RESULTS OF A COMPARATIVE SURVEY ON THE PSYCHOLOGICAL PERCEPTION OF TECHNOLOGY AND RISK

O. Renn and Chr. Schlupp

Programme Group Nuclear Energy and Environment, Nuclear Research Centre, Jülich, Federal Republic of Germany

ABSTRACT

Our survey was aimed to combine two methodological approaches (object perception and attitude theory of the Institut of Perceptronics in Oregon and the IAEA Risk Assessment Group in Vienna to analyse risk perception and develop a methodology of measuring attitudes toward technologies. The results of psycological experiments in the field of isolating relevant factors of intuitive risk assessment as well as demographic surveys of the belief structure on risk surces and in particular on energy systems can be presented in such a way that direct comparison with the data of the IAEA and oregon studies is possible.

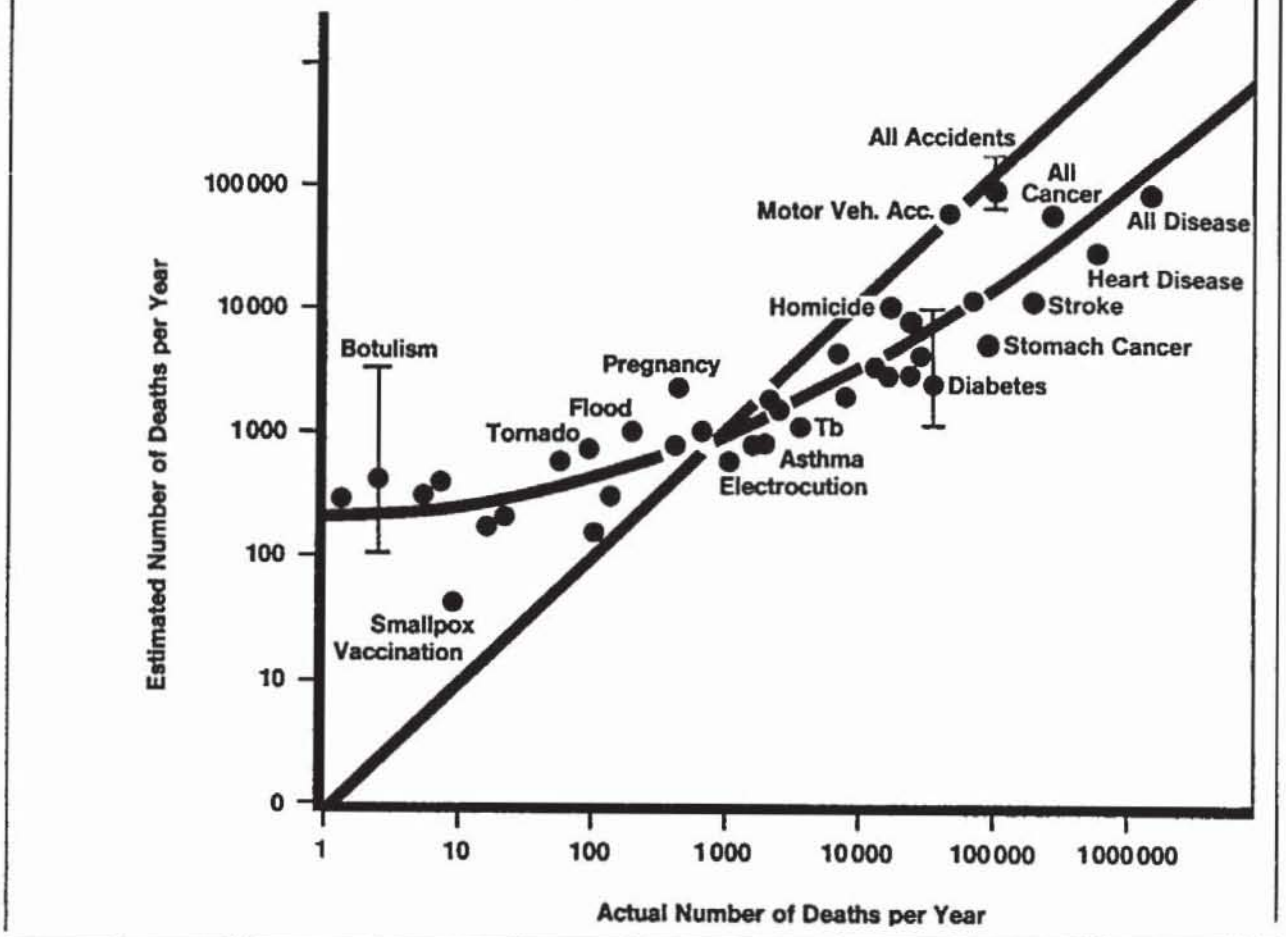
KEYWORDS

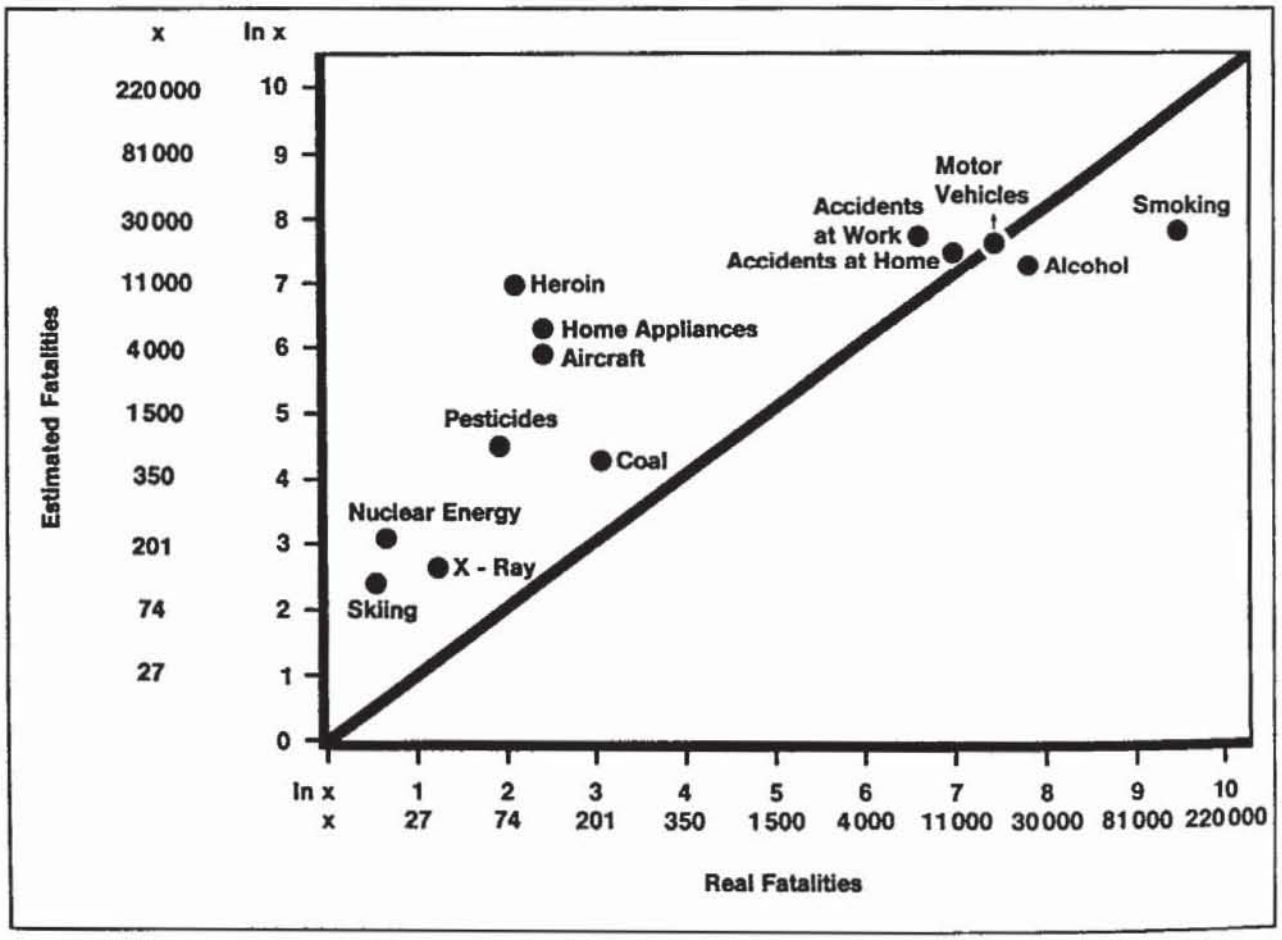
Perception of Risk, Risk Acceptance, Attitude Theory, Cognitive Psychology.

INTRODUCTION

From time immemorial, the relationsship between man and technology has been fraught with tension: using instruments, man has been able to refine and perfect his non-specialized organic nature in any direction he chooses. Using technology, he can move faster, see, smell und hear better than any other animal; he can provide himself with food in larger amounts and with greater speed, he can protect himself more effectively from dangers and natural risks, extend his life to its biological limits and ensure the intensive propagation of his species. However, there is a price to be paid for this progress. Increasing specialization and differentiation within a society mean that social structures become impersonal and incomprehensibly complex. Technological systems become ever more perfect and ever more enormous, increasing the risk for man. Increasing production efforts lead to increasing pressures on the environment which could result in the destruction of the basis of life itself. Not least, it must be borne in mind that technology is also capable of increasing the negative developments in human society: the more efficient the technology, the larger is the possible extent of disasters occurring in the event of aggressive outbursts, whether in the form of crime, terrorism, civil war or international strife.

Fig. 1/2: The difference between perceived and real fatalities
(US data upper figure, German data lower figure)





This ambivalence in technology is without doubt an objective phenomenon. Many societies have consciously decided against stepping up technological progress, because the social dynamics linked to the development of new instruments would have threatened the static relationships within the society.

