Tutorial # 5: Evaluating and Managing Risk

Introduction: We constantly make judgments about risk. Many are trivial: What's the likelihood of making it across the street in front of that car without getting hit? What are the chances of missing something crucial by taking a pass on today's lecture? Is it really worth the time to download and look at last year's ENV200Y December term test? Other judgments may be a matter of life and death: Can smoking in bars be all that bad? What's the likelihood of contracting HIV from just one incidence of unprotected sexual intercourse?

We see judgments about environmental risks play out in policy decisions all the time. Society judged the risks associated with stratospheric ozone depletion to be sufficiently serious to warrant action. CFCs are being phased out according to schedules outlined in the Montreal Protocol and subsequent documents. Society has not yet decided that the risks of global warming are high enough to warrant similar agreements on carbon emissions. Governments continue to vacillate putting the Kyoto Protocol on virtual life support.

How does an individual or a society come to a decision with respect to risk? One aspect of evaluating risk is **risk assessment**: determining the likelihood that the event will ever take place. Actuaries are mathematical scientists trained to calculate probabilities. Many of you may be aware of actuarial tables used by insurance companies when they set their rates. Actuarial tables estimate the likelihood that someone with a set of specific characteristics will die or have an automobile accident or default on a loan payment or *etc.* But simply knowing how likely it is that some event may happen is not the only component to risk assessment.

We also need to know the probability of the harm that would accompany an event. We know (in the actuarial/statistical sense) that we are far more likely to be injured in an automobile accident than in an accident at a nuclear power plant. Yet most of us accept the former, climbing into cars with regularity. Society as a whole has grave reservations about accepting the risks associated with nuclear power. Part of this reservation is the degree of harm associated with a nuclear accident, even though the probability that there will be such an accident is very low.

But there is more to risk management than just the scientific assessment of the risk. Once we have assessed a risk, we need to decide whether we need to implement some sort of **risk management** protocol and then we need to **communicate** this information to the general public. This latter aspect of risk falls into a category known as **risk perception**. It is not as amenable to mathematical analysis as is actuarial risk assessment and people trained to work in the area of risk perception/communication are often psychologists or sociologists. The combination of risk assessment with risk perception helps us understand why society seems prepared to accept some activities that are highly dangerous, yet rejects activities only remotely likely to do harm.

Objective: To compare the actuarial risk of participating in a series of activities with our perceptions of how risky that activity is. Ultimately we want to: (1) develop an appreciation for the differences between risk assessment and risk perception; (2) come to an understanding of factors that contribute to differences in risk rankings by different individuals and (3) see if by examining those factors we understand better why society has decided that ozone depletion is more risky than are accumulations of greenhouse gases or why drinking contaminated water appears to be regarded as more of a risk than breathing contaminated air.

What to do before Tutorial:

Reading about the issue: Read the article by Paul Slovic entitled *Risk Perception* (included with the Tutorial) on how people think about and respond to risk. You should also look carefully at the figure in that article.

Thinking about the issue: You need not write out the answers to the questions in this section, but some of them will form the basis for discussion in your tutorial and thinking about them may help you answer the questions associated with your risk rankings.

1. How does an individual risk differ from a societal risk? Think of an example of each.
2. How does a voluntary risk differ from an imposed risk? Think of an example of each.
3. Why do you think many people tend to be overly pessimistic about exposure to radiation and overly optimistic with regard to exposure to cigarette smoke?

Writing about the issue: Using the list towards the end of the tutorial (page 54), identify what you believe to be the 10 most risky activities by assigning them a number from 1 - 10 with 1 representing most risky. Don't agonize unduly especially regarding which activity is 9th and what 10th! In tutorial, we're going to concentrate on the 3 risks common to everyone's list (assuming there are 3 in common!). We'll also comparing your rankings with rankings of these same risks compiled by university students 25 years ago along with a comparison to the "real," *i.e.* the actuarial assessment of those same risks. Ignore the small sub-scripts beside each activity for the moment.

