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RISK PERCEPTION: CHANGING THE TERMS OF THE DEBATE

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Summary

Involuntary risk has a new, quite different meaning today than the term did when used in 1969 by Chauncey Starr. He believed that the public, in its trust in authority, would accept an imposed risk, and he saw the difficulty with involuntary risk as one of delay in feedback time. Today, public trust in authority is at a low ebb, and involuntary risks are more likely to be resented and rejected. So "involuntary risk" represents a different kind of problem in 1989 than it did in 1969. With more historical perspective, differences over risk assessment and risk perception will not be entangled in differences in the meanings of the terms.

Introduction

Risk assessment and its twin, risk perception, began at least as early as about 1300 when insurance rates, proportional to the risk, on merchant shipping were established. Over the years the basis for risk assessment and perception changed as they were used, in addition to marine insurance, for actuarial tables and life insurance rates, for safety factors on engineering projects, for public safety when threatened by natural hazards such as floods and hurricanes, for environmental and health risks, and for chronic risks. Through all this evolution of the concept of risk, the terms of the debate as to whether the risk was acceptable, have changed. Public discontent with management of chronic risks is at a point where discontents or perceptions might be more successfully dealt with if the terms of the debate were revised once again.

Two things have undergone major changes as risk assessment and risk perception have evolved:

1. Involuntary risk, not selected by the individual, has altered the recourse available to the public. In earlier times one acknowledged the inevitable natural risks to life and property. The choice was that of buying or not buying marine or life insurance in which case one accepted the risk but weighed the cost of the risk. The new risk perception either results in political action (write your congressman), community action (call a protest meeting), or in starting a boycott (don't buy apples, grapes or cake mix).

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2. The consequences of the reaction to a risk once was to raise or lower insurance rates. Today the consequences of the public being unwilling to accept a risk have been to force major changes in government policy and to cause turmoil in consumer markets.

When risk was associated with insurance, the buyer could shop for the best policy with the lowest premiums. In the case of a chronic risk, especially from a carcinogen, recourse is either to trust the risk assessor's results and assurances, or to take political or economic action: by demanding prohibitory regulatory action and by resorting to the devastating economic sanction of refusing to buy products suspected of contamination. The disturbing effects of public response to risk has prompted risk professionals to attend to risk perception.

Acceptable risk

When an individual examines a risk, it is with the intent of determining whether to accept the level of risk, reduce the risk or avoid it altogether. Commentators on the problems associated with the individual reaction to risk, referred to as risk perception, have used the term "acceptable risk" when puzzling over the question: How safe is safe enough? One answer was a tautology: "A thing is safe if its risks are judged to be acceptable" [1].

Whether a risk is "acceptable" or "safe" are modern concepts that accompany a technological world in which risks are not a part of nature but are produced as a consequence of technology. Much can be learned from the history of the idea of risk because the concept of risk has changed while the terms have not been redefined to clarify the debate.

The origin of the word, risk, is thought to be a nautical term meaning literally "to go against a rock". For centuries the term risk was associated with insurance and signified the chance of loss of property that an insurance company would make good on in return for a recurrent payment called a premium [2]. From the outset, then, risk was defined as measure of the likelihood of a loss, and that measure was the means of establishing insurance premiums. The loss was neither acceptable nor unacceptable; it was merely a part of nature as when a ship sank or a person died.

The origin of the idea of insured risk was first applied to voyages of merchant ships and the concept was probably invented sometime around 1300. Over the next 300 years the process of obtaining insurance for voyages developed and began to be institutionalized. Near the end of the seventeenth century, men with capital to invest met in London with shipowners in Lloyd's coffee house to negotiate premiums for the insurance against loss of a ship.

