

**RISK PERCEPTION: A SYSTEMATIC REVIEW
OF CONCEPTS AND RESEARCH RESULTS**

Dr. Ortwin Renn
Head
Nuclear Research Center
Juelich, West Germany

1. INTRODUCTION

In the year 1968 the survey research institute of Allensbach (FRG) conducted a national poll in the Federal Republic of Germany asking a representative sample of German women what kind of profession the ideal husband should have. In 1968 the most attractive profession for a man was the nuclear physicist. Eleven years later the same question again was asked to all females between 16 and 70 years old. In this poll the nuclear physicist was not even mentioned among the first twenty nominations. The top of the list was occupied by a complete different type of professional activity. The winner of the game was the forest ranger! (Allensbach, 79)

What has the attractiveness of male professions to do with risk perception? There are two answers to this question:

1. The shift of prestige assignment from a technology oriented to a nature oriented profession reveals a semantic change in the public understanding of risk. Was technology in the past predominantly perceived as a powerful mean to reduce risks posed by natural catastrophes, climate variations, infectious diseases and biological competitors for food and biotope (Markl, 80), so it became more and more associated with causing risks and threats to human beings and the natural environment in recent years. People became aware of the fact that the tools which liberated them from natural constraints posed themselves new risks on their lives (Hohenemser, Kaspersen and Kates, 81, p.2; Renn, 84; Renn and Swaton, 84).
2. Furthermore the change of professional prestige in modern societies demonstrate the interdependencies between perceptions, general social attitudes, values and world views. There is no doubt that science is dependent on the concept of isolating specific phenomena from their natural or social context in order to construct modes of causal or sequential relationships with the aid of analytical techniques.

This is also true for studies on risk perceptions. But it should be kept in mind that in real life risk perception does not exist as a distinct psychological process among other types of perception, but that it forms an integral part of assembling and representing beliefs and perceived characteristics of an object or event in the mind of an individual. Considerations about risks might or might not play a major role in this opinion or judgement forming process. Potential benefits, side effects come up, symbolic meanings, value orientations, the attitudes of reference groups about the risk source, the prestige and image of those persons who promote or oppose the implementation of the risk source are just some of the many factors that influence people's perceptions of objects or events apart from risk considerations (Hoss, 80; Conrad, 81; Thomson, 80; Pearce, 78).

The division into features relating to the risk and those relating to the risk source is admittedly purely and analytical expedient for psychological research. In reality, people only judge objects, events and activities, and not risks (cf. Brown and Green, 80).

Would it then not be better to expel the concept of risk perception from the terminology of cognitive psychology and replace it by object perception? This sort of recommendation can indeed be justified in view of the often unthinking use of the concept of risk perception, but it is not necessary from the nature of the case. For perception of an object naturally also includes perception of the hazardous consequences of this object, their mental assimilation and general mechanisms to cope with the situation of uncertainty (Renn and Peters, 82). Thus, the hierarchical rank of aspects related to risk, benefit and uncertainty with respect to object assessment can be analytically investigated. In the same way the separate measurement of object and risk perception can answer the question whether

there are typical patterns in the intuitive perception of risk sources which can give us some pointers towards the "Common Sense" assimilation of uncertainty through potential danger sources.

2. BASIC CONCEPTS OF RISK PERCEPTION

For the purpose of reviewing the major theoretical concepts and empirical studies in the field of risk perception it is necessary to define the main terms frequently used in the literature on risk perception.

Object perception: Object perception describes the process of mentally representing and assimilating information and experience with respect to a physical object or entity (Renn, Peters, 82).

Values: A value is a conception, explicit or implicit, distinctive of an individual or characteristic of a group, of the desirable which influences the selection from available modes, means, and ends of action (Kluckhorn, 51).

Beliefs: A belief represents the cognitive images a person has about a given object, i.e. it is a probability judgement whether an attribute is or is not, and to which degree associated with the perception of an object. The subjective feeling of goodness or badness which is linked with each attribute refers to the effect a person might have and is called subjective evaluation (Fishbein, Ajzen, 75).

Attitude: Attitude is a mental and neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related (Allport, 35).

Concerns: A concern refers to a state of positive or negative responsiveness of individuals to become aware of and process any information or personal experience regarding salient areas of interest on that matter (Renn and Swaton, 84).

Risk Perception: Perceived risk is the combined evaluation that is made by an individual of the likelihood of an adverse event occurring in the future and its likely consequences (The Royal Society, 83, p. 34).

In Fig. 1 the attempt is made to illustrate the interconnections between beliefs, concerns, values, attitudes and perceptions. The model includes five basic categories: the physical environment, the social environment, the cultural environment, the psychological motives and the socialized world view. Any individual is confronted with a specific object which is embedded in a social situation and a cultural context (symbolic meaning). The physical properties of the specific object as well as the characteristics of the situation are elements of the individual perception process. The perceived properties are not necessarily identical with the real properties. Limited access to information, intuitive selection filters and pre-evaluations bias the perception process. Parallel to the perception of properties the social characteristics are assembled and perceived: both processes are combined in the subjective assessment of consequences that are associated with the object. Also, at this stage, associations derived from the cultural context or from personal experience are activated and compared with the subjectively assessed consequences.

The next step refers to the phase of processing the perceived object properties, situational characteristics, predicted consequences and associations into a belief system. The selection as to what enters into the belief systems, the mode of abstraction from personal experience and mediated information in order to form generalized convictions and the way of ordering the perceptive items into salient clusters are influenced by the value orientations, emotions and attitudes towards similar objects. In addition, general heuristics and personal style of reasoning have to be taken into account.

The last step refers to the process of balancing the positive and negative beliefs aiming towards a general evaluative judgement with respect to the object. For this purpose the beliefs are ordered according to their subjective importance, the judgements of reference groups are incorporated, the personal consequences of each possible judgement are assessed and the possible outcomes

are compared to earlier experience with similar objects.