In the 19th century, technological progress was synonymous with overcoming inflexible hierarchies and postfeudal power structures. Until ten years ago, the development of science and technology was considered to be one of society's most urgent tasks, connected with a high positive rank and a progressive image. However, within a short time, the problems of large-scale technological plants, an increasing awareness of research and technology in major fields, such as cancer research, unemployment problems caused by rationalization and saturation phenomena in the consumer sector have set in motion a process of re-interpretation, which has placed the ambivalence of technology squarely in the forefront of perception. The drawing up of "counter-technologies", of the soft or alternative energy style, have played a large part in fuelling the increasingly critical debate as to the consequences of technology and its specific effects on the environment and society.

It is for this reason that risk estimation by the general public and by specific groups of the public is invested with more than merely academic significance. The general value concepts and the specific risk assessment criteria among the public provide important reference points for rational political action in a democratic society, reference points which ensure both legitimacy and expertise in decision-making. So far, a paradoxical situation seems to be arising in the political and social debate on energy systems (in particular in the case of nuclear power), in that probabilistic risk analysis award a particularly low risk status to those technologies which are intuitively perceived as being especially high risks by the general public. Here, we are forced to consider the question as to which criteria are acutally used by man to assess risks.

As a response to this criticism scientific risk analysis has been promoted in the last years, to give aid to the decision making bodies for the evaluation of technologies. But more important than this is the question how people and relevant groups in society perceive risky situation and the consequences of modern technologies.

Intuitive Risk Perception

Since the general public assesses a risk in a different manner from the risk theoreticians, who work on the basis of scientific risk definition, any of the three causes below may apply:

- People are unaware of the results of risk analysis and construct their own intuitive risk assessments.

- People are aware of the results of risk analysis but do not believe them, preferring to trust their own intuitive convictions.

- People are aware of the results and believe the expert estimations; however, they do not evaluate this information as providing decisive criteria for their own risk assessment process.

