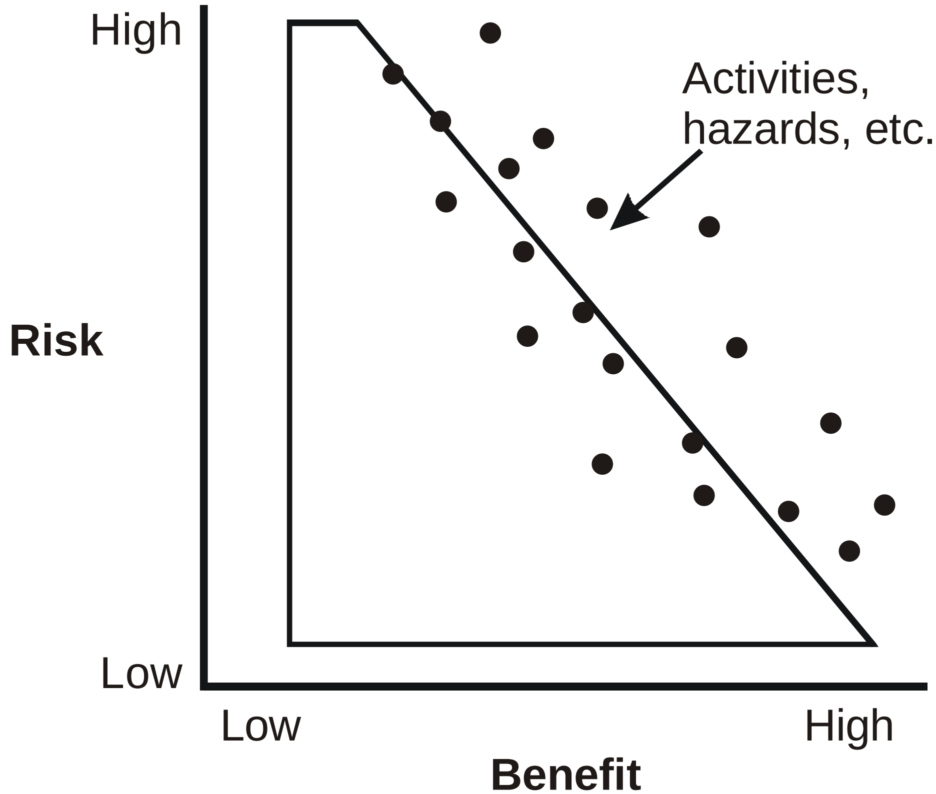
More on “The Feeling of Risk”

- Risks and Benefits are fused in the mind into an overall feeling of risk
- An insight based on the inverse risk/benefit relationship.



In the world, risk and benefit are **positively** correlated.

In people's minds, they are **negatively** correlated.



Relationship between risk and benefit in people’s minds

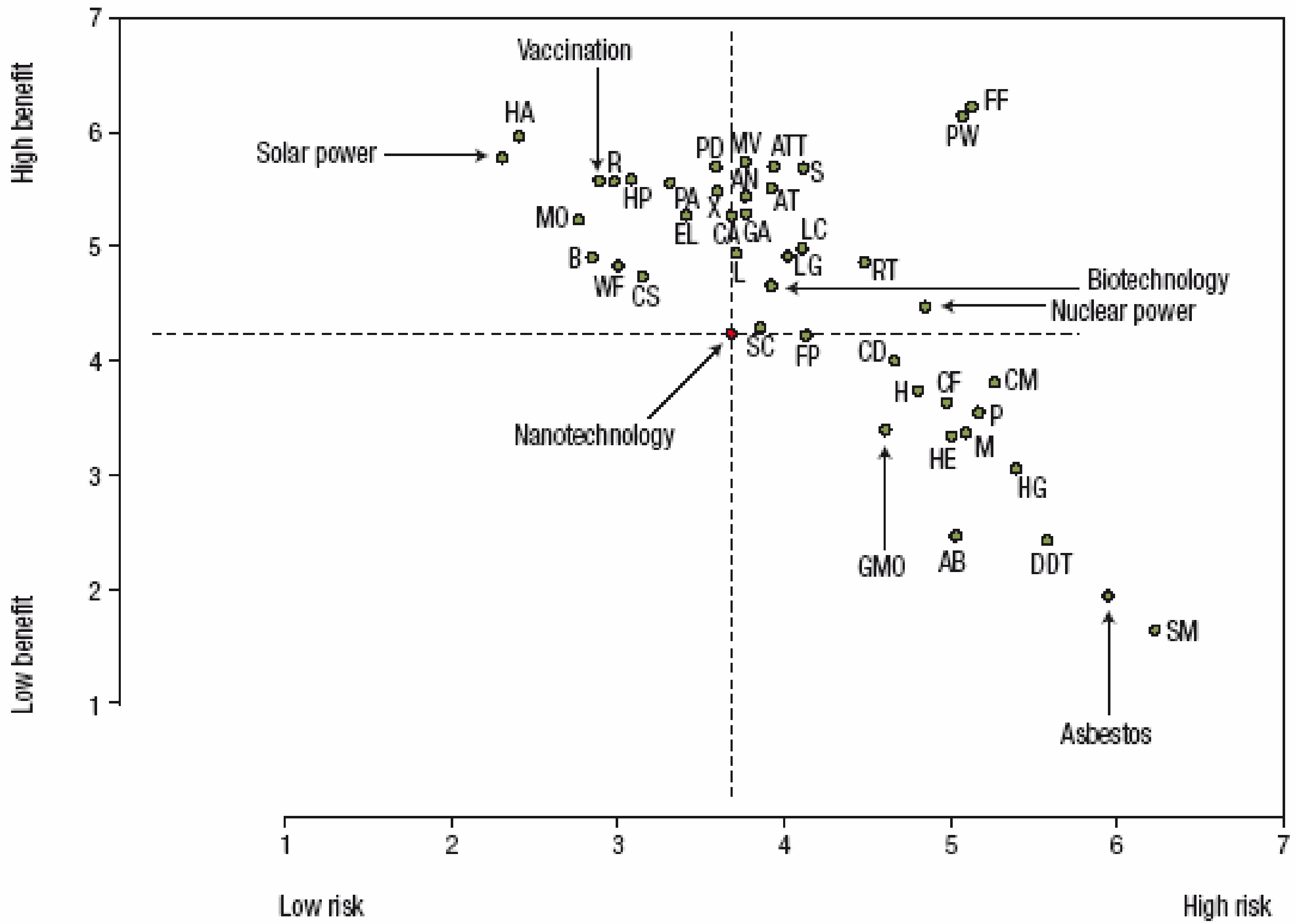
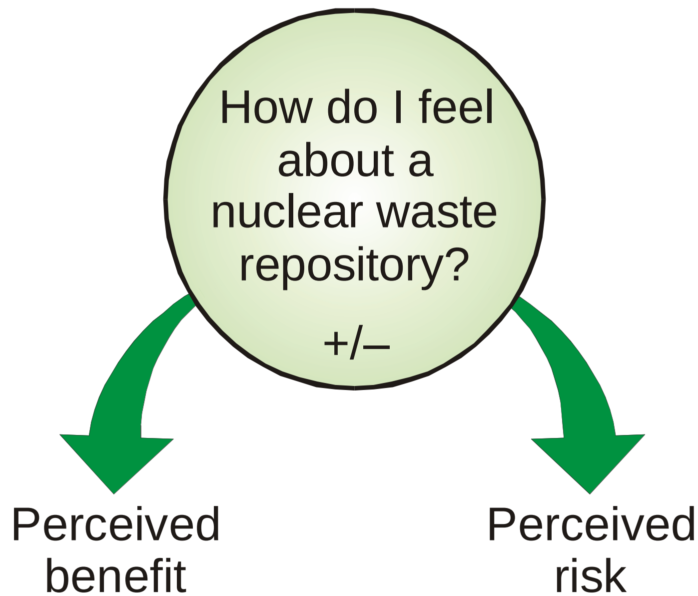