In addition to ranking the risks, fill out the last two columns on page 54 by indicating:

I. Whether you think the risk tends towards being voluntary (circle a 1), imposed (circle a 5) or some where in between (2-4) and

II. Whether the risk is individual (circle a 1), societal (circle a 5) or some combination (2-4).

When you have finished your ranking, answer the questions on pages 55 and 56. The sheet is to be turned in at tutorial.

Perceiving Risk

Condensed from Paul Slovic's 1987 paper: Perception of Risk that appeared in Science, Volume 236 pages 280-285. This groundbreaking paper helped establish the discipline of risk perception of which Slovic is considered founding contributor. Dr. Slovic is professor emeritus of psychology at the University of Oregon and president of Decision Research.

Abstract

Studies of risk perception examine the judgments people make when they are asked to characterize and evaluate hazardous activities and technologies. My research [meaning Professor Slovic's] aims to aid risk analysis and policy-making by providing a basis for understanding and anticipating public responses to hazards. This work assumes that those who promote and regulate health and safety need to understand how people think about and respond to risk. Without such understanding, well-intentioned policies may be ineffective.

In recent decades, profound developments in technology has been accompanied by the potential to cause catastrophic damage to the Earth and its life forms. The mechanisms underlying these complex technologies are unfamiliar and incomprehensible to most citizens. The most harmful consequences are rare and often delayed. Hence they are difficult to assess with conventional statistics and not well suited to management by trial and error learning. The illusive, hard to manage qualities of today's hazards have created a new intellectual discipline, risk perception, to assist in the identification, characterization and communication of risk.

Whereas technologically sophisticated analysts employ risk assessment to evaluate hazards, the majority of citizens rely on intuitive judgments that I call "risk perceptions." For these people, experience tends to come from the news media, which rather thoroughly documents mishaps and threats throughout the world. The dominant public perception (and one that contrasts sharply with the views of professional risk assessors) is that people face more risk today than in the past and that future risks will be even greater than today's[1]

How extraordinary! The richest, longest lived, best-protected, most resourceful civilization in history is on its way to becoming the most frightened. What has changed? Forget Chernobyl, there are numerous small dams whose failure poses a far greater than does a nuclear accident. Why is one feared but not the other?

During the past decade, a small number of researchers have been attempting to answer such questions by examining the opinions that people express when they are asked to evaluate hazardous activities. This research has attempted to develop techniques for assessing the complex, 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."

Sociological and anthropological studies[2] have shown that perception and acceptance

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[1] according to a 1980 poll: "Risk in a complex society" by Marsh and McClennan Co. New York
[2] M. Douglas and A. Wildavsky, 1982. *Risk and Culture.* University of California Press

of risk have their roots in social and cultural factors. Short[3] argues that response to hazards reflects the social influences of friends, family, co-workers and respected public officials. In other cases, risk perceptions form after an event, as an *ex post facto* rationale for one's own behaviour.

Douglas and Wildavsky[2] 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 basic perceptions and cognition has shown that difficulties in understanding probabilistic processes, biased media coverage, misleading personal experiences cause risk to be misjudged (sometimes over and sometimes under-estimated), and judgments of fact to be held with unwarranted confidence. Experts appear to be prone to many of the same biases as those of the general public, particularly when they are forced to go beyond the limits of available data and rely on their own intuition[4]

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 or erroneous.[5]

One strategy for studying perceived risk is the "psychometric paradigm," which uses

[3] J.F. Short. 1961. *Annu. Rev. Psychol*. 12: 473.
[4] Kahneman, D., P. Slovic, A. Tversky [eds] 1982. *Judgment Under Uncertainty: Heuristics and Biases.* Cambridge University Press
[5] Nisbett, R. and L. Ross. 1980. *Human Inference: Strategies and Shortcomings of Social Judgment*. Prentice Hall