This outline is, of course, just an analytical tool to understand the process of attitude formation. The different stages are interlinked in the real world and proceed much more unconsciously as pointed out here. Yet, it represents a theoretical framework which helps to analyse our research concepts and results of risk perception studies.

- Insert Figure 1 here -

According to the analytical framework of object perception and attitude formation risk perception studies focus on three key questions:

1. What are the social goals, values, or motives that drive persons or social groups to attribute special concerns to specific risk sources?
2. In what way do people process information about risk sources, and what kind of logical structure and reasoning do they follow in arriving at an overall judgement on the acceptability of a perceived risk?
3. What kind of motivational or cognitive biases are incorporated when people select information from the various sources which they have access to, and why do they apparently violate their own rules of reasoning?

Taking into account these three questions, a more integrated approach to the investigation of risk perception can be developed. For this purpose, we can divide the risk perception studies into four rough categories: classical decision analysis, psychological decision theory, social-psychological judgement and attitude theory, and sociological concepts including policy analysis.

Classical decision analysis focuses on the rationality of the decision-making process under the assumption that we can make use of formal axioms to optimize our own judgement (Keeney and Raiffa, 76). If we go a step

further and demand that the optimization process be adapted to the individual metarational criteria of reasoning, this kind of research fits right into our key questions 3 above.

Psychological decision theory (including social judgement theory) has put its emphasis on the individual process of common-sense reasoning incorporating the social desirability of perceived consequences and specific motivational factors in processing uncertainty (Hammond et al., 78). Research in this field can be best classified under key question 2, because the purpose of this research is to head towards the individual process of understanding the representation and assimilation of perceived hazards and their probabilities, leading to the formation of an overall judgement.

Social-psychological research concentrates on the interaction between social environment (social values, norms, and roles) and personal judgement. Risk perception is being understood as a process of deriving attributes about specific objects from general social values and personal attitudes and linking these attributes to the perceived properties of the risk object or risk situation (Janis and Mann, 77). This research lies on the borderline between key questions 1 and 2.

Finally, sociological research addresses the problem of group responses to risk concentrating on the influence of social values, institutional constraints, reference group judgements, communication, and power interchange (Frederichs et al., 83; Nelkin, 77b; Otway and von Winterfeld, 82). It is interesting to note that the sociological concepts of risk perception, in particular the studies on power and pressure groups, have some features in common with the concepts of the mathematical decision analysis - the other extreme of the scientific spectrum. Both concepts assume that individuals try to maximize their own utility (in sociological terms, their interest) and that objective measures can be identified to indicate if individuals or groups are better or worse off after the risk has been taken. In

decision theory, the expected utility is an objective measure of a person's gain or loss; in sociological theory, gain or loss of power is an objective yardstick to measure social influence. In our framework, sociological research deals primarily with key question 1.

Table 1 gives an impression of the scope of scientific research in the field of risk perception. It should be acknowledged that the systematic overview simplifies the complex situation of risk research and ignores much of the conceptual differences within each class. For a more detailed classification one should refer to the corresponding literature (see Covello, 83; Otway, 77; Royal Society, 83; Becker, 80; Renn, 84).

- Insert Table 1 here -

3. RESULTS OF RISK PERCEPTION STUDIES

According to the various disciplines involved in risk perception research different conceptual frameworks have been applied to determine the main factors that influence people's judgement on expected consequences and their likelihood. Researchers who worked with utility concepts investigated predominantly the individual balancing procedure and the intuitive heuristics which govern the process of assimilating and evaluating information about risks. The most applied instruments in this category of research studies are psychometric scales, semantic differentials and correlation circles for determining spatial differences between various risks (Fischhoff et al., 78; Vlek and Stallen, 81; Peliclar et al., 77; Pagés et al., 82).

Researchers who pursue the attitude concept are searching for salient beliefs and effects that determine the overall feeling of an individual towards the object and influence the willingness to take actions in correspondence with that feeling. (Thomas et al., 80; Otway, 80; Swaton and Renn, 84). Attitude researches usually use questionnaires to collect beliefs and

affective patterns which are later processed by factor analysis in order to detect the salient factors of risk perception.

Researchers who focus on value commitments and concerns analyse the course of social interaction between promoters and opponents of the new risk object or risky activity and observe the process of attitude formation as a function of avoiding dissonances between value orientations and the selective perception process of the information concerning the properties of the risk object and the position and values of the people associated with the object. Within this research tradition surveys and direct observations on the most common instruments in order to analyse the causes for the development of different positions towards a risk source and to reveal the social constraints that filter the information which each individual is exposed to and predetermines the willingness to take account of positive and negative consequences (Bechmann, 81; Conrad, 81a; Wynne, 84).

In addition to the three basic concepts more sociologically oriented approaches have to be mentioned which regard risk perception as an element of the continuous struggles of social groups for power and social influence (prestige, status, etc.). But since this approach takes no interest in the investigation of the underlying psychological and social factors of risk perception, it does not need a more specific consideration in this chapter (Kitschelt, 80; Nelkin, 77a; Mazur, 75; Douglas and Wildavsky, 82).

The three perspectives on risk perception are not exclusive, but focus on different aspects of the perception process: the rational of people to come up with a balance judgement, the genesis of beliefs about objects and the social dynamics of processing and evaluating information. Hence, it is not necessary to present the results of empirical studies separately for each research tradition. Rather it seems appropriate to initiate a review based on a more fundamental insight into the individual

process of formings beliefs about risks and risk sources, and enlargen the discussion step by step with more remote factors, like value orientations and trust in sources of information. Since the field of risk perception has become rather popular in recent years and numerous studies have been published, the following review can only address the highlights of the studies and discuss the main results. In order to be as brief and precise as possible, the review is organized as a collection of theses:

1. In general people are doing a good job in assessing the magnitude of a risk that is familiar to them. In principal they are quite aware of the threats and dangers which they are exposed to. Figure 2 shows the results of two surves, one American, one German. A random sample of persons in Germany and several groups in the US were asked to estimate the average losses per year from various sources of hazard: estimated values are plotted on the y axis and the actual statistical figures on the x axis. There is a general tendency, both in the USA and in Germany, to overestimate low risks and underestimate high risks, although the German sample tends rather to exaggerate the real figures. Nonetheless, the extent of agreement between estimated and actual values is fairly high (Lichtenstein et al., 78; Slovic et al., 79; Remm and Peters, 82).