So which of the three explanations is correct? Figs. 1 and 2 help to answer this question. The graphs show the results of an American and a German survey. A random sample of several hundred people were asked to estimate the risks involved in various hazard sources, from smoking to nulcear power stations, in terms of losses per year. The estimated values are plotted on the y-axis and the actual statistical

figures on the x-axis. It is possible to see at first glance that the estimated loss figures and the statistically determined "actual values" are relatively close together. There is a general trend, both in the USA and in Federal Republic of Germany, to slightly underestimate risks involving very high losses, and to slightly overestimate risks involving very low losses, i.e. in their perception of extreme values, people tend to gravitate towards the average. Nonetheless, the extent of agreement between estimated and actual values is surprisingly high. Therefore, the first premise, that people are merely misguided in their assessment, cannot apply. It is, however, interesting to note that the intuitive ability to determine the order of magnitude of risks disappears as soon as questions are asked relating to the number of lives lost during the span of a lifetime. Either all risk sources are graded almost uniformly (all disaster losses being approximately 3,000), or exorbitant estimates are made, for example, an average of 22,000 deaths for narcotics, 4,000 deaths in skiing accidents and as many as 600,000 deaths caused by nuclear power.

When making estimates for a normal year, experience and common sense can bring about a relatively good approcimation of the statistical values. However, when questions are related to disasters which can be expected over 80 to 100 years, these two intuitive evaluation processes will not function, since the extent of catastrophes cannot be drawn directly from a person's own experience. Could it be, there, that fear of disasters is the decisive motive behind the evaluation of risks?

This natural hypotheses does not apply eihter. Table 1 shows the degree of correlation between the two loss estimates (normal year, disastrous year) and the risk evaluations estimated by the survey participants. The degree of correlation shows the extent to which two values are interconnected. The closer the correlations value is to 1, the stronger the connection between the two values concerned. The relationsship between "perceived loss rate" and "risk assessment" shows clearly that people do take account of the perceived loss rate when making risk assessment, but that this rate can only explain a very small part of this assessment. Therefore, there must be more important factors which people apply in the evaluation of risks.

Imagined Complaints as an Indicator for the Psychology of Risk Perception

Before investigating the type and quality of risk assessment independent of losses, results from another survey will be described. The average values of risk assessment obtained from three totally independent random samples from several areas in the Federal Republic of Germany have been collected. Although each sample involved only 100 or 500 people, so that one would expect the results to be widely distributed, the risk assessments for all three groups are almost identical. This is made all the more astonishing by the fact that the distributions within the individual groups are also small, meaning that most people give almost identical responses in the assessment of risks. Obviously, evaluation criteria exist which lead to a similar form of risk assessment in most members of society. It has already been demonstrated that this homogeneous response behaviour cannot be traced back to the perceived or actual average loss rate. It becomes even more important to find an answer to the question as to which factors in the process of intuitive risk evaluation are capable of causing such a similar perception of a risk.

In order to derive an insight into the forms of risk perception, a small sociopsychologcal experiment will be described which was carried out in the Nuclear Station in Jülich (KFA = Kernforschungsanlage Jülich.

Two randomly selected groups of test persons were requested by the director of the experiment to take part in a pharmaceutical trial. The participants were told the experiment was to test three different capsule coatings for possible unpleasant side effects. The director of the experiment claimed that the first capsule had a radioactive coating, the second a bacterial coating and the Third an acid coating, and that all three capsules would dissolve more quickly in the stomach than conventional materials. The participants were told that there was no health risk involved for any of the three capsules. In actual fact, the three capsules were three absolutely identical, commercially available vitamin tablets. The first group of test persons were allowed to select any one of the three capsules, the people in the second group being given one capsule each by the director of the experiment. After swallowing the capsules, the test persons had to complete a questionaire, giving information about any discomfort (stomach pains, feeling ill, etc.) which they underwent.