Figure 1 Perceived risks and benefits of nanotechnology and 43 other technologies, based on 503 responses to a national telephone survey. Source:Currall et al. 2006

The Affect Heuristic



A model of the affect heuristic explaining the risk/benefit confounding observed by Alhakami and Slovic (1994). Judgments of risk and benefit are assumed to be derived by reference to an overall affective evaluation of the stimulus item.

One implication of the affect heuristic

Probability and Relative Frequency

Are they the same or different in communicating risk?

e.g., 1% chance

vs.

1 out of 100

RISK COMMUNICATION:

A patient – Mr. James Jones – has been evaluated for discharge from an acute civil mental health facility where he has been treated for the past several weeks. A psychologist whose professional opinion you respect has done a state-of-the-art assessment of Mr. Jones. Among the conclusions reached in the psychologist's assessment is the following:

EITHER:

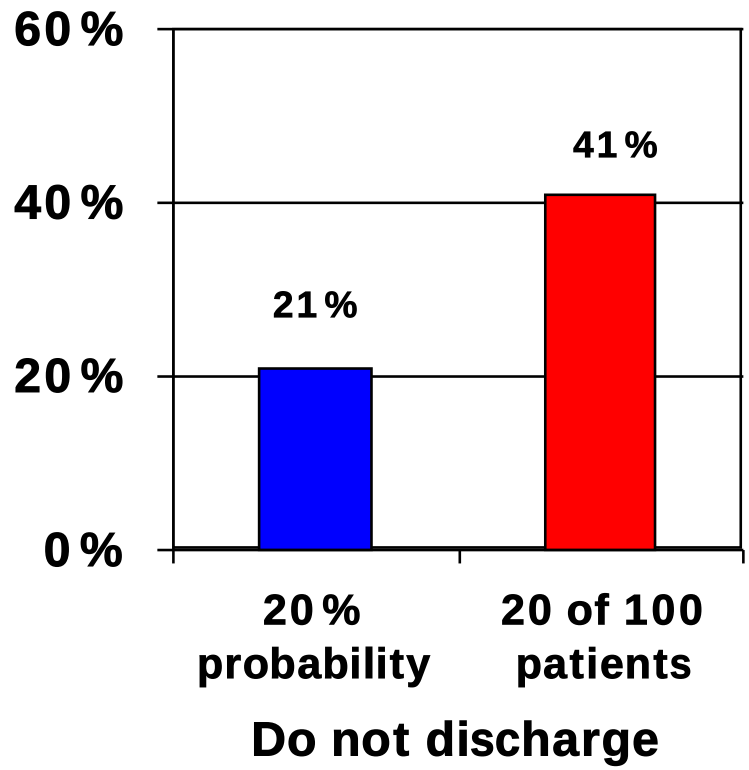
Patients similar to Mr. Jones are estimated to have a 20% probability of committing an act of violence to others during the first several months after discharge.

OR:

Of every 100 patients similar to Mr. Jones, 20 are estimated to commit an act of violence to others during the first several months after discharge.

Question:

- If you were working as a supervisor at this mental health facility and received the psychologist's report, would you recommend that Mr. Jones be discharged from the hospital at the present time?



Patient Evaluation

A. 10%

- Very few people are violent
- 10% = 1/10
- Probably won't hurt anyone, though

C. 10 out of 100

- Visual of 100 people and 10 who commit crimes
- Mr. Jones committing an act of violence
- People being harmed by the 10/100 patients

B. 1 out of 10

- He could be the 1 out of 10
- Some guy going crazy and killing people
- The patient attacking someone
- An act of violence

Example from toxicology

Human consumption of bottled 1.5 liter of bottled water daily

for 70 years at a daily dose of benzene equal to 0.0002

mg/kg/day can be estimated to produce a cancer risk.

There are two ways of expressing this risk:

a)one method extrapolates a probability based on a linear multistage model: risk is about 10 cases per million exposed.

b)second method uses NOAEL: exposure is about 100,000 times lower than the NOAEL.

Survey Respondents Were Shown Both Formats

Suppose that you were to drink two quarts of bottled water daily for 70 years and this water contained a very small amount of each of two chemicals, X and Y. Below is some information about the risk of getting cancer from this exposure to chemicals X and Y.

Chemical X has been observed to cause cancer in animals, but only at doses more than 100,000 times greater than what you will drink. At doses less than 100,000 times greater than what you will drink, no cancer in animals has been observed.