- Insert Figure 2 here -

2. The intuitive ability to determine the order of magnitude of risk disappears as soon as questions are asked relating to the number of lifes lost in a catastrophic year to be expected once during the span of a lifetime. Either all risk sources are graded almost uniformly assigning around 3,000 losses for each risk source, or exorbitant estimates were made, for example, an average of 22,000 death for

drug abuse, 4,000 death for skiing accidents, and as many as 600,000 deaths caused by nuclear power - all figures related to the Federal Republic of Germany (Renn, 81). When making estimates for a normal average year, experience and common sense can bring about a relatively good approximation of the statistical values. However, when questions are related to disasters which can be expected over 80 to 100 years, there the intuitive evaluation processes will not function, since the extent of catastrophes cannot be drawn directly from a person's own experience (v. Winterfeld et al., 81; Slovic et al., 79; Renn, 81).

3. If one relates the statistical or intuitively estimated values for expected losses to the intuitive rating of the benefit level, or a risk-benefit ratio, one obtains an astonishing result. Presumed loss rates per year and risk perception (also risk-benefit perception) are practically independent of each other, i.e., most people do not assess risk sources according to the presumed losses per year, rather they concentrate on other points of view (Renn and Peters, 82). This insight is true not only of the German interviewers; American, English, French, and Australian studies confirm the low relation between the public's loss estimation and risk perception (Slovic et al., 79; Royal Society, 83; Glenmon, 80; Pages et al., 82).

Thus most people are more or less aware of the expected values of well-known risks; however, the expected values are merely one factor among many in the perception of these risks and, as correlation analyses show, a factor with only slight explanatory value.

4. Most people are not familiar with the rationale of probability. When the probabilities of adverse effects are not intuitively comprehensible (as in the unlikely example of a jumbo jet crashing into a football stadium), the perceived degree of riskiness is likely to be related to the worst imagined accident. If the imagination of catastrophes

is enhanced by media coverage, the negative risk perception is further reinforced. This coping mechanism tends to evoke high sensitivity for low probability/high consequence risks and a strong degree of disinterest in high probability/low consequence risks (Tversky and Kahnemann, 74; Ross, 77; Jungermann, 82).

5. The attendant circumstances, the way in which people are exposed to a certain risk, are considered in the literature as qualitative features which influence the perception process. According to the investigations of Slovic et al., there are three main factors shaping the intuitive assimilation of risk related information: the severity of losses when they occur (dread), the familiarity with the risk and the "degree of personnel exposure" (societal versus personal risk taking) (Slovic et al., 81). Studies on the quality of hazards lead to similar results: The two Dutch researchers Vlek and Stallen came to the conclusion that risk perception is dependent upon the "size of a potential accident" and on the perceived "degree of organized safety" (81, p. 235 ff.). Green and Brown report a high preoccupation of people for natural vs. man-made risks, necessary vs. unnecessary activities, major consequences vs. minor impacts, personal control vs. out of control and easy vs. difficult to escape (Green and Brown, 80; Perusse, 80). In contrast to the above studies which use aggregational procedures for all risk sources in order to reveal universal factors for characterizing risk qualities, the studies by Gardner et al. (80, p. 26 ff.) and the ones by the author were designed to analyse qualitative characteristics independency for each risk source (Renn, 81).

- Insert Figure 3 here -

Figure 3 shows the significance of the individual qualitative features for the evaluation of the risk in question for 9 risk sources. The corresponding correlation coefficient is on the y-axis, that is to say the intensity of

the relationship is depicted, and on the x-axis are the boxes with the individual feature classes for nine different risk sources.

If one first considers the primary factors, that is to say the features which exert the greatest influence on risk evaluation, then it becomes apparent that benefit-related points of view predominate. People first of all evaluate risks according to the possibilities and accompanying circumstances of their application, for example whether they themselves can profit from them, whether they are of benefit to everyone or only a minority, whether there are not further alternatives, which provide the same benefit with less risk. In the case of nuclear energy, pesticides and electrical appliances the emphasis is on risk features. Whereas the voluntariness of utilization brings about a positive weighting of the concomitant risk in the case of electrical appliances, the dominance of the factor "catastrophic consequences possible" in the case of nuclear energy and "possibilities of long-term damage" in the case of pesticides has a negative effect on risk perception. It is thus clear that statistical loss rates are not the decisive motives for scepticism towards nuclear energy and pesticides.

6. Apart from qualitative risk features which are believed to be universal factors in risk perception process, research has been conducted to find salient clusters of beliefs relating to different sources of risk. Large-scale experiments carried out by the "Risk Assessment Group" of the International Atomic Energy Agency in Vienna showed that people classify their attitudes towards energy systems according to the following criteria: "indirect effects from the risk source" (e.g. health hazards); "economic benefits" (e.g. increase in the national income); "environmental risks" (e.g. pollution); "psychological and physical implications" (e.g. capacity for control of the risk,

artificiality of the risk source); and "effect on social and technical progress (e.g. providing security of supply, social levelling). These four dimensions in attitudes were obtained on the basis of the results of surveys on the assessment of various energy systems (Otway, 80; Thomas, 81). Since energy systems only cover some of the possible risk sources, the author conducted a similar experiment in the form of an intensive survey involving twelve different types of risk sources. The aim was to discover the most important attitudes and their systematic structure. Using various statistical procedures, the attitudes subjected to enquiry were traced back to their central basic pattern (factor analysis) and comparable sets of factors were developed by means of aggregation. This interpretation gave rise to an allocation and, finally, to an evaluation, of risk sources under the following five points:

- Effects on the person himself and on the social environment (health, supply level, security, etc.)
- Extent to which persons are directly affected (personal benefits, damage, comfort, well-being; liberty, etc.)
- Effects on economic and social welfare (employment market, social levelling, general standard of living, quality of life, etc.)
- Sociopolitical and social values (social justice, democratic rights, equal distribution of benefits and detriments, etc.)
- Effects on the conditions for coping with the future (maintaining output level, defence of liberty, ensuring supply level, etc.).

