Technology, risk and public perception

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Zusammenfassung

Das Spektrum der psychologischen und soziologischen Arbeiten über die Wahrnehmung von Risiken aufzuzeigen, ist das Anliegen des vorliegenden Artikels.
Bislang orientieren sich die meisten Studien zu diesem Thema an drei unterschiedlichen methodischen Ansätzen:
- dem Modell universeller Wahrnehmungsfaktoren, wie Freiwilligkeit oder persönliche Kontrollmöglichkeit,
- dem Modell der Einstellungsbildung gegenüber riskanten Objekten,
- dem Modell der Ableitung von Wertorientierungen auf konkrete Risikoobjekte oder Situationen.

Auf der Basis dieser Ansätze entwickelten wir ein integratives Konzept, um die Wahrnehmungs-Muster bei einer Vielzahl von Risikoquellen zu erfassen. Unsere empirischen Untersuchungen weisen nach, daß die Bevölkerung zwar die statistisch errechneten Verlustraten von Risiken ungefähr kennt, sie aber diese nur als eine Einflußgröße unter vielen für die Einschätzung der Riskantheit von Objekten zugrundelegt. Auch die universellen Wahrnehmungs-Muster spielen eine wichtige Rolle bei der intuitiven Einschätzung von Risiken; die These aber, daß sie den Grad der empfundenen Riskantheit bestimmen, mußte zurückgewiesen werden. Von größerer Bedeutung sind die Vorstellungen und Assoziationen, die mit der Risikoquelle verbunden sind.

Technology, risk and public perception

Abstract

The scope of risk perception studies stemming from psychological or sociological research work has been discussed in detail.
Previous studies on risk perception have been based predominantly on three methodological concepts:
- the model of universal risk perception characteristics like voluntariness or personal control,
- the model of attitude formation in respect to risk sources,
- the model of value attributions to risky objects or situations.

On the basis of these concepts we developed an integrative approach to the measurement of perception patterns for a variety of risk sources. Our empirical results show that people in general are well informed about the expected losses of various risks, but that they use these figures only as one factor among others to judge riskiness. Also the universal risk characteristics that were investigated could be identified as influential factors, but the thesis was rejected that these characteristics determine the perceived degree of riskiness. More important was the overall belief structure regarding the source of the risk, thus combining risk-specific and object-specific variables. Value orientation and attitudinal system had only an indirect effect on risk perception.

Technologie, risque et perception du public

Résumé

Le spectre des études psychologiques et sociologiques sur la perception du risque fait l'objet d'une discussion détaillée.
Les études menées jusqu'à présent sur la perception du risque reposent pour l'essentiel, sur trois concepts méthodologiques:
- le modèle des facteurs universels de perception des risques, comme la spontanéité ou le contrôle personnel,
- le modèle de formation des attitudes par rapport aux sources de risques,
- le modèle d'attributions de valeurs aux objets ou aux situations aléatoires.

Sur la base de ces concepts, nous avons développé une approche intégrée pour mesurer les schémas de perception pour des sources de risques variées. Les résultats empiriques de ces recherches démontrent qu'en général, la population a une bonne connaissance de l'espérance des pertes associées aux divers risques, mais qu'elle n'utilise ces estimations que comme un facteur parmi d'autres pour évaluer les risques. De même, les facteurs universels de perceptions des risques qui ont été analysés se révèlent avoir une influence, mais la thèse selon laquelle ces facteurs détermineraient le degré perçu de risques n'est pas confirmée. Beaucoup plus importante semble être la structure d'ensemble des croyances concernant la source du risque, structure qui combine des variables spécifiques du risque et des variables spécifiques de l'objet. Les valeurs et le système d'attitudes n'ont que'un effet indirect sur la perception du risque.

1 Risk and technology in a sociological perspective

Since the beginning of the history of man technology has played a decisive mediating role between man and nature. Man succeeded in offsetting his, compared with those of other forms of life, inadequate motorial and sensorial capabilities by making use of technical instruments and thus alleviating the pressure of natural selection. Technology enabled man to broaden his receptiveness to various environmental conditions and to evade the danger of his biotic and abiotic environment by creating artificial biotopes. The significant proof of this escape from nature's mechanisms of selection is the increase of the average life expectancy.