The cost of the insurance gradually became more mathematically determined. The premiums were made more closely dependent on the circumstances of each risk; these included such things as the character and condition of the ship, the crew and cargo, the length and route of the voyage, the season and

the current rate of interest [3]. Probability and the predictability of a possible loss were ideas first associated with risk. Questions about avoidance of that loss or whether the risk was worth taking at all were in the hands of the risk-takers, namely the ship's owners and the crew. The risks, in other words, were voluntary and were not public issues.

The law of large numbers forms the basis for life insurance. Actuarial calculations establish with mathematical exactitude the probability of the number of people within a given age, occupation, and class who will die over a given period of time. The death of an individual cannot be predicted. But the number of people within a statistically established group that will die during a given period can be predicted with accuracy.

In the one case of ships the probability of a loss due to risk is predicted, but the certainty of that prediction is based upon judgment along with some statistics. But where there are large numbers of statistics, as in the case of mortality rates that are gathered over many years, the accuracy of the estimate of loss is greater and that is what is termed the law of large numbers [4]. Statistics, in the case of ships, are not as large as in the case of life expectancy and predictability is less certain in the former than in the latter case.

Chronic risks without the historical accumulation of statistics of mortality rates require that risk assessments be calculated using a number of estimates and assumptions. Risk calculations based on epidemiological statistics are more certain than those based on animal studies and bioassays [55]. In epidemiology as in mortality rates, the statistics address the questions of risk historically where in the case of bioassays the effect on humans must be inferred from the reaction of animals. One source of the uncertainty of chronic risk assessment is that animal studies are used in order to obtain a statistically significant number of tumors or birth defects. How can the law of large numbers based on animal studies be transferred to humans? That transfer of statistics from animals to humans is based on the well-established principles used to construct actuarial tables. But the public lacks a clear understanding of what is involved in the change of meaning of terms when animal data are used to explain chronic human risk. The distinction between acute and chronic risk is not a clear one and not easily explained or comprehended by the public. Why else would the public demand the immediate banning of the use of a substance when it was shown only to have long term effects on laboratory animals?

Acceptable technology

In a landmark study in 1969, Chauncey Starr asked the question: how much was society willing to pay in order to benefit from a particular technology? The cost that he counted was the number of accidental deaths caused by new technologies such as automobiles and airplanes. He used historical data on fatalities as a yardstick for measuring what is "traditionally acceptable". The as-

sumption was that since society had tolerated the number of accidental deaths due to the new technology, the cost (deaths) was acceptable when weighed against the benefits of the new technology. In Dr. Starr's view, the public's implicit risk assessment for automobiles and airplaces can serve as a model for predicting what costs society will bear in order to benefit from a technology. He called this implicit risk assessment "historically revealed social preferences" [6].

Starr used new terms, "voluntary" and "involuntary" to denote the difference between risks assumed by individual choice and those imposed "by a controlling body". The significance, as he saw it, between the two was in feedback time.

A voluntary activity undertaken by an individual, say the decision to move to the suburbs, will gain him benefits and costs that will become immediately evident. The benefits of better schools and less crime in the suburbs can be balanced against the travel time and the risk of accidents that the commuter encounters. Voluntary activities provide quick feedback and the individual uses a personal value system to judge whether in the move to the suburbs the benefits were greater than the risks [6].

Involuntary activities, as Starr considered them, were imposed on individuals by some group, usually a government agency, a political entity, a leadership group, an assembly of authorities or opinion-makers, or any combination of such bodies. (Why were corporations left out of this group?) The most extreme case of such activities, Starr thought, was war. The feedback was a slow process for involuntary activities because the response to cost/benefit must be a cumulative one of a large group of individual reactions. The societal communication channels (usually political or economic), Starr thought, operated slowly as did the response of the control group that imposed the involuntary risk [6].

Not only did involuntary activities require a longer period of data in assessing acceptance of risk, but Starr also believed that in the case of involuntary activities that the public was psychologically more accepting of the decision of authority and therefore less likely to challenge that decision. Involuntary risks imposed by an authority were less likely to be questioned because the public assumed that government bodies made rational analyses of social benefit and social risk.