Not all of these five criteria are brought to bear for every risk source and the significance of the individual factors differs greatly. In order to obtain an overall view of the intensity and composition of the five criteria for various risk sources, the average values for the individual factors have been compiled for six risk sources in Fig. 4. The bars which extend below the zero line show negative estimations with respect to the risk source under consideration, while the bars above the zero line show the corresponding positive evaluations (Renn, 81).

- Insert Figure 4 here -

7. People seem to avoid risks that pose a pending danger to them. The randomness of occurrence is perceived as a potential threat, because the dangerous situation might occur at a time when the individual is not prepared to react in an appropriate manner. Instinctively, human beings react to dangerous situations with the responses of aggression, escape or playing dead. If a dangerous situation is to be expected, stress is likely to occur in order to perform the instinctive reaction fast and almost automatically. Stress, however, cannot be sustained over an extended period of time. Therefore, people feel uneasy if a dangerous situation can occur any time without prior notice. In this situation, they prefer risk avoidance behaviour. If they cannot initiate actions to move away from the dangerous situation, they demand collective regulation as a means to maintain control over the impending danger. This aversion to randomly occurring hazards is not related to any probability, but just to the nature of randomness. The feeling of uneasiness is reinforced if people have the impression that there will be no time to flee or to protect themselves against the potential hazard (Green and Brown, 80; Renn, in press).
8. Risk refers to a compound judgement constructed on the assessment of personal utilities and associations with the risk source. This explains

some of the difficulties that experts encounter when applying risk comparisons in public. Risk in connection with skiing, for example, has a different connotation compared to risks related to nuclear energy. Risk in the former application is perceived as a peculiar thrill to the individual. In the latter case, though, nuclear energy is perceived as a threat to personal health. Any attempts to logically compare both risks fail to convince anyone, except the risk expert (Gardner et al., 80; Renn, 85).

9. People are willing to accept risks more frequently if they feel that risks and benefits are distributed equally. Thus, justice is a key factor in risk perception. When risks are confined to an identifiable population (e.g., the neighbourhood in the vicinity of a hazardous waste disposal site), this population is likely to respond negatively to the risk.

The notion of justice implies two categories: equity of risk and benefit distribution, and exclusiveness of exposure to risks or benefits (Keeney, 80; Renn, 84).

10. In general, it has been proven that value orientation and the general attitude system will increasingly influence risk perception if the risk sources have already undergone politicization. For example, scientists of the "Arbeitsgruppe Angewandte Systemanalyse" (Working Group on Applied Systems Analysis) in Karlsruhe discovered that the formation of judgements on nuclear energy strongly depends on one's own value orientation (more materialistic, more postmaterialistic, more environmentally conscious) which however, has practically no bearing on the perception of coal (Frederich et al., 83).

With respect to nuclear energy a relationship between value orientation and risk assessment was also revealed in studies calculated

by the author. Even if general value orientation - similar to the studies carried out by the Social Science Research Centre in Los Angeles (von Winterfeldt et al., 80) - is hardly directly related to the determining factors of risk perception, it nevertheless codetermines indirectly the perception process via the formation of related attitudinal patterns (Renn, 81). With regard to the perception of the nuclear energy risk, the perceived risk level is particularly influenced by five socio-political attitudes (Figure 5).

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Low confidence in statements of scientists and technologists, combined with a high priority for environmental protection, produce a more negative perception of nuclear energy risks at the outset. Conversely, confidence in science and technology and a low degree of environmental awareness represent an attitude which from the start tends to develop positive expected values. But there is no deterministic relationship between attitudes in the sociopolitical field and those towards nuclear energy.

11. Credibility is the source of information about risks and risk sources has turned out to be a crucial factor in risk perception. If a person distrusts the source of information, he or she is more inclined to pay attention to counter-information and to demonstrate a risk averse behaviour in order to be on the safe side. In particular, scientific dissent and politisation with respect to risk sources lead to a risk perception process which is highly overruled by sympathies and value commitments in favour of one of the involved parties. Symbolic beliefs are substitutes for instrumental considerations (Wünschmann, 74; Tubiana, 79). But the perception of objects does not depend solely and not even primarily on widely acceptable solutions within the scientific system:

First of all, scientific dissens will only have an impact on public perception if scientists themselves regard the issue as a political one and will therefore transfer the dispute into a public debate. Secondly the general public will only be aware of any scientific dispute, if the consequence of the dispute will either affect their own living conditions or their belief system. Thus it is essential that the perceived consequences of any technology are evaluated as salient in respect to the individual formation of attitudes, before an issue gains political weight.

Finally, empirical studies of the author on the loss of credibility by social institutions concerning the peaceful use of nuclear energy show that despite the loss of confidence in science and politics a maximum degree of credibility continues to be given to scientists working in the field of nuclear research and in universities as well as the pertinent politicians (e.g. Minister of Research and Technology). This statements apply to both proponents and opponents of nuclear energy (Renn, 81).

4. CONCLUSIONS

The paper intended to review the state of the art in the field of risk perception with specific emphasis on European studies. Like in any review a selection has to be made with respect to the concepts, the analytical frameworks and the empirical results reported. The review is certainly biased by subjective preferences and interpretations of the author, but it was attempted to include all relevant information and to put the results of the research studies in a perspective. Only a small fraction of conducted empirical research could be presented in order to keep the paper brief and precise, but enough cross references have been made for those who want to study the formation of risk perception more intensively.