Despite the undisputed advantages of technical development for improving man's chances of survival, technological innovations have always been controversial and the direction of technological progress towards a humane future cast in doubt. Not only at the present time, a period in which nuclear power stations, microprocessors and chemical plants are increasingly being perceived more as a threat than a blessing, has criticism of technology penetrated man's everyday awareness. Even the 19th century witnessed many forms of resistance to new technologies. Particularly impressive was the scientific debate concerning the introduction of the railway in which no agreement could be reached about the dangers to health posed by high-speed travel (which was in those days approx. 30 km/h). However, even the less dramatic changes such as the introduction of gas lamps induced opposition and uneasiness.

Although the history of resistance to technological innovations subsequently assumed an anecdotal character, these innovations nevertheless seem to be of importance to a basic appreciation of the relationship between man and technology. The fact that technology has the face of Janus and the assessment of its applications is always ambivalent, is nothing more than a trivial observation that holds true for all human activities. Of greater sociological interest is the question, why certain forms or characteristics of technology cause so much controversy and which social conditions result in changing attitudes to technological progress.

At this point it is appropriate to distinguish between two categories for the analysis of technically induced changes. Firstly, transformation of the social structure created and conditioned by technology, and, secondly, changes in the pattern of awareness induced by this process. As Otto L. Bettman [5] or James C. Whorton [23] were able to prove in their environmental studies at the beginning of the 20th century, the number of persons whose health was impaired by environmental pollution was without doubt higher than today. However, in times when pestilence, epidemics, and lack of hygiene still constituted primary risks to society and when the major concern was to satisfy physiological needs, the negative side-effects of pesticides or emissions from factory stacks were not topics of public discussion. The increasing awareness of environmental damage caused by the industrial society can, therefore, not primarily be considered to be the result of actual environmental endangerment, but as a process of perception. Perception, though, is only partially attributable to the inherent effects of technology and industry, but primarily to the change in the pattern of attitudes towards the environment, technology, and progress. Apart from the globalization of environmental pollution as a qualitatively new endangerment to mankind (in contrast to the local or regional environmental catastrophes that frequently occurred in history), other important factors pertain to the formation of an – in the meantime fully stabilized – environmental consciousness.

This new consciousness includes

- increasing interest in an undisturbed natural environment, which steadily grew as primary needs were met and risks due to natural causes reduced,
- changed patterns of values for interpreting social reality (e. g. percieved status of industrial production),
- changes in the structure of social values (e. g. precedence of quality of life over the standard of living),
- formation of a new cultural counterelite with emphasis on self-realization, affectionism and anti-technological resentiments [37].

These patterns of socio-cultural perception of technologies and their effects are the main factors that actually trigger the fear of or enthusiasm for technology and condition the reaction of certain sections of the population to new technologies.

In this respect, the rank and meaning of the concept of risk have also undergone significant change. Within the social context the term risk has a functional meaning for one's own behavior only if the future is perceived as something which can be mastered or at least predicted. Natural disasters, war, famine, and diseases will remain unavoidable events, caused by God, nature or fate, as long as man does not have or recognize the possibility of intervening with foresight. However, the more man was able to produce situations and structures in his artificial biotope for the purpose of restricting or gaining control over potential damage, the more important it became to him to deal with the consequences of his own actions. Thus, man arrived at the paradoxical situation in which his awareness of risks and the realization that he lives in a dangerous world grew as the objective risks of life declined – in this context the probability of suffering damage as a result of hazardous circumstances.

With the taming of the natural forces for productive purposes and the growth of the economic consumption

of goods it was possible to achieve a net profit in terms of safety with the aid of technological progress only by the fact that costly safety devices and behavioral adaptation largely prevent the danger potential from being released. It is, therefore, a feature of modern technology that the extent of potential damage increases while the probability of occurrence of a disaster is small. No matter whether we are dealing with dams, aircraft production, nuclear energy or chemical plants: they all have in common that accidents occur very rarely but can involve high losses when they do occur. This is not a feature peculiar to technology: Natural disasters also follow this pattern. Small earthquakes or minor floods occur much more frequently than major ones. And in analogy to this natural phenomenon the possibility of disasters has "deliberately" been included in the production process in order to achieve certain other objectives such as efficiency, energy density or risk minimization.

This feature again is not peculiar to modern technology: During the course of time, man has not only gained more freedom of action with the aid of technology, but technology has also forced certain patterns of behavior on him. With the transition from a nomade's to a settled farmer's life man achieved a higher degree of subsistence and improved physical protection; but farming also demanded more regular work, a fixed daily routine and normally a longer working day. Similar to the fact that the concept of risk entered the awareness of man only when the future was perceived as being something which can at least partially be mastered or calculated, man also first anticipated the possible restrictions that may result from the consequences of technology already applied after the future conditions of life were considered to be controllable.