In 1969, according to Starr, involuntary risks were likely to be accepted by the public because of the trust in authority. He perceived that authority was being influenced by the public in a slow and roundabout way; that accounted for the slowed registering of public reaction to an imposed risk. But in 1986, William D. Ruckelshaus, former Administrator of the Environmental Protection Agency, told an audience that the "public response to these two national traumas (the Vietnam War and Watergate) was to take back power that had been delegated to the government" [7].

In the seventeen years between 1969 and 1986, the term "involuntary" had undergone a subtle but important change. The debate about public acceptance of risk had acquired a new significant term: "public trust". In evaluating public perception, one no longer could assume that the public placed an unquestioned trust in the authority of a federal agency. In the 1980s it appears that public distrust of federal agencies and their expertise is more the case.

Risk assessment for regulatory action

The idea that risk estimates might be used to predict a chronic health hazard, so that preventive action might be taken, began in federal regulatory agencies in the 1970s. The foundation of that idea was some studies published in 1969. Research for these studies indicated that a large fraction of cancers were attributable to exposure to toxic agents found in cigarette smoke, some foods, and the environment. Therefore, regulatory control of these toxic agents would reduce the risk of cancer [8].

Public concern about the chronic hazards was part of the impetus for the creation in the U.S. of the Environmental Protection Agency (1970), the Occupational Safety and Health Administration (1970), and the Consumer Product Safety Commission (1972). In addition, other agencies, in particular the Food and Drug Administration, were given added powers and responsibilities to control the use of chemicals that caused chronic health effects. These agencies cooperatively and independently developed risk assessment procedures for identifying health hazards and estimating the public health risks. The risk assessments were preliminary to deciding whether or not to regulate. But the new process of regulatory decision making, rather than quieting public concerns, raised questions about the procedure itself [9].

Chronic risk assessment as practiced in the federal regulatory agencies today has its roots in the assessments made in the 17th century for marine insurance which, in turn, was the basis for the calculation of life insurance premiums. The differences between the historic use of risk assessment and the present types of assessments are as important as the similarities. Today, there is virtually no data on the human carcinogenesis of chemicals. The list of chemicals that are known to cause cancer in humans is a short one and the specific cases where cancer was known to have been caused by a chemical are only those involving excessive exposure.

The regulatory agency must set standards based on animal studies for acceptable levels of human exposure to carcinogens that are *known* to cause cancers in humans as well as to carcinogens which are *thought* to cause cancers in humans. Those substances that are suspected but not proven to cause cancer have been labeled carcinogens based on inference from animal studies. The whole idea of regulation means that standards of exposure or limits of use must

be set for chemicals that are believed to cause cancer and the data for setting these standards are meager.

The procedure for risk assessment usually follows four steps:

1. hazard identification — to determine whether a chemical can cause a chronic health effect.

2. dose-response assessment — to determine the amounts of the chemical that cause adverse health effects.

3. exposure — to determine how many in the population are exposed to the chemical and the extent of that exposure.

4. risk characteristic — to determine the nature and the magnitude of human risk as well as to indicate the uncertainty of the results [9].

After this involved process entailing assumptions and inferences, risk assessments arrive at a statistical result, such as, at the present level of use this chemical will cause 4 cancers in an exposed population of 100,000. For the agency this macrorisk calculation is useful in determining which chemicals present a serious public health risk, which of these ought to be regulated first, and what is a safe level of use for the chemical, that is, what standard ought to be used to limit the use of the chemical.

The decision about which chemical the agency will regulate first, has been done in a scientific, objective way, and the agency can feel assured that it is fulfilling the charge given to it by the Congress (Parliament). Problems immediately arise as to the accuracy of the risk assessment and the validity of the underlying assumptions. Industry claims that the assessment is too cautious, and public interest groups tell the courts that the assessment is in error and allows too high a level of pollution. The agency, these critics assert, is endangering the public health. Those controversies about the scientific accuracy of risk assessments and the validity of the assumptions underlying the assessment are one aspect of the controversies surrounding risk assessment.