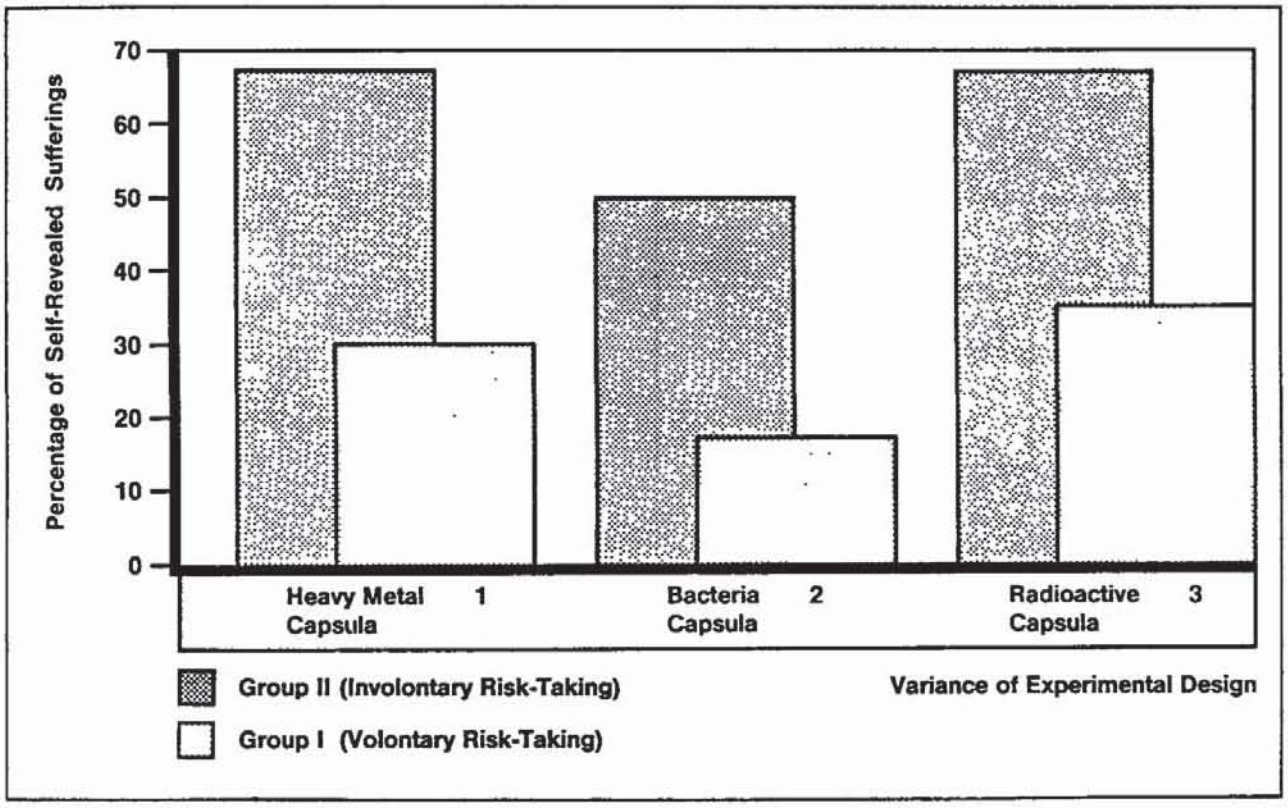


Fig. 3: The effect of volontary risk taking

The results of this experiment are given in Fig. 3. Although all the test persons had swallowed identical capsules, the people in Group, who had not been allowed to select a capsule, complained of feeling unwell twice as often, on average, as those people who had selected their capsules. This result was totally independent of which capsule coating had been chosen or had been administered in each case. It is interesting to note, in passing, the fact that the capsule which was said to be radioactive was the most frequent cause of discomfort in both groups. However, the important result obtained from this experiment is as follows:

The statement of an identical risk factor and the absence of an actual risk are not sufficient, in themselves, to overcome the subjective impression of a possible danger. An increased perception of danger can be expected if people feel that they have been "steamrollered" into taking a risk, i.e. that they have no freedom of choice in the matter.

The fact that voluntariness plays an important role in risk perception has long been a significant component of psychological risk and decision-making theory. However, this experiment provides the first empirical, unambiguous indication of this relationship. The American risk theorist, Ch. Starr, stressed the significance of these variables in a completely different way. He made a comparison of statistical loss rates from various risk sources and came to the conclusion that risks voluntarily accepted by society show a loss rate which is higher by a factor of 1,000 than risks which can be regarded as having being forced on people.

Voluntariness is just one example of a whole chain of variables which are independent of loss rates, and which are described as "qualitative risk/benefit features". Other features of this nature are "personal control possible", "external consequences conceivable", "danger not subject to sensory perception", etc. Surveys make it possible to roughly estimate the positions occupied by these characteristics in the perception and evaluation of a risk source. Figure 4 provides information on the proportion to which the individual qualitative features are involved in the explanation of risk assessment. The coefficient of correlation in each case, i.e. the strength of the connection, is plotted on the y-axis, the x-axis showing boxes with the individual characteristic classes for nine different risk sources.

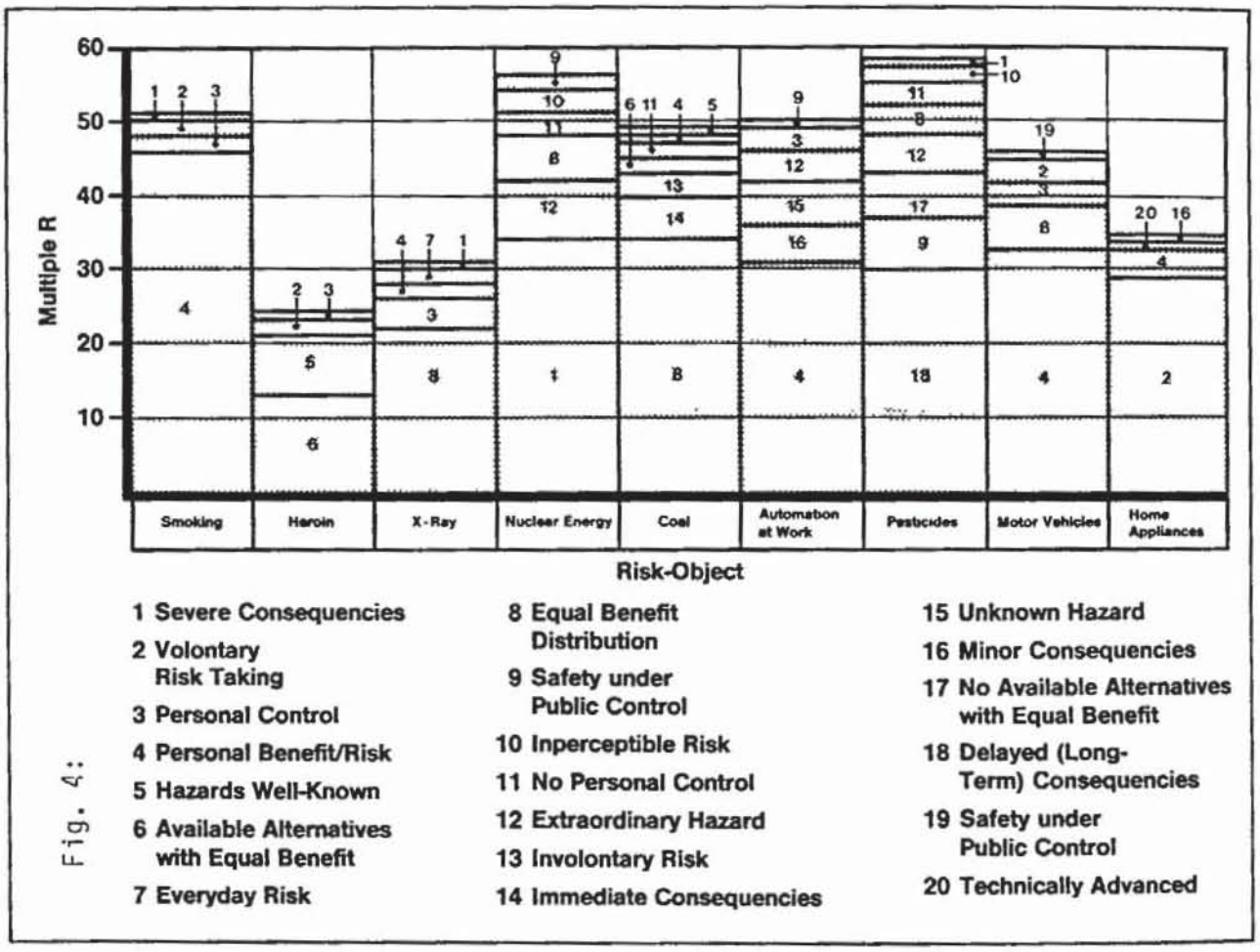


Fig. 4:

If one first considers only the primary factors, that is to say those features which have the greatest influence on risk evaluation, it is easy to see that, for the most part, benefit-related points of view are predominant. A person evaluates risks initially according to the possibilities and concomitant circumstances of the benefit application of the risk. In the case of nuclear power, pesticides and electrical appliances, the risk features are in the foreground. Although the voluntariness involved in the use of electrical appliances gives a positive weithting to the risk concerned, the dominance of the factor "catastrophic consequences pos-

sible" in the case of nuclear power, and of "possibility of long-term damage" in the case of pesticides, has a negative effect on perception of the risks involved here. This shows plainly that the statistical loss rates are not the decisive motive behind the scepticism with respect to nuclear power and pesticides.

Let us cross the national boundary again and take a look at the USA. Four risk characteristics taken from the German survey, were also assessed in an American study. It can be clearly proved that there is a uniformity in the response behaviour of German and American respondents, in the same way as occurred in the case of intuitive risk evaluation. With the exception of the valueas for car journeys and X-ray diagnosis, the average values for both countries are to be found in a small strip, at a distance of + 1 from the bisector of the angle (theoretical uniform distribution). This astonishing coincidence makes the assumption that qualitative risk characteristics can be regarded as psychological weighting criteria with universal application seem even more likely.

The Risk Source is More Important than the Extent of the Risk

The expected loss rates and the qualitative risk/benefit characteristics are two important value-classes used for personal risk evaluation. However, it is clearly demonstrated by the experiment with the capsule coatings that it is not only the abstract statement of the risk which must be regarded as the criterion for decision-making (the director of the experiment told the participants that the risk involved was identical for all the capsules), but, to a greater extent, the attitudes and opinions pertaining to the risk source. Thus, the radioactive capsule released the largest number of negative associations and, accordingly, caused the most frequently occuring "imagined" discomfort. In risk perception, people do not separate the extent of the risk from the object which causes the risk. It makes a difference to the observer whether the same risk is caused by a nuclear power station or by a skiing accident. The assessment of a risk is only thought out graphically if the individual is able to create a connection between his attitudes and opinions with respect to the object causing the risk. The extremely high risk associated with driving a private car is seen to be less great because the car owner connects a whole series of real and symbolic properties with his vehicle, and these cause a positive pre-weighting of the perceived risk. Conversely, the consumer eating his food associates a large number of threatening concepts with the use of pesticides which make him extremely sensitive to even the smallest danger. Attitudes and associations concerned with a risk source are, therefore, an important link in the chain of intuititve perception of risks.

Measuring people's attitudes to each risk source and tracing a typical pattern of perception causeslarge problems in empirical research. Large-scale experiments carried out by the "Risk Assessment Group" of the International Atomic Energy agency (Internationale Atomenergie-Behörde = IAEO) in Vienna showed that people classify their attitudes 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. Since energy systems only cover some of the possible risk sources, a further experiment was carried out at the KFA, Jülich, in the form of an intensive survey involving twelve different types of risk source. 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 devel-

oped 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 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 detriment, etc.)
- Effects on the conditions for coping with the future (maintaining output level, defence of liberty, ensuring supply level, etc.).