Fears about society developing into a police and/or nuclear state reflect the societal risk awareness which is directed more towards the social impacts of technology rather than the health hazards involved.

In the area of tension between the objective facts and the subjective evaluation thereof, risk research today plays an important role. In its more technical and/or normative approach as "risk assessment" or "impact assessment" it is confronted with the task of collecting data relevant to decision-making, of developing techniques for evaluating the various technologies and offering decision aids for the political and economic sectors. In the field of risk perception and the *psychological* processing of risks, public attitudes towards risks and technology must be clarified, possible factors of threat or fear associated with technical risks researched, the alienation processes between man and his artificial environment investigated and adequate criteria for a human technology discussed. Furthermore, for the *political* control of our society it is necessary to analyze the cultural pressure among the proponents and opponents of different technological strategies and to develop possible methods of integration. Finally, *socio-philosophical* efforts will be required to reflect the direction of technological advancement, to determine the position of risks in modern life and to examine it for the future.

This article deals with the individual perception of risks in the field of technology. In the subjective processing of risk-related factors two levels are simultaneously reflected:

- the intuitive, psychic heuristics unconsciously controlling certain processes of perception,
- the social and cultural patterns which influence that which is perceived.

Both areas will be examined in the following chapters.

2 Risk perception: the basic concept

According to the psychological benefit theory, which serves as the focal point for studies on risk perception, the relationship between the expected benefit and loss determines the willingness to accept a risk source. This rationalist approach can be interpreted as a variant of the value-expectation-concept within the framework of the psychological theory [11].

Fundamentally studies on risk perception are based on the idea of a judging individual who subjectively weights the advantages against the disadvantages of a risk source, thus arriving at an overall judgement.

Which factors are considered in the relevant literature to be of decisive importance to the perception of risks? In order to answer this question, it is useful to break down the studies into two categories: firstly into research approaches that are strictly based on a universal criterion of risk perception and which classify specific associations with a risk source as being of less relevance (this would mainly apply to the studies conducted by the "Decision Research Group" in Oregon), and, secondly into research approaches that apart from the risk acquisition and assessment standards also include specific ideas of the particular risk source and the situation characterized thereby (e.g. flow of information, credibility of data etc.) in the analysis (this would mainly apply to the studies of Yale University, e.g. [9], of the Social Science Research Center of the University of Southern California, e.g. [35], the studies of the Risk Assessment Group of IAEA, e.g. [26], and the studies by the German Battelle Institute [1; 2]).

A look at the narrower approach in the analysis of risk perception reveals the following structures of intuitive assessment to be relevant:

- the expected losses (personal, for society),
- the disaster potential,

- situation-related risk properties (the so-called qualitative characteristics such as voluntariness, controllability, reversibility etc.),
- situation-related benefit properties (such as equal distribution of benefits and risks, exclusive benefit for only a few etc.),
- general benefit expectations.

If the concept is broadened to cover factors not specific to risks, this list must be supplemented by the following additional influential factors:

- associations and ideas pertaining to a certain risk source (the so-called belief-system),
- affects and emotions triggered by a risk source (the so-called evaluation-system),
- confidence in institutions providing information (such as approving authorities, science etc.),
- assessment of "risk management" (efficiency, profit orientation etc.),
- general value orientation which influences the weighting of risk-related criteria or the credibility of the relevant institutions,
- personal and social properties and characteristics.

3 Expected losses: the difference between risk assessment and risk perception

In the risk theory in the fields of insurance and natural science the distribution of expected values for the negative consequences of a technological failure or an abnormal activity over time has the same meaning as the term risk. Risk sources are assessed according to the number of losses per time unit that can be expected and are calculated on the basis of experience or hypothetical computations. The question, therefore, is whether

- people know the statistical expected values and use them as a basis for their risk assessment, or whether
- they know the statistical expected values but do not use them as a basis for their risk assessment, or whether
- they do not know the statistical values and estimate the "expected values" intuitively using them for their risk assessment.