What has been learned from the numerous studies in risk perception? Among the major results of the risk perception studies conducted by psychologists, sociologists and decision analysts, the following have immediate impact on the process of risk management and policy making:

- o The expected losses over time are only one and even minor element of the public perception of risk. Even the catastrophe potential cannot be regarded as decisive in the sense that the number of perceived victims in a disaster is related to the degree of the perceived riskiness. Rather the subjective probability regarding the strength of the belief that a catastrophe can happen, is one of the characteristics that people apply by judging the magnitude of risk.
- o Two kinds of variables are found to be important for the process of risk perception: qualitative risk characteristics and beliefs about the risk source. In case that risks are perceived as dreadful, involuntary, unaccustomed and personally uncontrollable, people will give special attention to this kind of risk and are eager to get more information of the risk source.
- o Beliefs about risk sources vary from risk to risk. There is no universal threshold for risk acceptance either for different risk sources perceived by a single individual or for a single risk assessed by different individuals.
- o Social psychological and sociological studies show that judgements on risky technologies or activities depend not only on psychological factors like the ones mentioned above but also on reference group judgements, salient beliefs about the risk source, perception of the proponents and opponents of the risk source, degree of loyalty towards official policy makers and commitment to social values and cultural ideas. Since all these factors including the psychological

ones are interrelated and sometimes reflect mere post-rationalizations of unconscious feelings and social constraints, it is very difficult to set up a reliable model of how people actually perceive risks and evaluate them. What we know, is what matters, and partly to what degree it matters; but analysts are still searching for a theory that can explain the process of people's judgement on risks.

What are under these premises the main lessons for policy makers on risk management considering the results of the perception studies, so far?

Primarily it had become evident that the artificially constructed contrast between the rational assessment of the experts and the supposedly irrational assessment of the layman has not only disguised the true relationships in the current discussion about risk, but has at the same put considerable difficulties in the way of the dialogue between the two sides. The technological calculation of risk dimensions must be regarded as an important component of any decision concerning risk sources and is also an ideal instrument for constantly improving the safety measures for protecting the public. However, the public is not disputing the fact! To make calculations of this kind the sole criteria for "acceptability" and/or "desirability" of technologies or of other civilizing risk sources, however, contradicts the intuitive view of risk acceptance and is also unreasonable from political and social standpoints. This should not be misunderstood as a plea towards substituting scientific risk assessment by means of risk perception. The analysis of perception has also demonstrated that the assimilation of uncertainty and the intuitive coping mechanisms with risks are biased by heuristics, personal experience, media coverage and other factors. Modern societies cannot afford to substitute science by common sense.

If the purpose of science is to explain and predict phenomena, we can expect that scientists do a better job in prediction than other people.

Otherwise science would be superfluous. Scientists have a better access to the collected general experience of society (empirical knowledge) and are better trained to use systematic and consistent models of extrapolating past experience (methodological knowledge). The superior degree of accuracy does not mean, though, that experts are not susceptible to cognitive biases, errors or misperceptions, but that they are less susceptible than all the other members of society (cf. the model of graduated rationality in Renn, 81).

Risk management, therefore, has to incorporate the results of risk perception studies in two ways:

- o First, the dimensions of each risk source or class of risk sources, which are perceived as potential violations of one's own values or interests.
- o Secondly, the prevalent tradeoffs between conflicting values, for example cost versus environment, which reflect the desire of each citizen for the living conditions preferred in the future.

In a pluralistic society the values of each citizen should have the same impact on policy making than those of experts or policy makers. The technical approach adopts those values that experts associate as adequate with respect to the problem. But such an adequacy does not exist. The decision analytic approach feeds in the values of the client, usually the regulator. His or her values are either home-made or reflect the regulator's perception of what the public really wants. Asking the public directly seems to be the optimal solution, but is not so easy as it sounds. Values and beliefs are interrelated. If beliefs are erroneous or their underlying cognitive heuristics biased, many values are formed in accordance with the beliefs and therefore distorted. Innovative survey methods combining attitude measurements, information and participation have to be developed to meet this new challenge to social science. A first attempt has been made in

this direction by a research team of the Nuclear Research Center Jülich, and the University of Wuppertal in applying the method of "planning cells" in order to investigate the preferences of ordinary citizens or future policies on risk management (Renn et al., 84; Dienel, 80).

Risk perception is a complex phenomenon that requires more investigations on a multidisciplinary scientific level. For the purpose of risk management it is essential to understand the structure of perception and to recognize the concerns that underlie the overt resistance against modern technologies imposing risks onto the public.