Based on animal studies, the probability that you will develop cancer from your exposure to **Chemical Y** is about 1 chance in 100,000. *Which risk do you perceive to be greater?* (circle one number)

1	2	3	4	5	6	7
Risk from Chemical Y is very much greater	Risk from Chemical Y is moderately greater	Risk from Chemical Y is slightly greater	The risks are about equal	Risk from Chemical X is slightly greater	Risk from Chemical X is moderately greater	Risk from Chemical X is very much greater

The 1 chance in 100,000 probability format seems riskier

Results:	College students (N = 138)	British Toxicological Society (N = 100)
Y is riskier (1 chance in 100,000)	66%	58%
X is riskier (safety factor of 100,000)	11%	2%
Risk of X = risk of Y	23%	40%

Conclusion: Expressing small risks from exposure to chemicals in probabilistic terms may unduly alarm the public.

Source: Purchase and Slovic (1999).

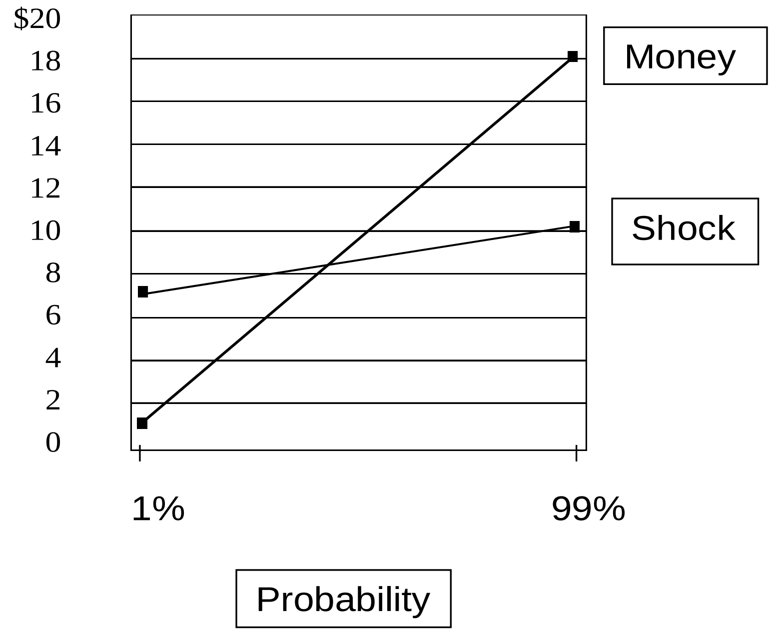
What if the probability was framed as a .00001 chance?

Expressing small risks from exposure to chemicals in probabilistic terms(e.g.1/N) may unduly alarm the public and inhibit effective regulation and policy making.

(Purchase & Slovic,1999)

Strong Affect Overcomes Probability

Prices paid to avoid electric shock and $20 penalty



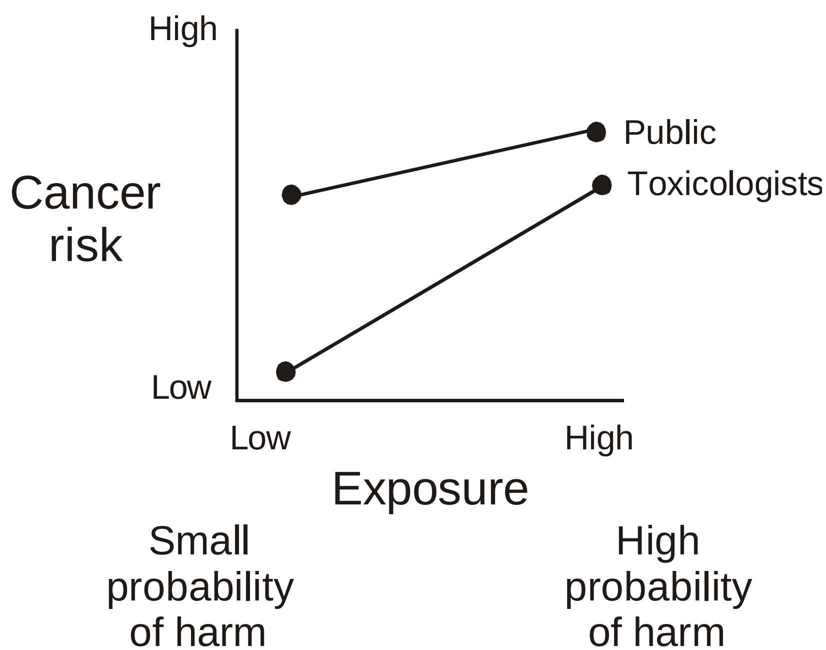
Payment to avoid a chance of electric shock is not much affected by probability

Source: Rottenstreich & Hsee:
Money, Kisses, and Electric Shock: On the Affective Psychology of Risk.
Psychological Science, 2001

Intuitive Toxicology — Main Result

Many people lack dose-response sensitivity for exposure to chemicals that can produce effects that are dreaded, such as cancer (high affect).

If large exposures are bad, small exposures are also bad.



Terrorism and Probability Neglect

Cass R. Sunstein

The Journal of Risk and Uncertainty, *26*(2/3); 121-136, 2003

- People are prone to . . . *probability neglect*, especially when their emotions are intensely engaged.
- Probability neglect is highly likely in the aftermath of terrorism.
- People fall victim to probability neglect if and to the extent that the intensity of their reaction does not greatly vary even with large differences in the likelihood of harm.
- When probability neglect is at work, people's attention is focused on the bad outcome itself, and they are inattentive to the fact that it is unlikely to occur.

Valuing Human Life

- Large inconsistencies

Risk Analysis, Vol. 15, No. 3, 1995

Five-Hundred Life-Saving Interventions and Their Cost-Effectiveness

Tammy O. Tengs,[1] Miriam E. Adams,[2] Joseph S. Pliskin,[3,6] Dana Gelb Safran,[4] Joanna E. Siegel,[5,7] Milton C. Weinstein,[6,7] and John D. Graham[6,7]

Received July 26, 1994

We gathered information on the cost-effectiveness of life-saving interventions in the United States from publicly available economic analyses. "Life-saving interventions" were defined as any behavioral and/or technological strategy that reduces the probability of premature death among a specified target population. We defined cost-effectiveness as the net resource costs of an intervention per year of life saved. To improve the comparability of cost-effectiveness ratios arrived at with diverse methods, we established fixed definitional goals and revised published estimates, when necessary and feasible, to meet these goals. The 587 interventions identified ranged from those that save more resources than they cost, to those costing more than 10 billion dollars per year of life saved. Overall, the median intervention costs $42,000 per life-year saved. The median medical intervention costs $19,000/life-year; injury reduction $48,000/life-year; and toxin control $2,800,000/life-year. Cost/life-year ratios and bibliographic references for more than 500 life-saving interventions are provided.