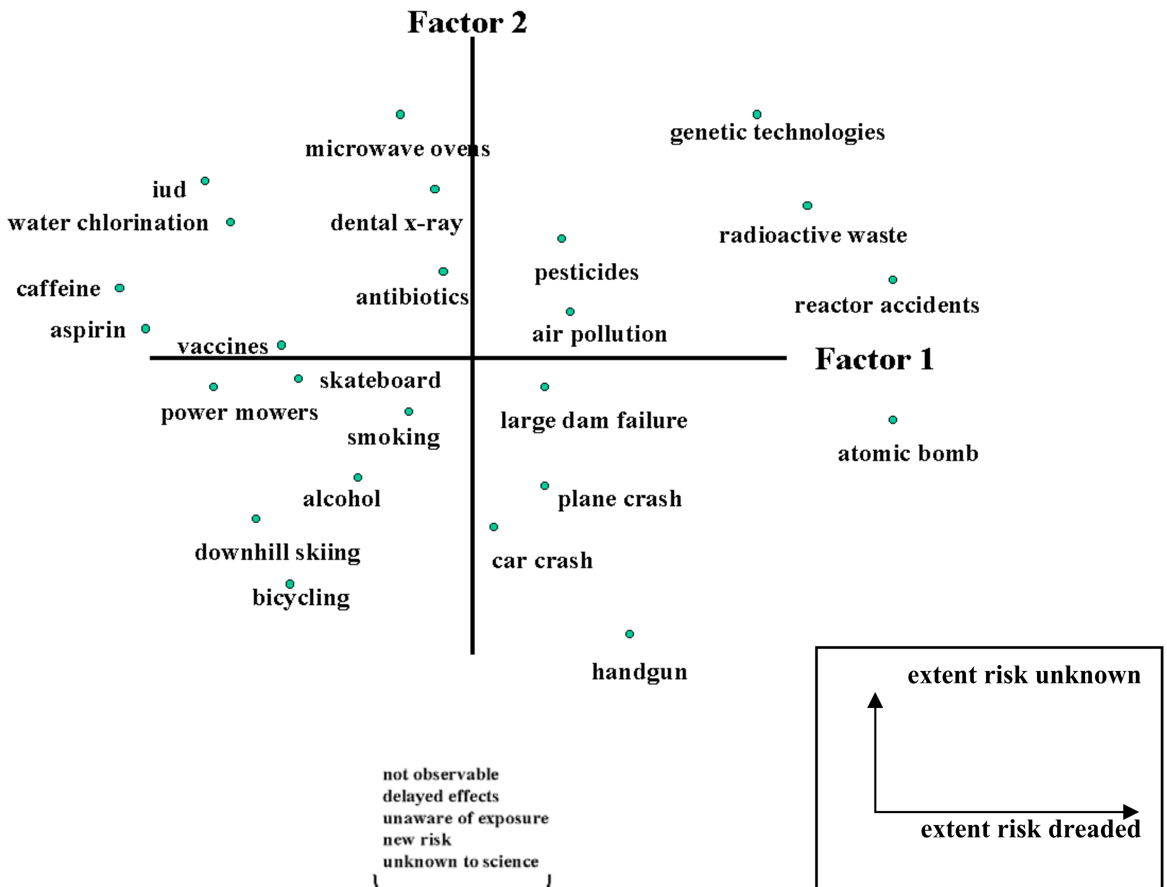
scales and multivariate statistical analyses[6] to produce a quantitative "map" of risk attitudes and perceptions. The original impetus for the psychometric paradigm came from the pioneering efforts of Starr[7] to develop a method for weighing technological risks against benefits in order to answer the question, "How safe is safe enough?"

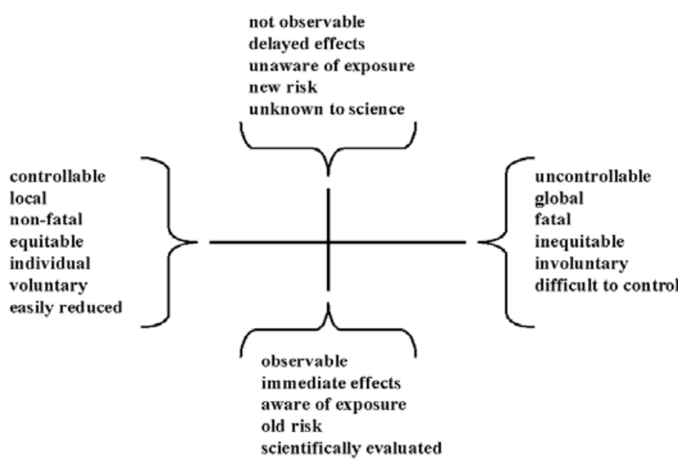
Starr concluded that: (1) acceptability of risk is roughly proportional to the cube of the benefits for that activity and (2) the public will accept risks from voluntary activities (such as skiing) that are roughly 1000 times as great as it will tolerate from involuntary hazards that provide the same level of benefit.