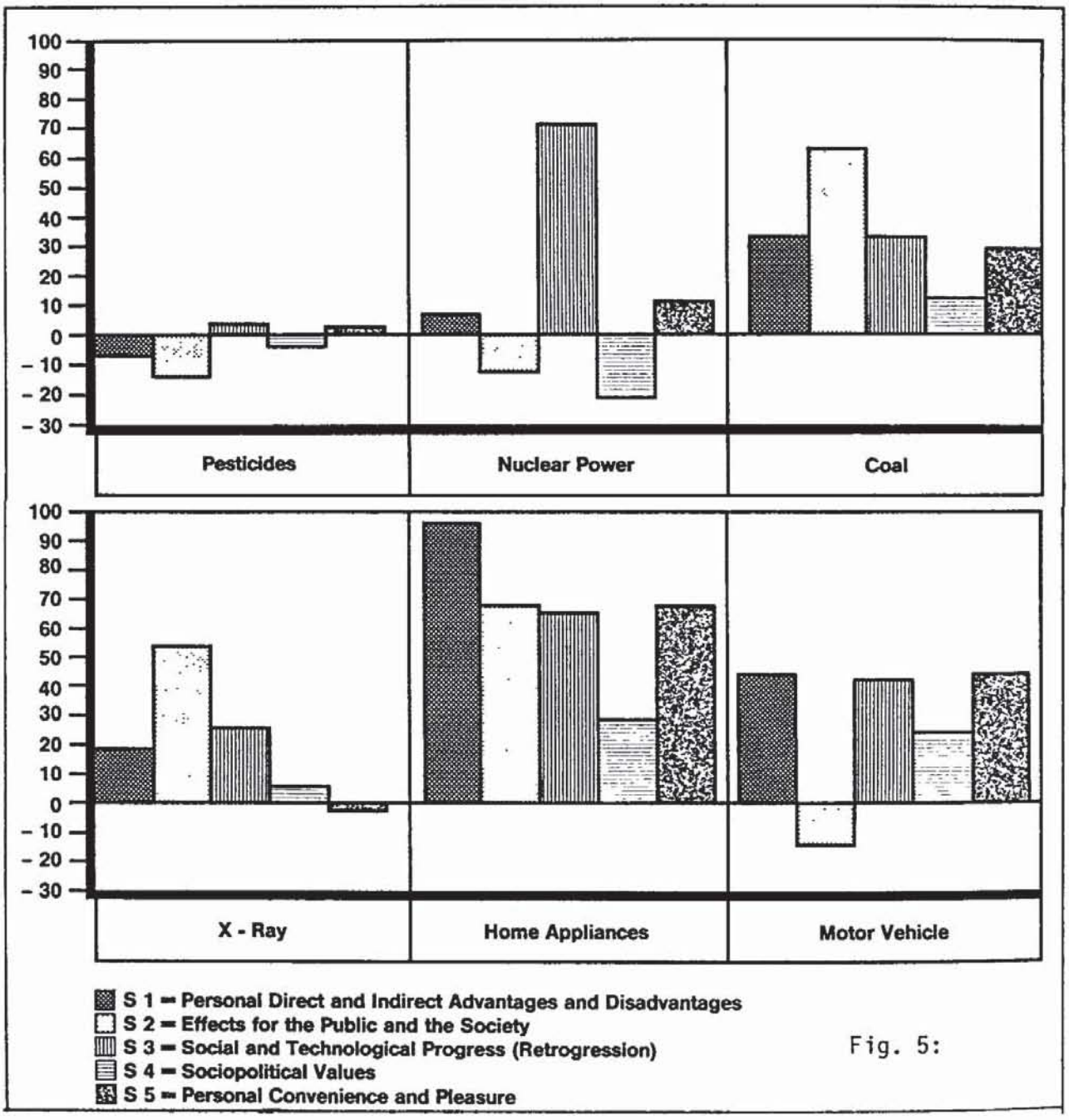


Fig. 5:

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. 5. 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.

A comparison of the bar diagrams for coal energy and nuclear power shows clearly why nuclear power has so many more acceptance problems than coal energy. The man in the street usually connects the use of nuclear energy with a negative influence on social welfare and on the realization of social values. On the other hand, however, the direct and indirect advantages of nuclear electric power for personal living standards are perceived only to a small extent. This negative Weighting can only be compensated by the belief in the future role of nuclear power for providing a solution to the ramaining energy problems. The hopes resting on the future necessity of nuclear power prevent a totally negative attitude to its use. In contrast to this situation, in the case of coal, only positive characteristics are mentioned, with the "general good" criterion having the highest value in this case. Thus, acceptance problems among the majority of people, at least, are not to be expected in the case of coal as an energy source.

The assessments with respect to pesticides are particularly ambivalent. While in the case of nuclear energy very negative aspects are competing with a few positive aspects, the values for pesticides are distributed around the zero level in a very small area. This preference for the zero range can be traced back less to an undecided ris evaluation on the part of the individuals, than to extreme differences between individuals, some of whom took very positive stands and some very negative. Thus, the average values in fact reflect a polarized range of opinions. In the case of the use of chemicals in the food chain a perception process stands out here whose characteristic phenomena more or less correspond to the situation in the case of nuclear power at the start of the public controversy in 1974. These investigations give those responsible in the fields of politics and economics the opportunity of avoiding in advance an escalation of the conflict and of taking the problem of chemical additives to the food cycle in hand at an early stage.

In contrast to the perception processes described above, Fig. 6 shows the attitudes with respect to cars, smoking and X-ray equipment. In accordance with expectations, smoking is linded to a negative assessment for society and welfare. On average, however, the perceived risks, in the form of health hazards, are superimposed on the personal advantages, such as enjoyment and relaxation. As has been shown in many studies on smoking, most smokers are aware of the dangers of their habit, but rationalize their nicotine dependence by ignoring or playing down the personal risk involved. this result was also demonstrated in the experiment being discussed here, since the direct effects on the individual himself were seen, on average (i.e. by smokers and non-smokers), as being only moderately negative in comparison to the general estimations.

In the case of attitudes to car journeys, it is interesting that the criterion "social welfare" did not show more positive values. Blocked roads, environmental pollution, accidents, etc. have sensitized people to such an extent that the negative effects of travel by private car assumes an important role in the field of perception. However, the wide range of the subjectively viewed direct and indirect advantages prevents a completely negative attitude and evaluation.

In the evaluation of X-ray equipment, it can once again be clearly seen that the radiation risk is also assessed in various ways, depending on whether a medical machine or a nuclear power station is involved. X-ray equipment received its most positive evaluation in the "social welfare" category, where nuclear energy came off particularly badly.

Rational versus Irrational Risk Perception - a Mistaken Starting-Point

If the determinants of intuitive risk perception are considered once again, three levels of influence, reflecting the evaluation of risks by the public to a great extent, stand out clearly. These are as follows:
- The perceived loss expectations,
- The qualitative risk and benefit features,
- The attitudes and opinions with respect to the risk source.

Certain personality characteristics could be added, such a risk propensity or attitude pattern to technical progress itself, for example. In particular general risk aversion attitudes and benefit orientation have a great impact an evaluating risk sources. One trend energies by analyzing the survey data. Individualizable stimulants like smoking or skiing are only classed as less acceptable if there is a conscious overall negative attitude to the risk. However, technological or industrialrisk meet with acceptance difficulties as soon as no actual positive attitude towards risk-taking is present.

It is only the interaction of these four influence variables which gives rise to that degree of intuitive risk evaluation which leads to relatively similar results between individuals and among different social classes. As a rule, when balancing risks, people tend to be fully aware of the appropriate statistically determined loss probabilities, even if they lack direct insight into the power of prediction of synthetic probability models. The statistically determined risk dimensions are not, however, the only criterion for risk evaluation. It is at this point, therefore, that the scientific definition of risk and its intuitive transformation differ. Whereas the experts limit their risk assessment to aspects of loss expectation in terms of time, for well-considered reasons, the layman processes this information together with considerations relating to risk-specific concomitant circumstances (such as voluntariness) and with ideas relating to the risk source in question. Thus, the layman's perception is more comprehensive and, accordingly, less precise.

The way in which test persons see the future of energy supply indicates, more clearly than a plain assessment of energy sources, their preferences for the different energy systems.

The forecasts on the energy structure of the FRG were asked in two ways: on the one hand, the test persons were asked to give a realistic estimate of the energy situation in the year 2000, on the other hand, they were to tell how it should look like according to their own wishes.