Cost-Effectiveness of Saving Lives

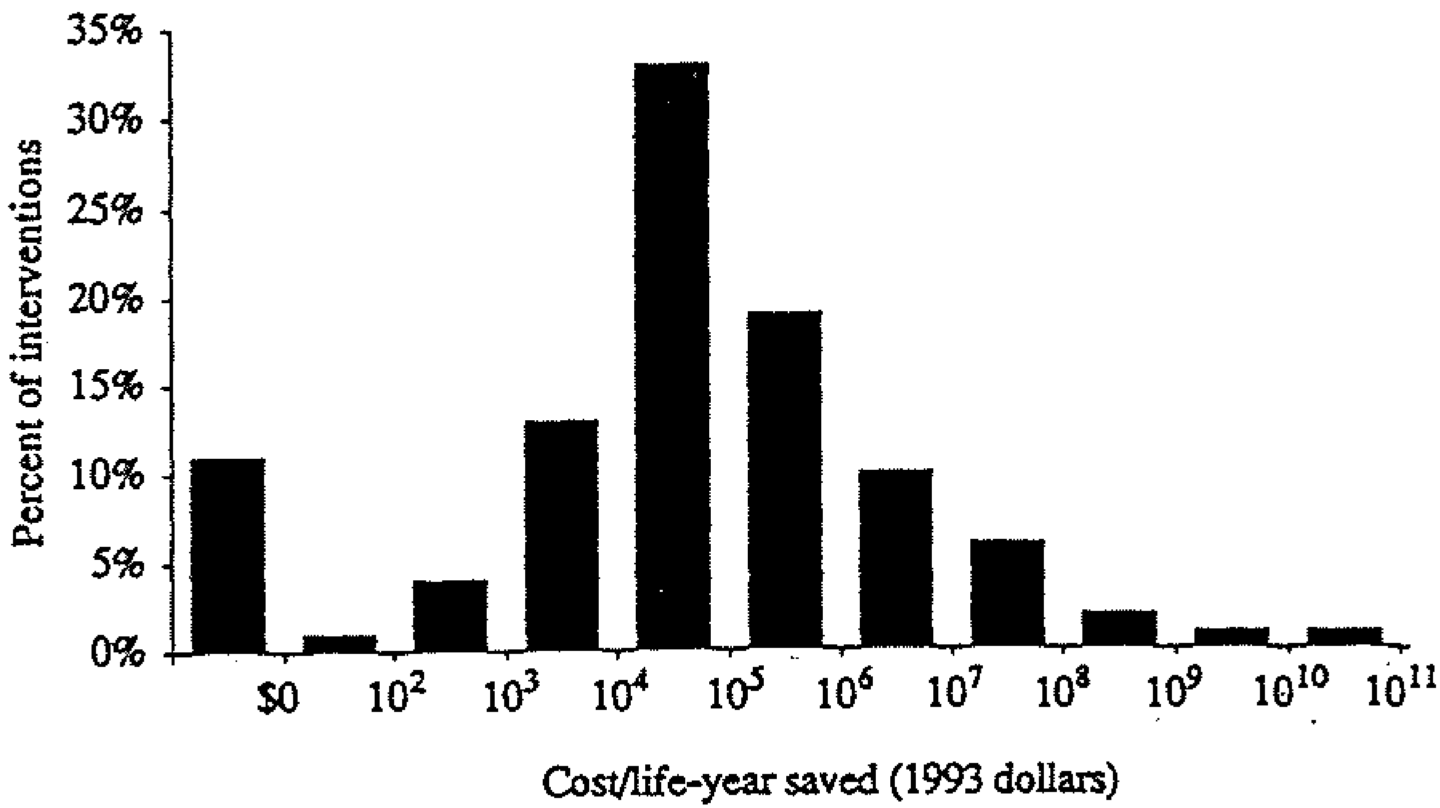


Fig. 1. Distribution of cost/life-year saved estimates (n = 587).

The More Who Die,the Less We Care:
The Twisted Arithmetic of Compassion

Individual vs Societal Risk

Singularity Effect vs. Psychic Numbing

One man's death is a tragedy.

A million deaths is a statistic.

Falsely attributed to Joseph Stalin

Singularity Effect

We place great value on saving individual lives.

Opposite Singularity is Psychic Numbing

<u>Rwanda</u> (1994)

800,000 people murdered in 100 days

about 8,000 a day

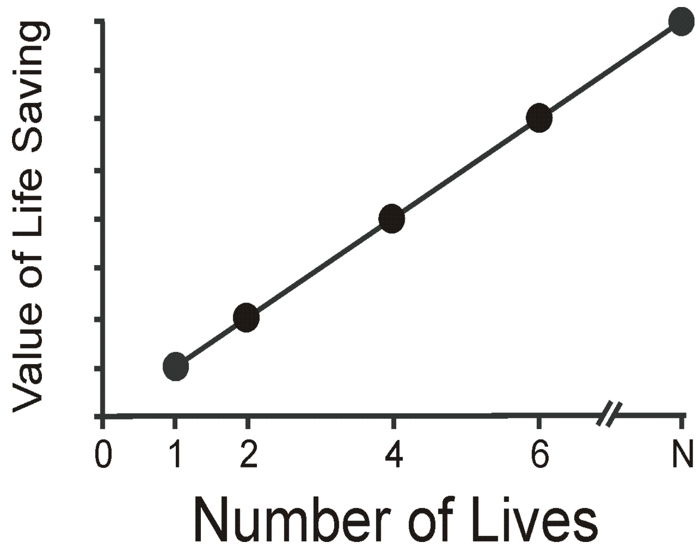
while the world watched and did nothing

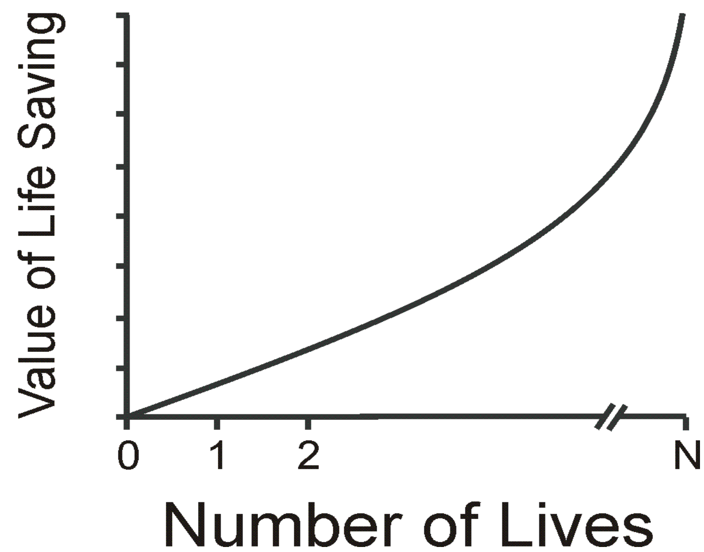
Some questions:

How should we value a human life?