It is not possible to state categorically which of the three hypotheses applies, for a comparison of the statistical expected values and the estimated values of the public depends on the selection of the risk sources and on the type of operationalization of expected values. When risks such as "data banks" and "open front-doors" are included in the spectrum of sources studied (e.g. [31] p. 243), it becomes evident that the perceived statistical losses (fatalities, injuries or financial losses) have a much lesser effect on the public's estimated risk values than is the case with the risk sources and automobile driving and overweight (see [35], p. 23). An equally important factor is whether the expected loss values have been defined as "individual probability of one's own involvement", as the "average losses per year for the reference society" (e.g. USA or FRG), or as "losses per one million people".

However, one central finding is nevertheless revealed by all present studies: with regard to known risk sources the estimated losses per year for the total society correlate remarkably well with the statistically computed values. In Figure 1 the results are shown of an American ([8] p. 37) and a German ([20] p. 244) poll on the estimated number of losses due to various risk sources. A random sample of persons was asked to estimate the average losses/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 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.

Turning from the finding that risk levels and their probability in an average year are perceived relatively correctly by the public, the question immediately arises as to whether these parameters also determine the subjective evaluation of risks. And here a surprising result is obtained. In almost every case, analyses correlating intuitive risk estimates and estimated losses reveal no relationship between the two. This result has been obtained by Slovic et al. for example who found a very low agreement between estimated risk level and risk evaluation [24]. Several studies on the acceptance of medical risks have reached the same conclusions [18]. Quite a few empirical investigations confirm this result that perceived risk levels represent only one, possibly low, factor influencing the estimation of risk. In the case of normal averages, the risk level estimates of experts and laymen are relatively homogenous. However, the experts consider these estimates to be a normative basis for accepting a decision, while laymen consider them to be only one weighting factor among many.

In order to explain this discrepancy the thesis has recently been advocated that the public by all means perceives the term risk as a combination of probability and the expected level of damage (which is in agreement with the technical definition of risk) but according to a more complex function than simply multiplying the two components. It is a well-known fact that the technical risk estimation is based on the same weighting for both components. This means that the same risk value is assigned to 1000 accidents per year involving one fatality as to one accident per year involving 1000 fatalities. However, since it is more difficult for society to