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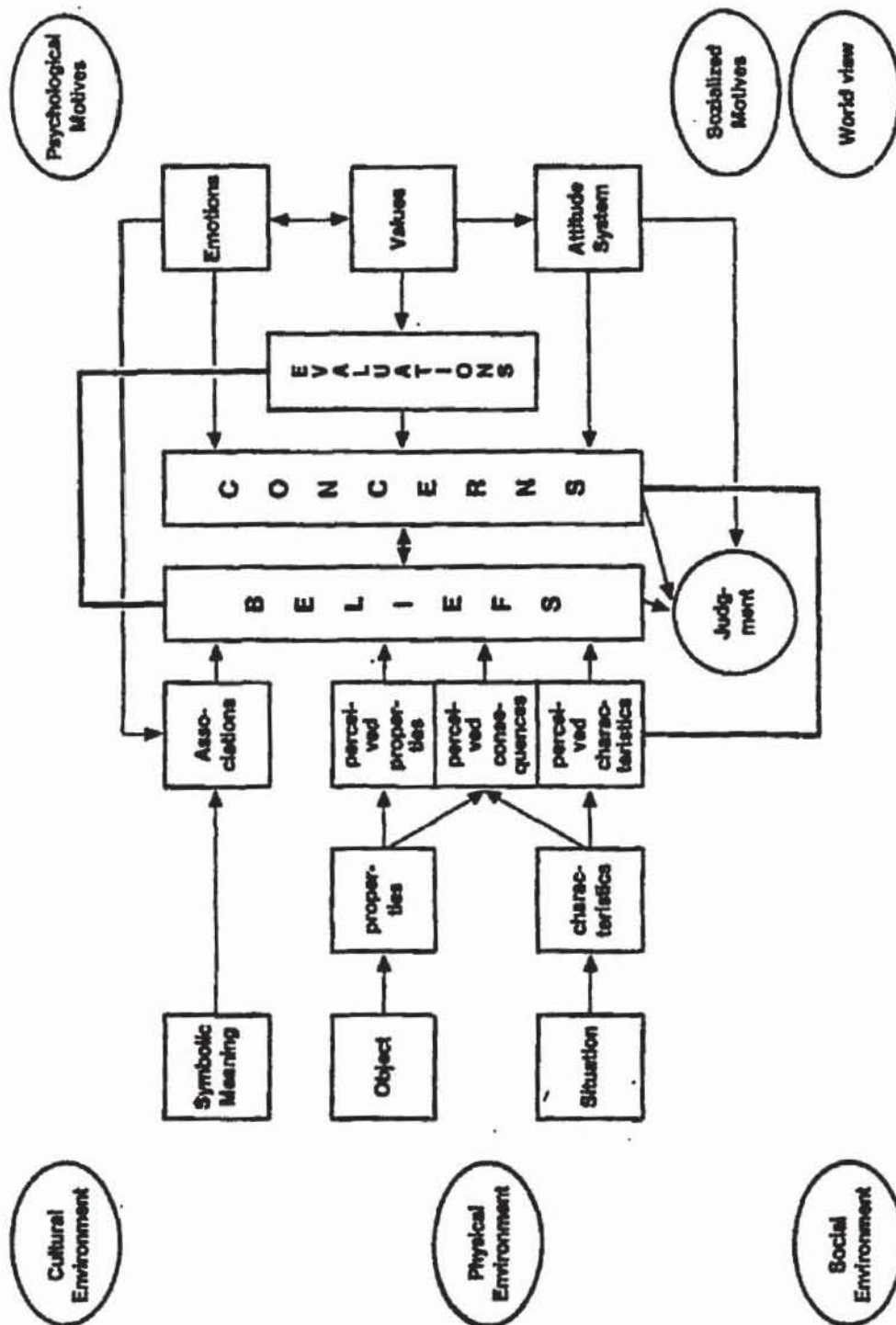


Fig. 1: A conceptual framework of the interdependencies between beliefs, concerns, values and attitudes

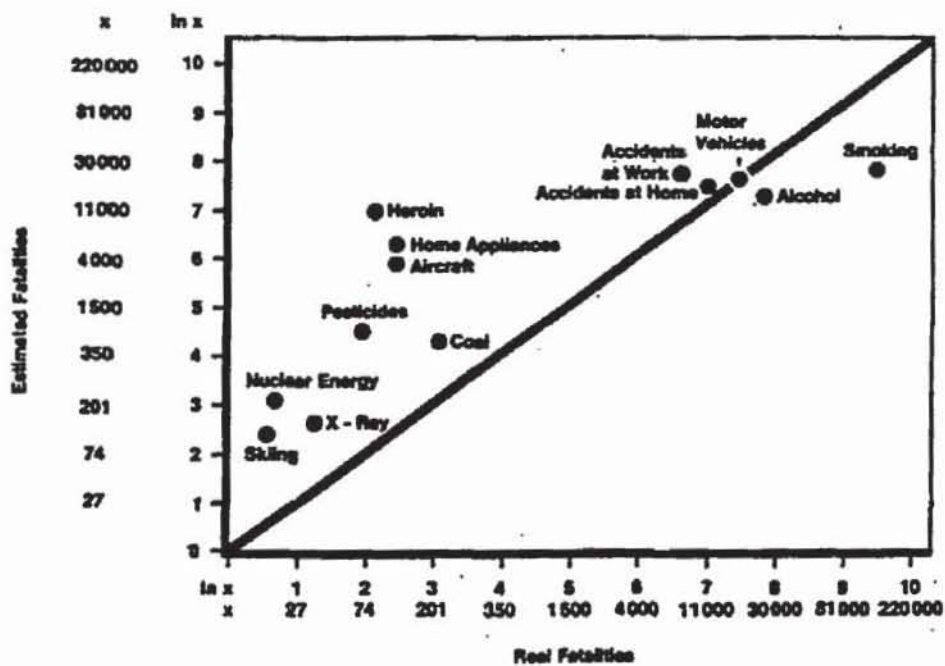
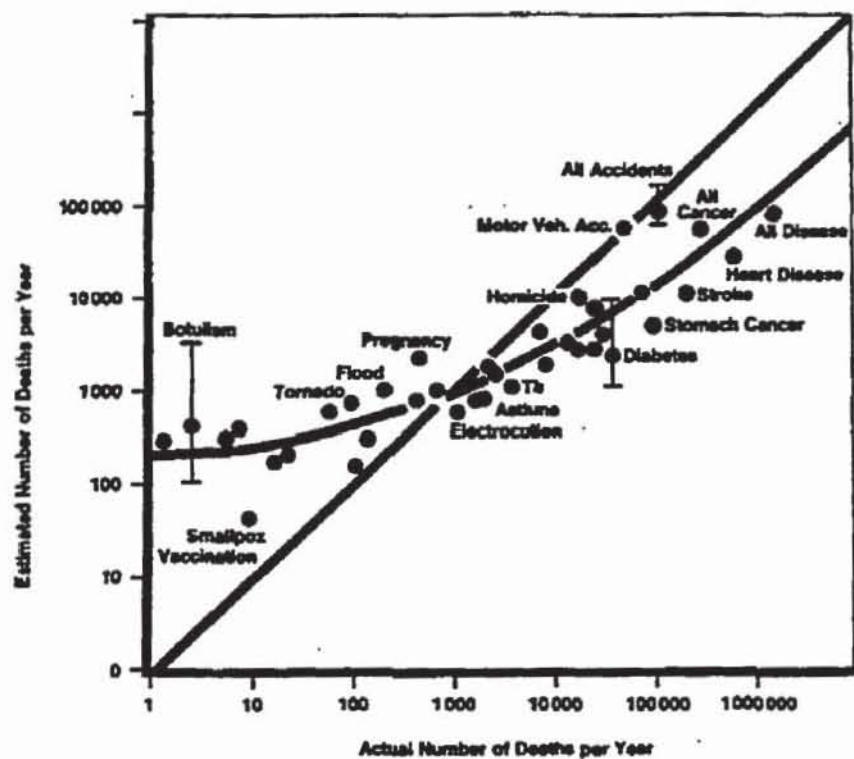