How do we value a human life?

How Should We Value the Saving of Human Lives?

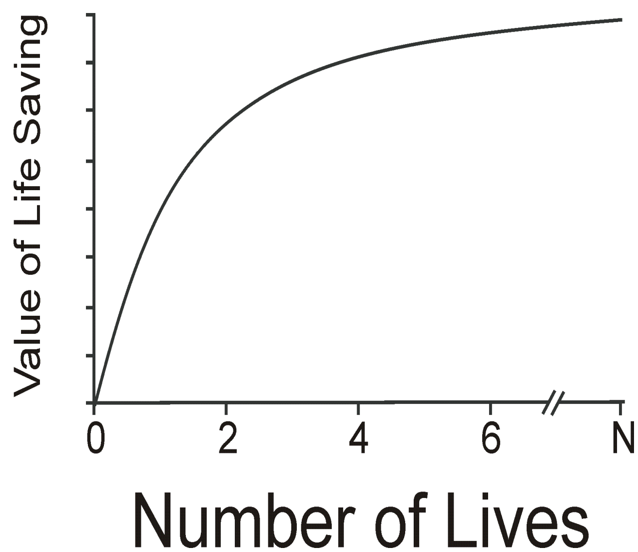


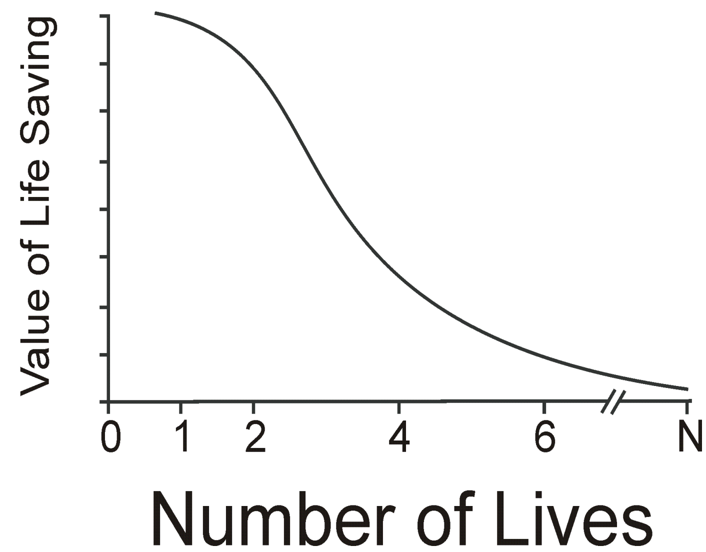


A normative model: Every human life is of equal value

Another normative model: Large losses threaten the viability of the group or society

How Do We Value the Saving of Human Lives?





A descriptive model of diminished sensitivity as *N* grows large. All lives are not valued equally.

(psychophysical numbing)

Another descriptive model: Psychic numbing and the collapse of compassion. Our capacity to feel (good or bad) is limited. Lack of feeling (value) leads to inaction when large losses of life occur.

Another Psychological Problem

The Prominence Effect

Choice vs Matching Discrepancies

Expressed values and preferences (matching)

differ systematically from values and preferences revealed through choices

- Values for national security and humanitarian lifesaving will be similarly high in expressed preferences

- But in choice, the prominent attribute, security, will trump lifesaving!

The Risk Game

- The concept of risk is like the concept of a game. Games have time limits, rules of play, opponents, criteria for winning or losing, and so on, but none of these attributes is essential to the concept of a game, nor is any of them characteristic of all games.

The Risk Game

- Similarly, a sociopolitical view of risk assumes that risks are characterized by some combination of attributes such as voluntariness, probability, intentionality, equity, and so on, but that no one of these attributes is essential. The bottom line is that, just as there is no universal set of rules for games, there is no universal set of characteristics for describing risk. The characterization must depend on which risk game is being played.

The Risk Game

- The rules of the risk game must be socially negotiated within the context of specific decision problems.

Thank You !

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Loss of Life Expectancy

	Days
Smoking (males)	3300
30% overweight	1300
Motor vehicle accidents	207
Medical X-rays	6
Radiation from nuclear power	0.02

1 in One Million Risks

- Spending 1 hour in a coal mine
- Traveling 10 miles by bicycle
- Traveling 1000 miles by jet plane
- Having 1 chest x-ray
- Living within 5 miles of a nuclear power plant for 50 years

Annual Fatality Rates Per 100,000 Persons at Risk

Risk	Rate
Age 65	2564
Motorcyling	2000
Age 55	1136
All ages	1000
Aerial acrobatics (planes)	500
Age 45	488
Smoking (all causes)	300
Age 35	215
Sport parachuting	200
Smoking (cancer)	120
Fire fighting	80
Hang gliding	80
Coal mining	63
Age 5	63
Farming	36
Age 10	26
Motor vehicles	24
Police work (non-clerical)	22
Boating	5
Rodeo performer	3
Hunting	3
Fires	2.8
1 diet drink/day (saccharin)	1.0
4 Tbs. peanut butter/day (aflatoxin)	0.8
Floods	0.06
Lightning	0.05
Meteorite	0.000006

Source: Wilson & Crouch (1982).

Risk analysts, recognizing the legitimacy and importance of public values, have begun to incorporate these values into risk-based decision making. For example, a Swiss-based engineering firm places hazards into one of four risk categories, depending on the degree to which activities pose risks that are voluntary, controllable, and known (Category 1), as opposed to activities posing risks that are involuntary, uncontrollable, and not well known (Category 4) as shown in Figure 3. The amount of money that society appears willing to pay to reduce risk tends to be much greater for involuntary risks.