Psychometric techniques seem well suited for identifying similarities and differences among groups. They have also shown how the meaning of risk differs among people. When experts judge risk, their responses correlate highly with technical estimates of the number of fatalities expected. Lay people can assess fatalities if asked to, however their judgements of "risk" are related more to other hazard characteristics (*e.g.* threats to future generations or the potential for catastrophe) and hence differ from fatality estimates.

Another consistent result from psychometric studies is that there is little systematic relationship between perceptions of current risk and current benefits. People seem willing to tolerate higher risk from activities seen as highly beneficial, but, the key mediators vary by activity. Characteristics such as familiarity, control, equity and knowledge have been shown to influence the relationship been risk, benefit and

[6] A statistical technique that uses more than 2 sets of variables [APZ]
[7] Starr, C. Science. 1969. Science 165:1232





acceptance. The picture that emerges is orderly, but complex.

For example, hazards judged to be "voluntary" tend to also be judged as "controllable." Hazards whose adverse effects are delayed tend to be seen as posing a risk that is not well known. Investigation of these relationships with multivariate statistical analyses shows that they can be reduced to a smaller set of factors The accompanying figure shows the location of 24 hazards on 2 multivariate axes derived from the relationships among 18 risk characteristics. Factor 1 represents the extent to which the risk is feared or "dreaded." Factor 2 represents the extent to which it is a known versus unknown risk.

Risks at the right-hand end of Factor 1 are perceived as uncontrollable, of catastrophic potential, likely fatal and inequitable in terms of who takes the risk and who derives the benefit, *e.g.* a nuclear bomb or a reactor accident. Risks on the left are not as feared, are seen as reasonably equitable, voluntary in nature and capable of being mitigated.

Risks at the top end of Factor 2 are unknown. They are perceived as newer risks, relatively unknown to science with delayed effects, *e.g.* genetic technologies. Risks at the bottom of Factor 2 are things we have known about for a relatively long time, we know when we have been exposed to them and their effects are immediate. Handguns may be dreaded, but the risks associated with them are well known

Research shows that lay people's risk perceptions and attitudes are closely related to the position of a hazard within this type of factor space. For example, the higher a risk scores on the dread axis (the further it appears to the right), the more regulation people want to see. In contrast, expert perception of risk is not closely related to the risk characteristics. As noted earlier, experts appear to see risk as synonymous with expected annual mortality. As a consequence, conflicts over appropriate risk management can result when experts and lay people having different expectations.

The 1970 nuclear reactor accident at Three-Mile Island (TMI) provides a dramatic demonstration. No one died, no latent cancer fatalities are expected. Yet no other accident in history has produced such costly societal impacts. The accident devastated the utility that owned and operated the plant. It imposed enormous costs on the nuclear industry (through stricter regulation that increased construction and operating costs), it reduced operation and construction of reactors worldwide, increased opposition to nuclear power and forced reliance on other sources of energy. Traditional risk analyses tend to neglect these higher order impacts and hence they greatly underestimate the costs associated with certain kinds of events.

An accident that takes many lives may produce relatively little social disturbance (beyond that experienced by the victims' families and friends) if it occurs as part of a familiar and reasonably well-understood system (*e.g.* a plane crash or a train wreck). However a small accident in an unfamiliar system or one perceived as poorly understood may have immense social consequences if it is perceived as a harbinger of further and possibly catastrophic mishaps.