Fig. 2: The respondents' estimated number of losses for the various risk sources as compared with the statistically computed values. The top graph shows the results of an American, the bottom graph of a German poll.

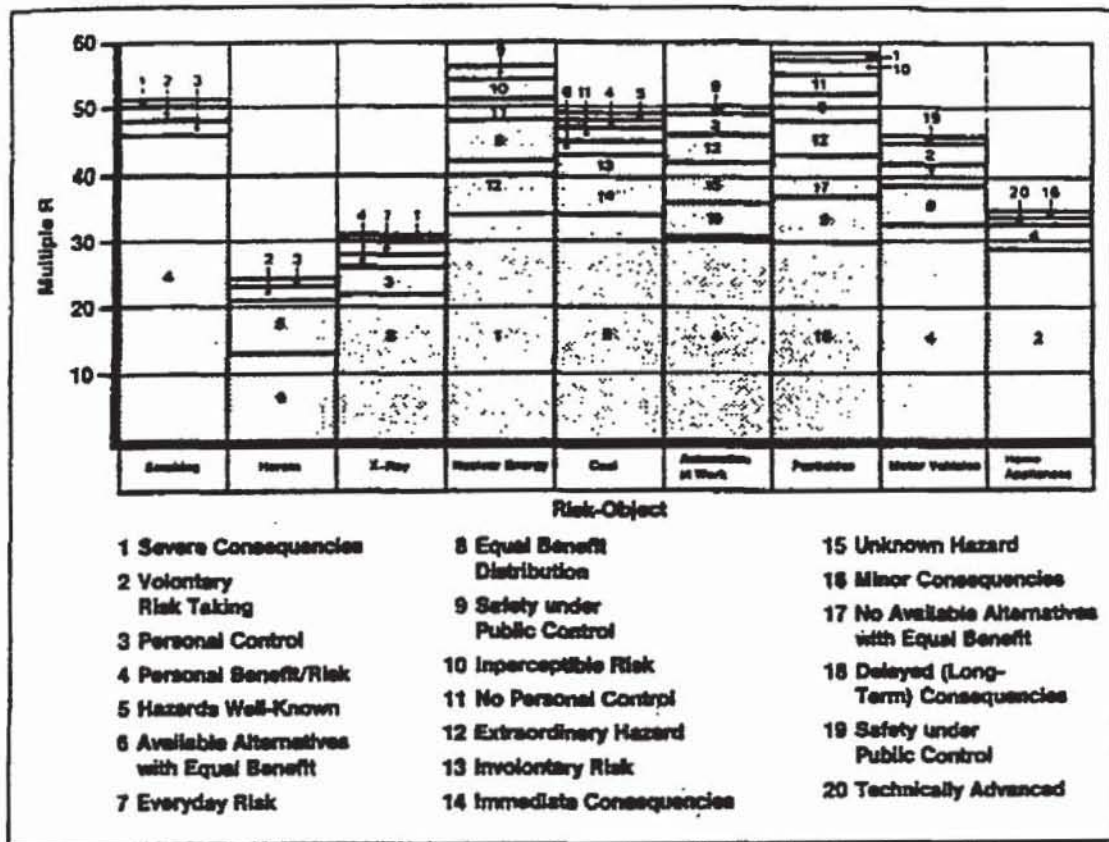


Fig. 3: The influence of qualitative risk and benefit characteristics on the general perception of risk and benefit from various risk sources (multiple correlation coefficient)