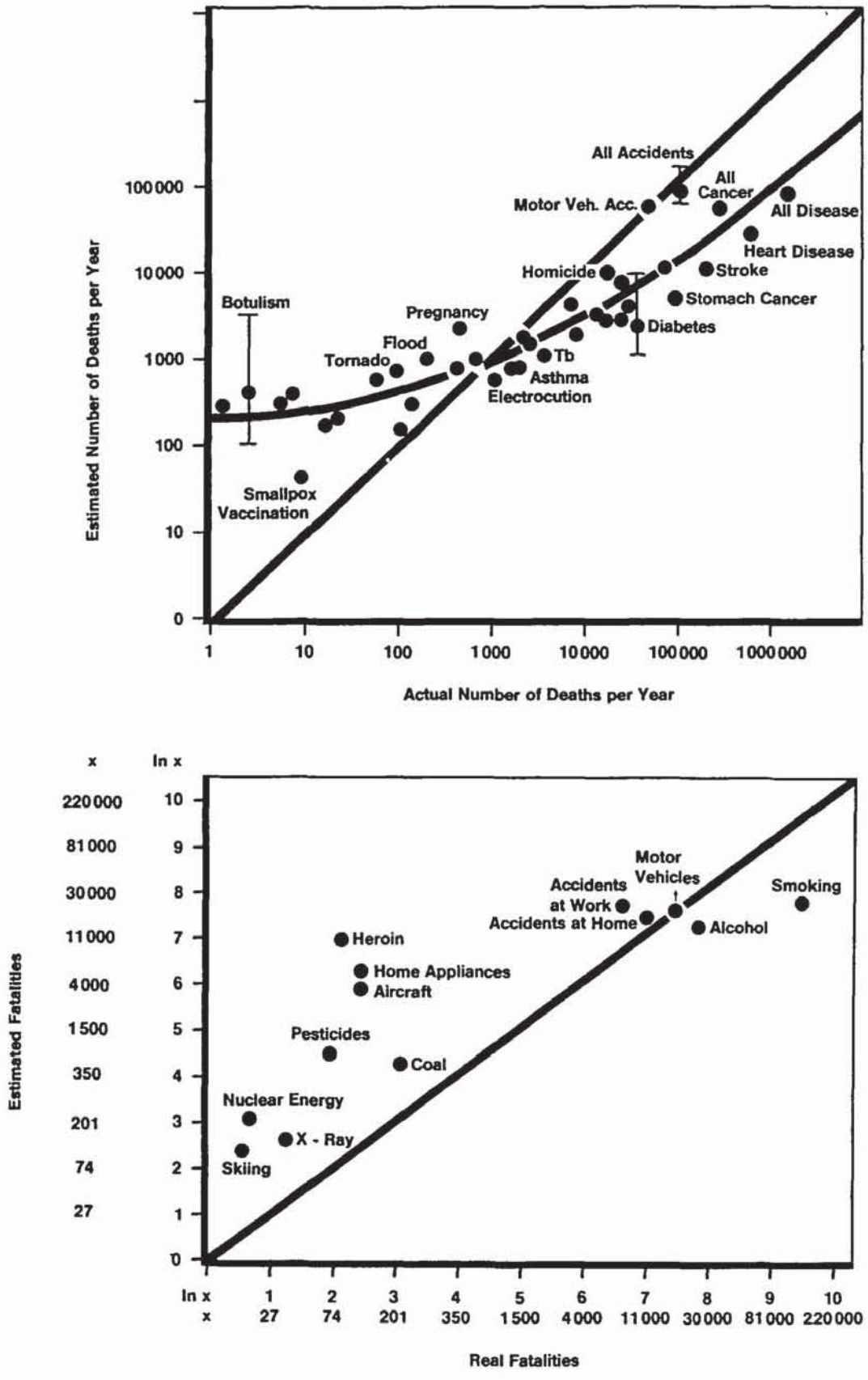

Figure 1: The respondents' estimated number of losses for the various risk sources as compared with the statistically computed values. The top graph shows the results of an American, the bottom graph of a German poll.

cope with single accidents with greater losses than a great number of minor accidents, the risk equation has to be given an exponent (alpha value) which assigns a higher risk value to rare but serious accidents than to frequent but less serious accidents [13].

Although it may be useful to try out new risk definitions for establishing political thresholds of acceptance, the chances of finding a clear-cut formula which best describes the public's perception of risk are low. The studies of the Decision Research Group (Oregon) showed that a clear relationship between disaster potential and risk assessment ([23] p. 36) existed only in the case of nuclear energy. The fact that the concern about disasters plays a role with quite a variety of risk sources was ascertained by von Winterfeldt et al. in their polls carried out in the USA and the Federal Republic of Germany. Yet the number of perceived fatalities and injuries was irrelevant for the estimation of the degree of riskiness [35].

Our own empirical studies propose a further conclusion: the intuitive ability to determine the dimension of risks is lost as soon as the highest conceivable losses within a lifetime are to be determined. Either all risk sources are almost equally rated (all with approx. 3 000 fatalities for a disaster) or exorbitant values are estimated, e. g. an average of 22 000 fatalities for drugabuse, 4 000 fatalities for skiing accidents and even 600 000 fatalities for nuclear energy in a peculiarly disastrous year ([19] pp. 126).

The result of all empirical studies to date may be expressed as follows: in general, people are able to give relatively good estimates for average losses of known risk sources, but they have little idea about the distribution of these losses over a longer period of time, at least when these losses have not been processed journalistically or politically. Neither the average loss expectations nor the extent of the feared disaster determine, however, the degree of the perceived riskiness of risk sources.

4 Qualitative risk properties: the universal yardstick

Since expected losses/year are not good indicators of intuitive risk assessment, the circumstances of the risk situation and the beliefs about the characteristics of various sources of risk become more significant. In order to demonstrate the significance of qualitative risk properties, a psychological experiment was carried out at the Nuclear Research Centre at Jülich:

Two groups of subjects picked at random were invited by the experimenter to participate in an experiment to test pharmaceuticals. Its purpose allegedly was to test three different capsule coatings for possible negative side-effects. According to the experimenter, the first capsule had been given a radioactive coating, the second a coating containing bacteria, while the third had an acid coating. All three capsules, he said, would dissolve more quickly in the stomach than conventional materials, involving no health risks at all. In reality, all three capsules were filled with identical commercial vitamin pills. The first group was allowed to select any