Consider the notorious exploding gas tank design problem of the 1960s that plagued the Ford Pinto. Documents show Ford knew about the problem but decided not to correct it because a cost-benefit analysis indicated that the correction costs greatly exceeded the expected benefits from increased safety.[8] Had Ford undertaken a psychometric analysis, it might have recognized that this particular defect (impact rupture, explosion and burn deaths/injuries) as one whose seriousness and higher order costs (lawsuits, damage to reputation) were greatly underestimated by conventional cost benefit analysis.

Risk perception explains and forecasts acceptance and opposition for specific technologies. Nuclear power has been a frequent topic of such analyses because of the dramatic opposition it has engendered in the face of experts' assurances of its safety.
Nuclear power risks occupy an extreme position in psychometric factor space. Research shows that people judge the benefits from nuclear power to be quite small and the risks to be unacceptably great. "Experts" sometimes appear as if they just don't get it. One noted psychologist wrote

[8] Grimshaw vs. Ford Motor Co. 1978 Superior Court 19776. Orange County, Calif.

that “the irrational fear of nuclear plants is based on a mistaken assessment of the risks.”[3] A nuclear physicist and leading advocate of nuclear power contended that “... the public has been driven insane over fear of radiation. I use the word insane purposefully as in loss of contact with reality. The public’s understanding of radiation dangers has virtually lost all contact with the actual dangers as understood by science.”[3]

Risk perception research paints a different picture. Attempts to “educate” or reassure the public and bring their perceptions in line with those of industry experts appear unlikely to succeed because nuclear risks are perceived as unknown and potentially catastrophic, even small accidents are highly publicized and produce large ripple effects.

Perhaps the most important message from this research is that there is wisdom as well as error in public attitudes and perceptions. Lay people may lack certain information about hazards. However their basic conceptualization of risk is much richer than that of the experts and reflects legitimate concerns that are typically omitted from expert risk assessments. Each side, expert and public, has something valid to contribute. Each side must respect the insights and intelligence of the other.

How the media saw it

Here’s a quandary

Based on an article by Oakland Ross in the 14 July, 2001 Toronto Star

Say someone offers you the following choice: A: You can accept a gift of $50, no questions asked or B: You can flip a coin. Heads you receive $100. Tails you get nothing. Here’s another quandary. A: You have to forfeit $50. B: You flip a coin. Heads, you have to give up $100. Tails you give up nothing

Which of these options would you choose? In the first quandary, most people elect to take the $50. The prospect of doubling that amount by flipping a coin is not a sufficiently powerful incentive to make them risk the loss of a sure thing. However people seem to be far more averse to loss than they are attracted by gain. So in the second quandary, most people will choose the latter option. Rather than face a sure loss of $50, they will risk a possible loss of $100 in hopes of facing no loss at all.

This is roughly the calculation former US president Richard Nixon made when he decided to cover up his office’s role in the Watergate scandal in the early 1970s, and it was the strategy former Alliance Leader Stockwell Day, former federal Privacy Commissioner, George Radwanski, and former Ontario Energy Minister Chris Stockwell all pursued. Rather than resign, each hung on, apparently in hopes of avoiding having to resign at all. At least one expert in organizational behaviour calls this a high-risk strategy, rife with the possibility of disaster. “People behave a lot differently when they’re avoiding losses than when they’re pursuing gains,” says Glen Whyte, professor of organizational behaviour at UofT’s Rotman School of Management. “It leads to a propensity for stupid decisions. You take bad bets and you usually lose.”

Daniel Kahneman, the first psychologist to win the Nobel Prize in economics, developed the concept of “loss aversion” in explaining why investors cling to losing stocks. Kahneman showed that investors were more likely to sell a stock they had purchased at $50 if it rose to $70 and was touted as overvalued than they were to sell the same stock if they bought it at $70 and it fell to $50 even in the face of information that the stock was still overvalued.

“Prospect theory helps explain biases of beliefs like ‘optimistic overconfidence’ – that people believe they can do what they in fact cannot do,” said Kahneman.