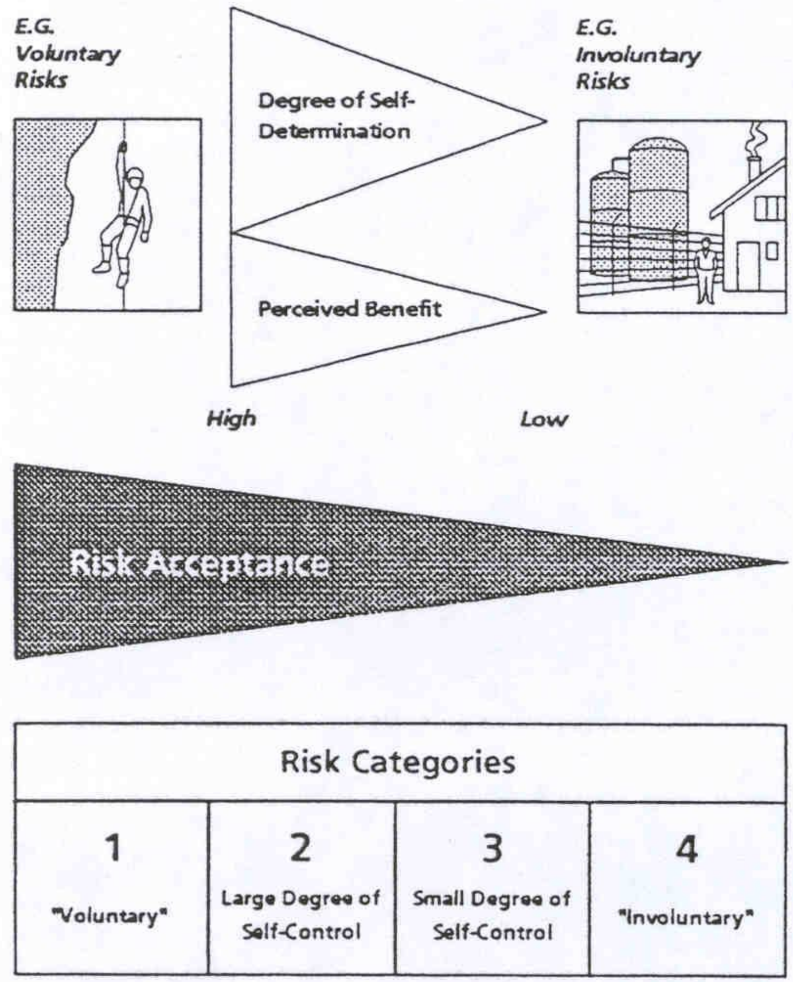
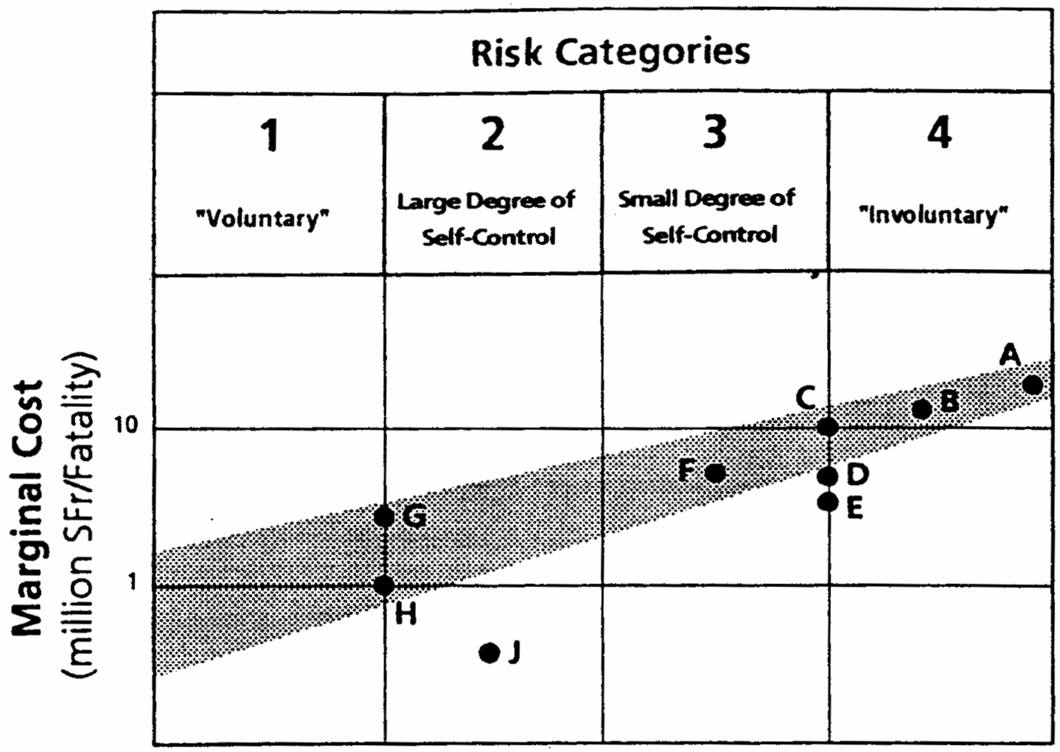


Fig. 4. Risk categories account for the different characteristics of risk.



A Fires Switzerland (1992)
B Tunnels Austria (1993)
C Air Traffic USA
D Tunnels Germany (1982)
E Derailments Switzerland (1992)
F British Rail (1992)
G Rail Switches Switzerland 1992)
H Grade Crossings Germany (1986)
J Road Traffic USA

Fig. 5. Marginal cost as a function of risk categories.