The other aspect is the public's *perception* of the risk and that is more personal. Although public perception of a risk may seem irrational, that perception is real enough to be the basis for a strong public reaction.

Two historic changes have taken place in the area of risk analysis, and these changes have drastically changed the public perception of risk. The difference in risk as applied to insurance and as applied to regulation are basic to the debate about calculating and applying risk. Those arguing the issue are using terms with quite different meanings.

The principle of insurance is that in cases of loss of property or of premature death, the large economic loss to an individual (or family) is distributed over a large number. All considerations in insurance are of the mass so that the law of large averages applies. As one nineteenth century commentator stated it: "Insurance begins when the liability to loss is recognized as common, and provision is made beforehand to meet it (the loss) from the common fund" [3].

In this view insurance represents a civilized approach to risk in which the

community agrees to share the burden of loss so that no individual need suffer economic loss and of being made destitute.

Today, over 600 years after the invention of insurance, the concept of risk is being applied to chronic effects where there is no certainty about those who suffer the loss because the loss occurs in the future and there is medical uncertainty as to whether the suspected chemical will cause cancer. The technical uncertainty in calculating chronic risk is much greater than the assembling of actuarial tables because there is so much less statistical data for chronic risks. The objective in calculating chronic risk is to regulate the chemical that is causing the risk, whereas in the case of insurance the object of risk calculation is to set a fair rate for the premiums.

The second historic change in the realm of risk is in the impact of the estimate of risk on the public. The amelioration of economic loss has been so successful that insurance is an integral part of society and insurance can be obtained on almost any risk, including the risk of no snow at a ski resort [4].

Federal health and safety regulation dates from the period when river steamboat safety was a concern about 150 years ago. The public outcry over the loss of life as a result of exploding high-pressure steam boilers resulted in a significant change in public attitudes towards risk. In response to the public demand, U.S. Congress passed legislation that imposed standards of safety on passenger-carrying river steamboats. Congressional action came in spite of the long-held belief that it was better to: "Let competition be entirely open,... allow steamboat owners to use their own discretion in building, equipping, and running their vessels; simply hold them responsible for the losses which may occur from explosions or other accidents due to their negligence or carelessness. In steamboat owners, humanity and self-interest would combine to produce greater safety than could be obtained from reliance on the mere judgment and discretion of a score or so of inspectors" [10].

Risk has continued to have a macro as contrasted with a micro aspect. An actuarial table will state how many 35-year-old males will die within the next ten years, and that impersonal view is macro in outlook. A 35-year-old male might see the table and wonder if he will die or avert the evil decree. Probably, his microrisk view is that he certainly will not die, although he will take out a life insurance policy to protect his family against economic loss.

By the same token, a risk assessment that indicates that 3 in a population of 100,000 will contract cancer is a macrorisk statement. But in this case the same 35-year-old man because of the dread of cancer will worry that either he or a member of his family are in immediate danger. The result of this man's perception multiplied by one million will wreck havoc in the grape or cake mix market. The microrisk view of a chronic hazard asks whether that apple or grape or slice of bread can be eaten without the chance of contracting cancer.

Another dichotomy exists in the perception of risk: the difference between the technical, objective view versus the personal, subjective view. In the tech-

nical or expert mind, risk is a quantifiable attribute of technology or of natural hazards. For both the actuarial statistician and the risk assessor in a federal regulatory agency, risk can be expressed with mathematical rigor. For those individuals with no mathematical bent and who have their share of fears, risk causes a visceral reaction that cannot be expressed in numbers. Government policy is heavily dependent on the expert risk calculation. The results of the calculations are an important guide to policy makers. The results are also "communicated" to the public, that is, regulatory agency decisions based on mathematical calculations have to be explained to a public that reacts to risk viscerally.