The result of this twofold question is given in the following figure. In the forecasts on the realistic evaluation of energy supply, the nuclear power takes undoubtedly the first place, but in the answer to the question about people's personal wishes, solar energy takes quite as clearly the first place. It should be mentioned in this context that the situation is then almost diamenteically opposed the foremost in one answer is at the same time the hindmost in the other answer.

The inversion of the order of the questions about people's personal wishes and the options they consider to be realistic, opens a gap between the ideas they have on what they would like their future to be and their expectation of what it will be one day.

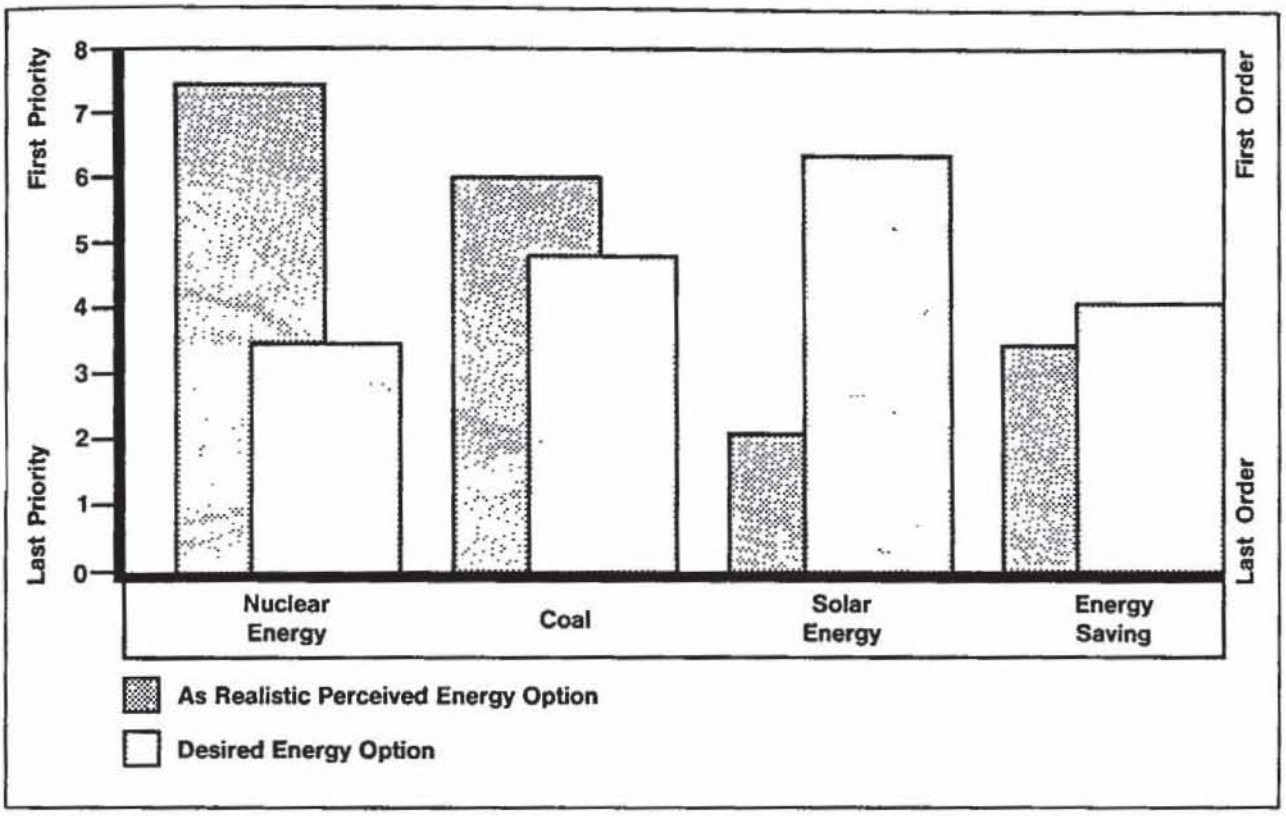


Fig. 6: The difference between the disired and perceived energy future

To be able to assess the sphere of influence of people's general social attitudes, we used in our empirical surveys 5 scales to measure similar attitudes which have shown, either in theoretical or in empirical studies, to be important for people's attitude towards nuclear energy

- a scale for environment consciousness
- a scale for confidence in science politics and technology
- a scale for conservatism
- a scale for participation
- a scale for political apathy.

By putting the results into a broader context, it was stated that there is a close relationship between the coefficients on the scale for general attitude and the ones on the scale for one's concrete opinion on nuclear power.

As the 5 scales are related to one another in context, it seemed suitable to estimate their influence on the general attitude towards nuclear power.
For this purpose, we used a multiple regression analysis, a statistical procedure in which the additional significance of several independent variables is used to find out the variance of the dependent variables. The following table summarizes these results.