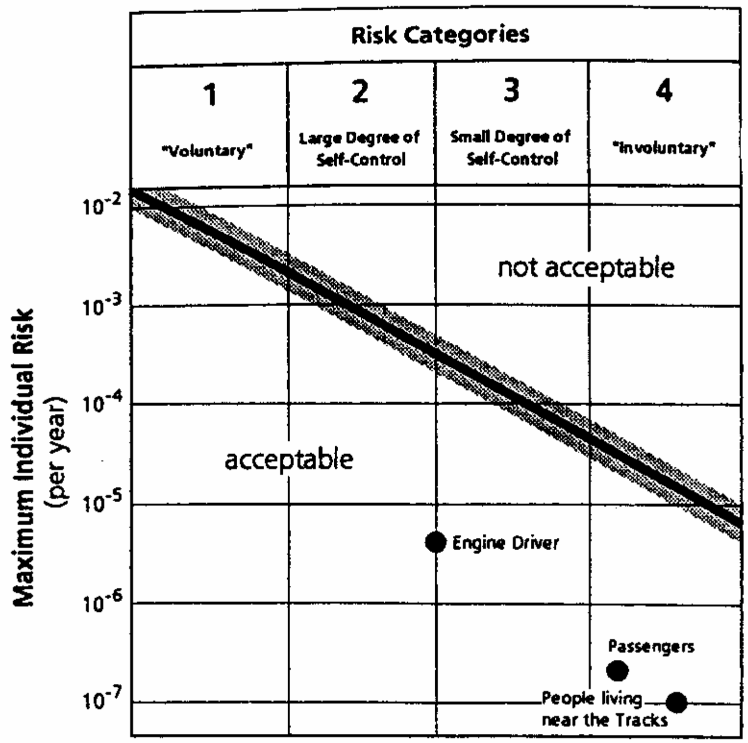


Fig. 6. Maximum individual risk as a function of risk categories. The three specific values refer to the transportation of hazardous materials which is discussed later.

“Risk” takes
societal values
Into account

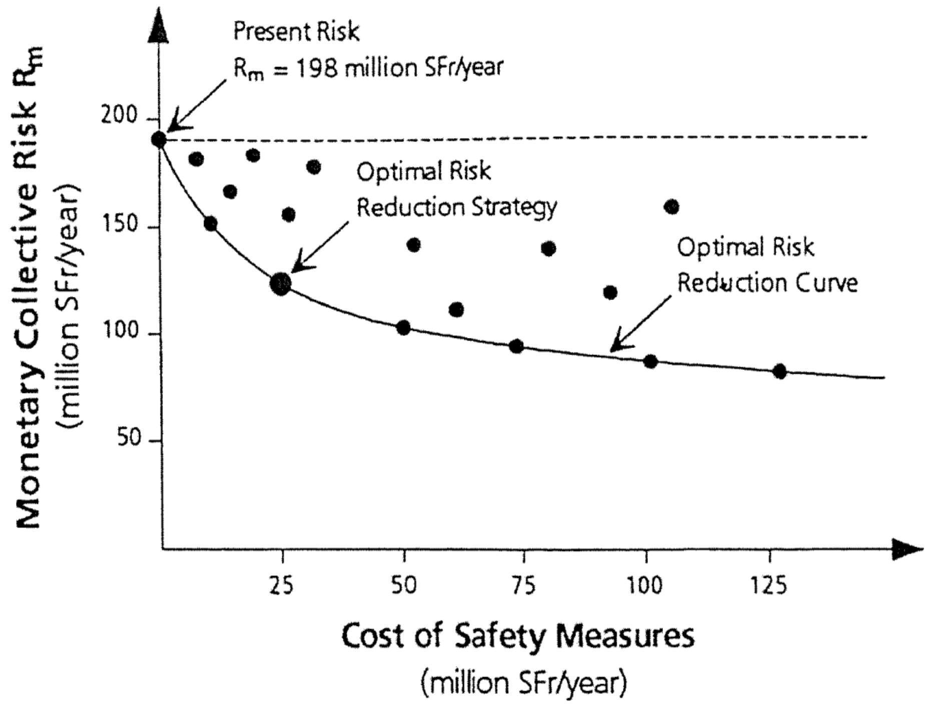
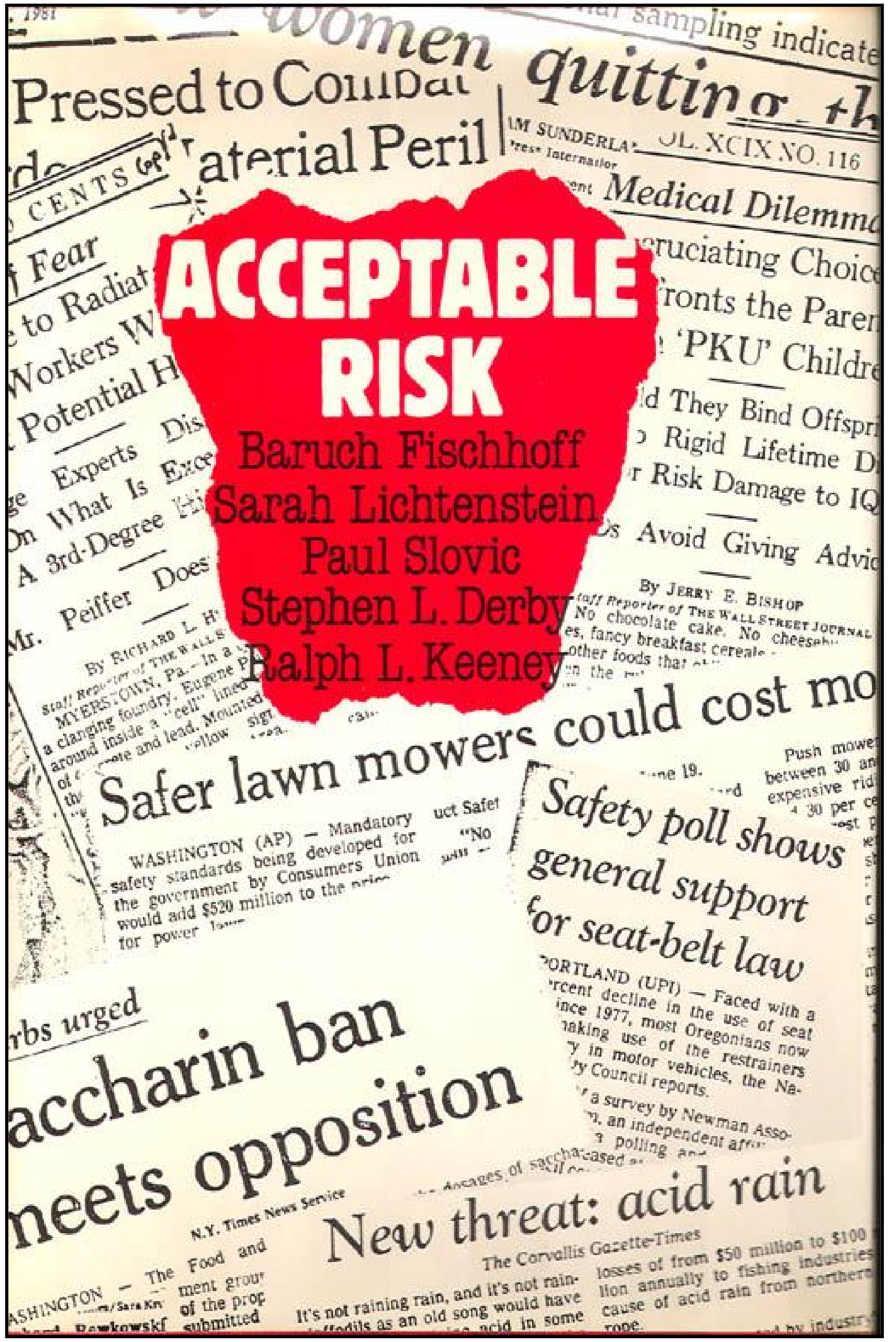