Rank	Activity or Technology	Voluntary	Individual
	Employment on a big construction projects$_{14,13}$	1 2 3 4 5	1 2 3 4 5
	Being a fire fighter$_{10,18}$	1 2 3 4 5	1 2 3 4 5
	Being a policeman$_{8,17}$	1 2 3 4 5	1 2 3 4 5
	Being vaccinated$_{29,25}$	1 2 3 4 5	1 2 3 4 5
	Climbing a mountain$_{22,29}$	1 2 3 4 5	1 2 3 4 5
	Consuming food colourings/dyes$_{20,21}$	1 2 3 4 5	1 2 3 4 5
	Consuming food preservatives$_{12,14}$	1 2 3 4 5	1 2 3 4 5
	Cutting the lawn with a power mower$_{28,28}$	1 2 3 4 5	1 2 3 4 5
	Drinking alcoholic beverages$_{7,3}$	1 2 3 4 5	1 2 3 4 5
	Flying on a commercial airline$_{16,16}$	1 2 3 4 5	1 2 3 4 5
	Flying in a private plane$_{15,12}$	1 2 3 4 5	1 2 3 4 5
	Generating nuclear power$_{1,20}$	1 2 3 4 5	1 2 3 4 5
	Having an x-ray$_{17,7}$	1 2 3 4 5	1 2 3 4 5
	Hunting$_{18,23}$	1 2 3 4 5	1 2 3 4 5
	Owning a handgun$_{2,4}$	1 2 3 4 5	1 2 3 4 5
	Pesticide exposure$_{4,8}$	1 2 3 4 5	1 2 3 4 5
	Playing high school/university football$_{26,27}$	1 2 3 4 5	1 2 3 4 5
	Riding a bicyle$_{24,15}$	1 2 3 4 5	1 2 3 4 5
	Riding in a motor vehicle$_{5,1}$	1 2 3 4 5	1 2 3 4 5
	Riding a motorcycle$_{6,6}$	1 2 3 4 5	1 2 3 4 5
	Taking prescription antibiotics$_{21,24}$	1 2 3 4 5	1 2 3 4 5
	Traveling by train$_{23,19}$	1 2 3 4 5	1 2 3 4 5
	Skiing$_{25,30}$	1 2 3 4 5	1 2 3 4 5
	Smoking cigarettes$_{3,2}$	1 2 3 4 5	1 2 3 4 5
	Surgery with a general anaesthetic$_{11,5}$	1 2 3 4 5	1 2 3 4 5
	Swimming$_{30,10}$	1 2 3 4 5	1 2 3 4 5
	Using a spray can$_{13,26}$	1 2 3 4 5	1 2 3 4 5
	Using electricity$_{19,9}$	1 2 3 4 5	1 2 3 4 5
	Using home appliances$_{27,22}$	1 2 3 4 5	1 2 3 4 5
	Using oral contraceptives$_{9,11}$	1 2 3 4 5	1 2 3 4 5

The questions you are to answer are on the next page which you will tear out and turn in to your TA in tutorial.

1. List the three elements 3 elements you ranked as most risky. The actuarial risk associated with each activity is indicated by the 2nd subscript following the activity. Are your 3 most risky activities also actuarially risky? Does some common theme emerge around your 3 that relate to differences between what you chose as risky and the activity's actuarial risk? Do you see any support for Slovik's hypotheses, *i.e.* are your most risky activities involuntary or of unknown exposure or societal rather than personal?

2. The first subscript following each activity is the perceptional ranking from a group of American college students over 25 years ago. How do your top three risky activities compare to the top three of those students? Can you account for any changes?

3. Most of the world seemed to panic in the face of the SARs outbreak. 42 people died in Ontario. We don't have the same reaction to the 5,800 people that the OMA estimates die prematurely every year from poor air quality or the 3,000 Canadians who die annually in automobile accidents. How would Slovic explain this? Do you think he is correct? What is your opinion?

4. There has been significant opposition to the introduction of various public health harm reduction policies such as needle exchanges or safe injection sites in spite of evidence that such practices reduce crime as well as HIV and hepatitis transmission rates among populations at risk. Do you see any connections between risk perception and such opposition or do you think such opposition has other causes?