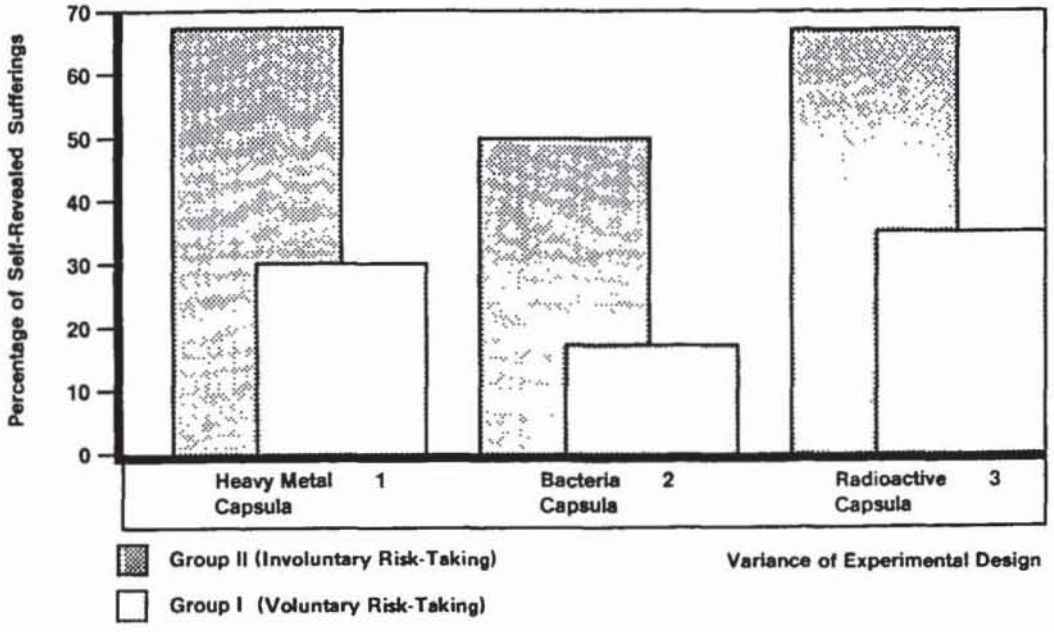

Figure 2: The results of the capsule experiment. Evidently the voluntary risk-taking resulted in a significantly lower number of complaints.

one of the three capsules, while the members of the second group were each given a capsule by the experimenter. After shallowing the capsules, the test subjects were requested to fill out a questionnaire in which they were to state any ill-effects (stomach pains, nausea etc.).

The result of this experiment is shown in Figure 2. Although all test subjects had swallowed an identical capsule, there were twice as many test subjects in group II (which was not allowed any choice) who stated that they felt some kind of ill-effect compared to those subjects who were free to select a capsule. The result was in no way related to the capsule taken voluntarily or involuntarily. In this connection it is interesting to note that the capsule which allegedly had a radioactive coating caused the most complaints in both groups.

The fact that freedom of choice constitutes an important factor in risk perception has for a long time been an essential element of psychological risk and decision theory ([19] p. 110 ff). The factor "freedom of choice" is a component of the so-called qualitative risk properties. Qualitative risk properties are universal assessment yardsticks which irrespective of the type of risk source are used as criteria for rating risks. They serve as initial points of orientation for estimating new and still unfamiliar risk sources both quickly and reliably. The extent to which such characteristics play a decisive role for all risk sources, is still the subject of controversy. However, it is safe to say that similar assignment problems apply to whole risk clusters, indicating common "concerns" in risk perception.

The Decision Research Group (Oregon) has once again broken new ground in the empirical investigation of the thesis concerning the influence brought to bear by qualitative properties on risk assessment. In earlier studies, the most important properties were identified as "dread" and "technological risk". In more recent approaches using larger samples and a broader spectrum of risk sources, the risk researchers in Oregon were able to identify a third dimension regarding the intuitive assessment of risks. Apart from "dread" and "technological risk" (which they now define more abstractly as "unknown risk") the factor "societal versus personal risk-taking" comes into play ([24] p. 21 ff).