Fig. 7. The optimal risk reduction curve or efficiency frontier and the optimal safety for the transportation of hazardous materials on the rail net of the Deutsche Bahn AG.


ACCEPTABLE RISK
Baruch Fischhoff
Sarah Lichtenstein
Paul Slovic
Stephen L. Derby
Ralph L. Keeney
Pressed to Combat
Medical Dilemma
Safer lawn mowers could cost mo
Safety poll shows general support for seat-belt law
accharin ban meets opposition
New threat: acid rain

1981

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SETTING STANDARDS: A SYSTEMATIC APPROACH TO MANAGING PUBLIC HEALTH AND SAFETY RISKS*

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Standards are an effective means for managing hazardous technologies only if three conditions are satisfied: (a) setting general standards is preferable to case-by-case decision making; (b) some general safety philosophy, balancing risk and other factors, can be justified on normative grounds; (c) that philosophy is faithfully translated into operational terms. In practice, standards are rarely developed and enforced in an integrated systematic way. As a result, they often miss their mark. This guide presents a general framework for the design, development, and implementation of safety standards. That framework is derived from the logical character of the standard setters' task and from experience with actual standards. It first identifies the conditions under which standards are an appropriate management tool. Second, it presents four generic methods that may be used to develop safety policy. Third, it characterizes the design issues that arise in making that policy operational. At each step, it suggests particular strategies along with their inherent strengths and weaknesses. In particular, it shows the sensitivity of a standard's effectiveness to seemingly technical aspects of the way it is drafted.

(GOVERNMENT REGULATION; HAZARD MANAGEMENT; COST-BENEFIT ANALYSIS; DECISION ANALYSIS; RISK)

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Integrating technical analysis and public values in risk-based decision making

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Simple technical analysis cannot capture the complex scope of preferences or values of society and individuals. However, decision making needs to be sustained by formal analysis. The paper describes a policy framework which incorporates both technical analysis and aspects of public values. The framework can be used as a decision supporting tool and helps decision makers to make more informed and more transparent decisions about safety issues. © 1998 Elsevier Science Limited.

1 INTRODUCTION

Dangers are a fact of life. Most human activities involve some kind of risk to man and environment. In their daily decisions people implicitly consider the risks they face. The same holds for many decisions made by private companies, public institutions and government. Many of these decisions affect safety issues which are only considered implicitly. In an increasingly complex world the resulting decisions are not always appropriate because the limits of the human mind do not allow for an implicit consideration of a large number of different factors. In the past many lessons had to be learned by trial and error. Formal analysis is needed to aid decision making in complex situations.

However, the application of formal analysis to safety issues raises new questions. The risks perceived by society and by individuals cannot be captured by simple technical analysis. There are many reasons for this which will be discussed in the following sections. However, it is clear that decision making needs to account for both technical analysis and public values.

Tools to analyze risk have been in existence for many years[1–3]. Also, the basic phenomena of risk perception have been the topic of many investigations[4,5]. What has been lacking to a large extent, however, is a framework on how to bring technical information and public perceptions together in order to be useful in a normative sense in decision making.

2 CONTENTIOUS ISSUES

The formal analysis of safety issues to aid decision making leads to many controversies which seem to be unresolvable. The actual point of discrepancy may not necessarily be related to safety. Often it turns out that controversies go back to basic disagreements between the different parties involved. Even the best safety analysis cannot resolve such issues.

While applying formal analysis, it is important to realize that the following contentious issues do exist:

- Pragmatism versus understanding. A typical controversy exists between those who strive for pragmatic and fast solutions and those who prefer to have a clear understanding of the complex problem under discussion before deciding about possible solutions.
- Objectivity. Many people insist on objective investigations. They do not realize the restricted scope of objectivity. Even in the area of scientific and technical data, objectivity can be strived for but is not achievable in most cases. The interpretation of facts and data always asks for many assumptions which are characterized by subjectivity and the values of the person making the assumptions. Moreover, many people demand objectivity with respect to value judgments, though values are by their very nature subjective.
- Rationality. Fear of certain risks is sometimes called irrational. However, there is more than one way to be rational. Rationality can be defined by a set of axioms. As long as these axioms differ among the parties involved a mutual understanding will hardly be possible.
- Probabilistic versus deterministic view. It is unwise to neglect the probabilistic character of many events. Many processes obey probabilistic laws. Furthermore, it is necessary to consider events

A Few Comments on Risk Comparisons as a Guide to Acceptable Risk

Placing Risks in Perspective: Risk comparisons

Mortality rates

Loss of life expectancy

One-in-a-million risks

Natural risks

Use Risk Comparisons with Caution

- Comparisons cannot, in themselves, indicate which risks should be accepted.
- Thus, the fact that a particular risk is smaller than some other risks that are considered acceptable does not necessarily imply that the smaller risk should also be acceptable.
- The acceptance of risk depends upon the existence of compensating benefits to the individuals bearing the risk, the presence or absence of less risky alternatives, and the weighting that one gives to contextual factors such as voluntariness, control, knowledge, and dread.

A statement 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” fails to consider how these two technologies differ on the many qualities that people believe to be important. As a result, such statements tend to produce anger rather than enlightenment