Objective, factual risk analysis prevailed in spite of the fact that the public remained unmoved by such analysis. Technologies (especially new ones) which experts considered safe encountered public opposition much to the consternation of the risk assessors. The failure of the public to "appropriately respond" to risk estimation gave rise to the term risk perception; by that term technologists meant risk "misperception" [11].

Risk perception has become a specialized field itself. As two critics of the risk perception enterprise stated recently: "We believe that risk perceptions can, to some extent, be assessed, but the very search for objective answers and generalizations, and indeed the very assumption that generalizations in the manner of natural science are even possible, is misplaced. The desire to find solutions to problems seemingly concerned with the public's misperception of risk has led researchers to provide, or attempt to provide, increasingly elaborate answers to the wrong questions" [11].

The gap between the cultural, subjective view of the world and the scientific, expert view of the same world has been a longstanding problem. In the nineteenth century, popularizers of science such as T.H. Huxley, John Tyndall, and Herbert Spencer established a professional standing based on their talent for communicating complicated, technical ideas. They filled lecture halls in England and the United States where people flocked to hear the latest in theories of light, electricity and evolution. Reading these lectures today one is impressed with the difficulty and complexity of the ideas that were explained by these men and women. A number of women popularizers such as Mary Somerville, for whom Somerville College in Oxford was named, were able to establish a place for themselves in the world of science also [12].

Since the public perception of risk is linked with the public understanding and trust in science, the question arises as to what is the present state of public knowledge and acceptance of scientific explanations? How well have the modern popularizers faired? Surveys indicate that in our technologically advanced country (the U.S.), the number of people who believe that science can explain the mysteries of the world has decreased; in 1980 only 27% of those asked believed that "everything has a scientific explanation". The same survey found

that almost half of the American people have given up on the idea that science would explain the mysteries of nature [13].

Has "Superstition Won and Science Lost" in our day as the title of a recent book claimed? That would be a remarkable occurrence considering that in 1900 six percent of those eligible graduated high school, and the rising curve had reached to 60 percent of the eligible population graduating high school in 1950 [14]. In spite of all the educational exposure that American children have, recent studies have found an abysmally low level of knowledge of science and mathematics in the school age population. Comparisons with children in other countries show that children in the United States are behind, Hungary, Japan, Finland, Sweden, Canada and Wales in college preparatory mathematics. College educated Americans are not prepared to comprehend the difficult concepts in risk assessment, and that lack of preparation extends to the lowest school grades [14].

Even the most knowledgeable person will have difficulty in absorbing technical information if that person is emotionally resistant. Chronic risks are risks which often result in cancer, and cancer is a dread disease that causes a mind closing reaction when the subject is broached. One expert in medical affairs expressed his frustration with Americans' attitude towards cancer this way: "When it comes to cancer, American society is far from rational. We are possessed with fear... cancerphobia has expanded into a demonism in which the evil spirit is ever present, but furtively viewed and spoken of obliquely. American cancerphobia, in brief, is a disease as serious to society as cancer is to the individual – and morally more devastating" [15].

More than one scientist has felt exasperated at the effect that this "Cancer Phobia" has had on American industry. An editorial in *Science* was just one of several such statements: "For more than 10 years, the public has been subjected to a media barrage leading to widespread, misinformed fear of chemicals. Through the use of questionable evidence, many major substances have been labeled carcinogens" [16].

The split between the experts and the general public was creating an atmosphere of tension and distrust in which regulatory agencies were finding it more and more difficult to function. Scientists may have been angered about the adverse effect of "Cancer Phobia", but the public was "likely to end up feeling that cancer is everywhere, that society is doing nothing but poisoning the environment, that it is not safe to trust anything or anybody, and that the products of technology are poison and disease" [17].