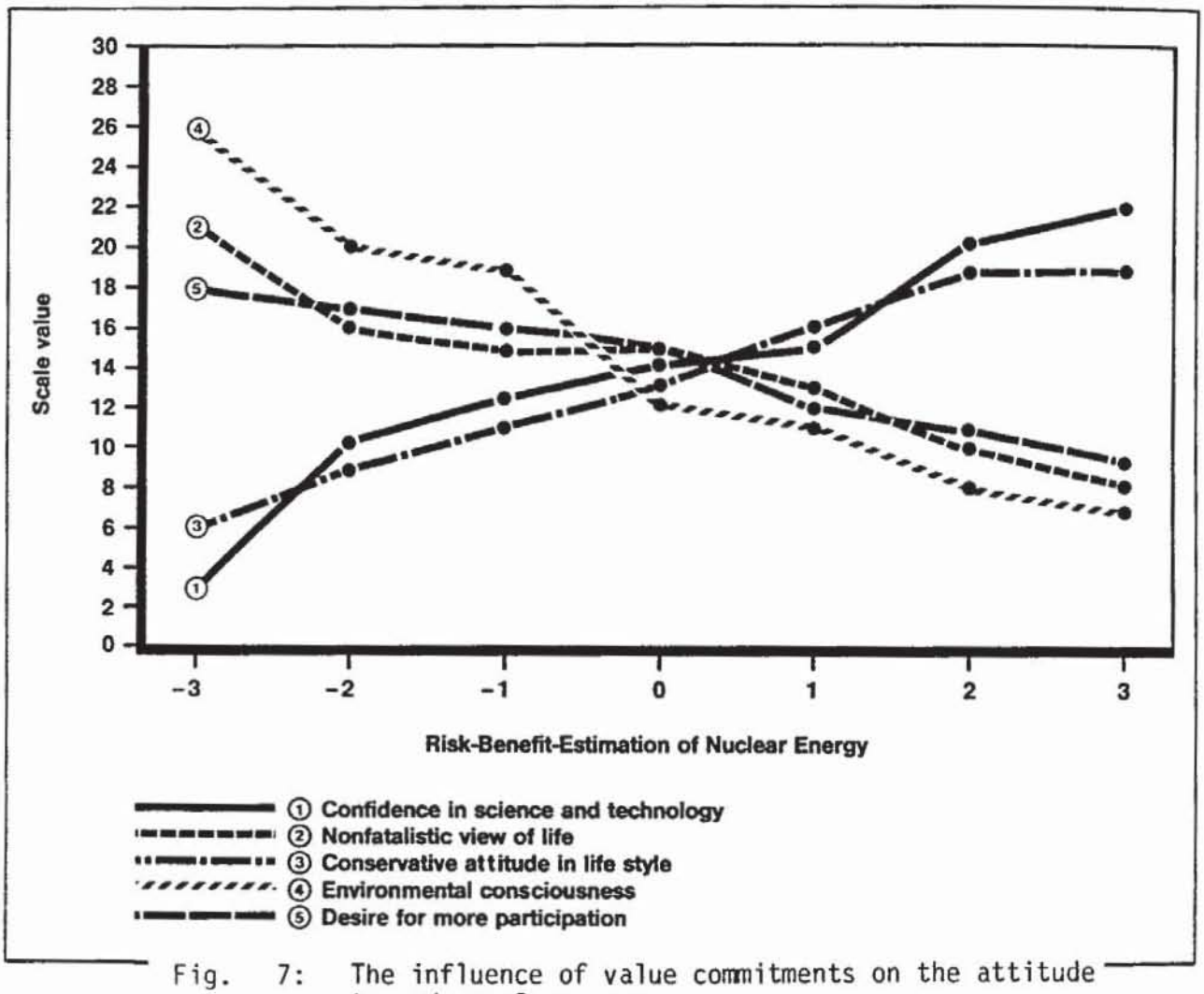


Fig. 7: The influence of value commitments on the attitude towards nuclear energy

It appears that nearly 40 % of the variance of the pattern of perception can be explained by the combined effect of the 5 scales. In this context, confidence in science and technology and the intensity of environment consciousness play a most important role.

The wish for participation usually leads to a still more negative opinion on nuclear power.

The high level of the correlation coefficients confines the conjecture that general sociopolitical attitudes play a role in people's perception of nuclear power. High correlation coefficients of the cost/benefit estimate correlate this acknowledgement.

All five realtionships with these variables are given in the following figure. Little confidence in science and technology, together with a high priority given to the protection of environment already mean a negative opinion on the risk of nuclear power.

Vice versa, conficence in scienca and technology and little environment consciousness rather lead to positive expectations regarding people's attitudes towards nuclear power.

Despite these convincing results, there remains a 60 % partion of unexplained variance.

The results of the survey prove the importance of social orientation towards given values and of similar patterns of opinions for adopting a certain attitude towards nuclear power.

At the same time, they contradict the modern hypothesis that people's attitudes towards nuclear power are but the product of fidelity to given values and general sociopolitical orientation patterns.

What is there to be learned from these survey results? 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 technolgical calsulation of risk dimensions must doubtless be regarded as an improtant 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 "acceptablility" and/or "desirablitity" 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. What is necessary is an analysis of the concomitant circumstances and an assessment of the consequences for man and for society, so that peopl's fears and attitudes with respect to the effects of the risk sources they can see can be compared to the actual situation, any aberrations can be corrected or diverted in advance, and, finally, reproducible decisions, reflecting all levels of intuitive perception, can be made. Only when we have learned to take a serious view of the structure and development of the layman's view of risk and purposefully to treat and approach the factors governing intuitive perception, will it be possible to initiate a fruitful discussion between scientists, decision-makers and the public. If we cannot achieve this, and talk at cross-purposes, then the next acceptance crisis is already almost upon us. Scientists, social scientists and politicians must analyse jointly the risk of our modern civilization and must plumb all their depths so that man, technology and Nature can continue to live harmoniously togehter.

References

Fischhoff, B., P. Slovic, S. Lichtenstein, S. Read, B. Combs (1978). How Safe is Safe Enough? A Psychometric Study of Attitudes Towards Technological Risks and Benefits. Policy Sciences, 9, 127-152.

Ohe, W. v., K. M. Schmals, A. Melcok (1978). Risikoperzeption und Risikoakzeptanz. Soziologisches Institut der Universität München, Konradstrasse 6. Report for the German Nuclear Safety Commission (Gesellschaft für Reaktorsicherheit), SR 122. Munich, FRG.

Renn, O. (1981). Wahrnehmung und Akzeptanz technischer Risiken. Vol. I, II and III. Jül-Spez-97, Nuclear Research Centre, Jülich, FRG.

Renn, O. (1981). Man, Technology and Risk. A Study on Intuitive Risk Assessment and Attitudes towards Nuclear Energy. Jül-Spez-115, Nuclear Research Centre, Jülich, FRG.

Starr, Ch. (1976). General Philosophy of Risk-Benefit Analysis. In: H. Ashley, R.C. Reedman, C.H. Whipple (Ed.), Energy and the Environment: A Risk Benefit Approach, Pergamon Press, New York, pp. 1-30.

Thomas, K., D. Maurer, M. Fishbein, H. J. Otway, R. Hinkle, D. Simpson (1979). A Comparative Study of Public Beliefs About Five Energy Systems. WP-79-5, International Institute for Applied Systems Analysis. Laxenburg, Austria.