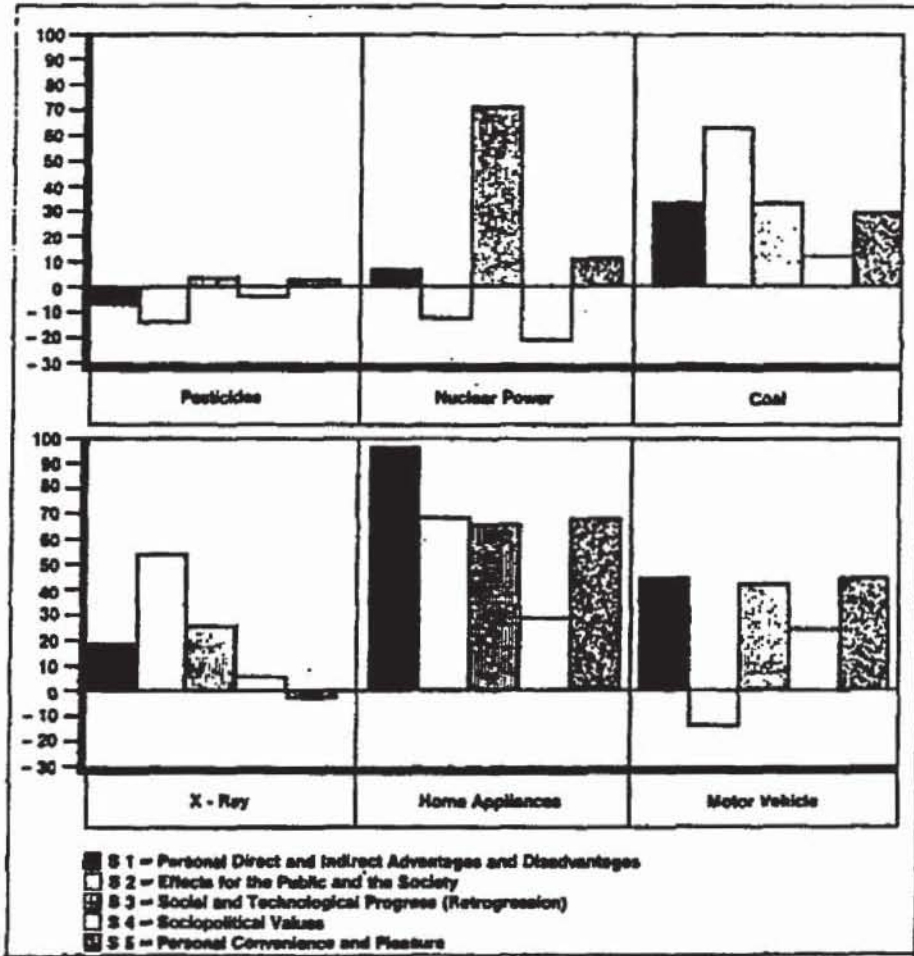


Fig. 4: Importance of five belief clusters with respect to estimates of the risks of various technologies

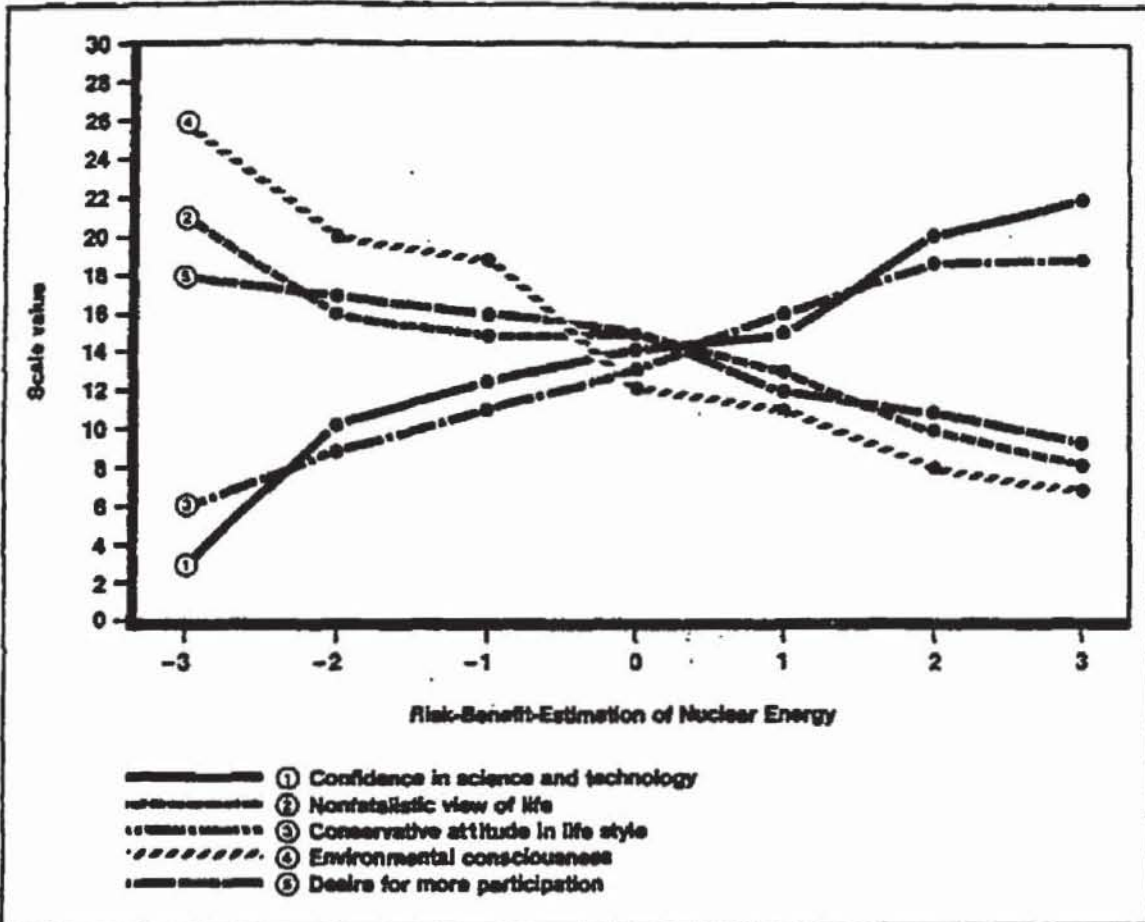


Fig. 5: The perceived risk-benefit-ratio of nuclear power as a function of five sociopolitical attitudes (x-axis: degree of risk-benefit ratio, y-axis: strength of attitude)

Table 1. Classification of risk perception studies.

Research Scope	Short Description	General Assumption	Application for Risk Perception
Decision Theory	Matching the decision process with normative model of rational reasoning	Maximizing utility of individuals or groups	Investigating the discrepancies between normative risk assessment and intuitive perception
Psychological Decision Theory	Analysis of the individual decision making process	Existence of typical sequential structures to make judgments under uncertainty	Investigating the cognitive structure of the risk perception process
Social-Psychological Theory	Analysis of the social environment as a determinant for the decision making process	Dominance of social influence factors in perceiving and evaluating risks	Investigating the influence of value commitments, social judgment and communication processes on the individual decisionmaking process
Sociological Theory	Effects and implications of social interrelations between groups and institutions on collective decisionmaking	Risk taking as an element of social exchange regarding resources and power	Investigating the interests and social positions which impose specific risk perception procedures