Public perception of chronic risk, then, was not a single unchanging view. Much of what was expressed about risk reflected changing social and political views. One moment the environmentalists were heroes saving society and the agencies were not to be trusted. The next instant environmentalists were boring and agencies were ineffective. Regulatory policy had great difficulty in finding a base of public opinion on which to judge what was wanted in the way of

protection from chronic hazards. The short range trends in public opinion or perception presented regulatory agencies with constantly changing response to efforts to control chronic risks. The long range historical trends in the social and political climate were another source of uncertainty for agencies.

The concept of risk as a means of calculating the degree of hazard to human life had its origins in marine insurance of 600 years ago but the conviction that the government has a role in reducing the risk to human life began in the United States about 150 years ago. In 1838 Congress passed legislation regulating safety on river steamboats. The public demand for that legislation was a result of a number of steamboat disasters, especially on the Mississippi and Ohio Rivers. The accidents occurred when high-pressure steam boilers exploded as a result of pushing the steamboats to their top speeds. The death toll rose to a staggering 695 during a twelve-month period in 1851. The reaction to this new hazard was more stringent regulation that gave responsibility for the safety of the steamships to the engineers and pilots [10].

In the early nineteenth century the main issue over regulation was property rights versus human life. A senator from New Jersey said that in high opposition to federal regulation he was found "a higher principle involved, namely, that of 'liberty and equal rights', which may be more important than even human life, which is 'transient and evanescent'" [10]. If the senator was using modern terminology he might have said what ought the government spend to save a human life?

Another perennial argument about regulating risk was raised in the nineteenth century. The American agrarian society was given its first experience with machine technology in the form of the river steamboat. Was it right for the federal government, some asked, to hinder the development of this technology by regulation? The first Congressional report wondered: "To what farther application the agency of steam is capable and to what extent it may be carried by the science and ingenuity of our mechanicians, cannot be anticipated, and your committee felt averse to fetter or discourage the ingenuity and skill for which the artists of this country are so distinguished" ([10] reference is to House Report 125, 18 Cong. 1 Sess).

Conclusion

Risk assessment and the perception of risk have their roots in history. The understanding and the meaning of the two terms have evolved, but the change in meaning is not always taken into account in present debates over risk assessment and perception. Any intelligent debate ought to begin with a common definition of terms so as to clarify the basis of disagreement. This essay has been a call for a conscious re-definition of terms on the assumption that much of the present disagreement as to what the public perceives in risks or ought to perceive is clouded by using the same terms to mean different things. For

example, do experts and technical people mean public "misperception" when they use the term "public perception", as one group argues?

Involuntary risk has a new, quite different meaning today than the term did when used in 1969 by Chauncey Starr. He believed that the public, in its trust in authority, would accept an imposed risk, and he saw the difficulty with involuntary risk as one of delay in feedback time. Today, public trust in authority is at a low ebb, and involuntary risks are more likely to be resented and rejected. So "involuntary risk" represents a different kind of problem in 1989 than it did in 1969. With more historical perspective, differences over risk assessment and risk perception will not be entangled in differences in the meanings of the terms.

Two important matters ought to be kept in mind when discussing risk and risk perception.

1. The concept of risk began as a term used in setting marine insurance premiums. When referring to chronic risks today the term implies a risk to human life and raises the question whether that risk is acceptable. In the past acceptability was not an issue since the risk was a part of nature. With risk more and more thought of as a creation of technology the question of acceptability is central to whether the technology is acceptable.

2. Risk and risk perception are terms much used in regulatory policy today. Knowing the public perception of a risk is vital to the decision of whether to regulate a technology or not. Regulatory agencies and industry have found to their chagrin that if something is not done to satisfy the public's adverse reaction to a technological risk, then the public will enforce its sentiment through the market place by not buying products which are judged too risky. When one remembers that risk assessment and risk perception are tied today to regulation, the terms carry a very heavy and important significance.

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