The two Dutch risk researchers Vlek and Stallen came to the conclusion that risk assessment is dependent upon the "size of a potential accident" and on the perceived "degree of organized safety". While the first dimension has an increasingly negative effect on the assessment of riskiness, the second dimension has neither a clear positive nor negative bearing on risk

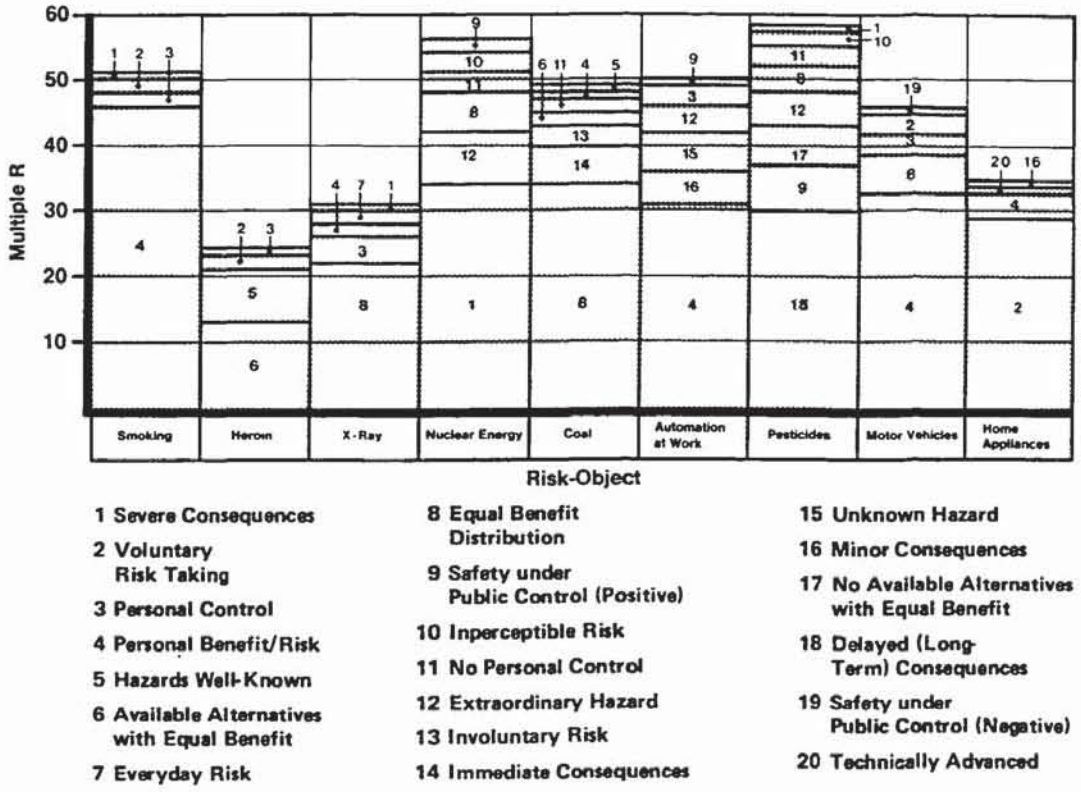

Figure 3: The influence of qualitative risk and benefit properties on the general perception of risk and benefit from various risk sources (multiple correlation coefficient)

assessment. Its effect with regard to safety-conveying aspects is positive, but it is negative in its remoteness regarding personal influence [31].

Our empirical work on the relevance of qualitative properties to risk assessment revealed further aspects pertaining to the value of the different qualitative properties (Figure 3). The individual property categories for 9 different risk sources are indicated by boxes on the x-axis while the respective correlation coefficients are presented on the y-axis.

When looking at the primary factors first, i.e. the properties that exercise the greatest influence on risk assessment, it became evident that the benefit-related aspects (factors 4, 6, 8 in Figure 3) are by far predominant. People evaluate risk in the first instance according to the possible benefits and accompanying circumstances, e.g. whether they will personally benefit, or whether everyone, or only a minority will profit, whether there are other alternatives which yield the same benefits but at a lesser risk.

The risk properties for nuclear energy, pesticides and home appliances are of particular significance. While factor 2 "voluntary risk-taking" is accompanied by a positive weighting of the risk involved for home appliances, the significance of factor 1 "severe consequences" regarding nuclear energy and factor 18 "delayed (long-term) consequences" regarding pesticides has a negative effect on risk perception. This shows quite clearly, that statistical losses are not the crucial motive behind the scepsis relating to nuclear energy and pesticides.

Despite its distinct influence, the value of the correlation coefficient does not indicate that the qualitative properties play a dominant role in intuitive risk assessment.

5 The structure of beliefs about risks

Expected losses and qualitative risk and/or benefit properties constitute two important categories of factors according to which people evaluate risk. However, even the capsule coating experiment revealed that not only the abstract risk indication (the experimenter confirmed equal riskiness for all capsules) is regarded as a criterion for decision-making but rather the ideas and attitudes about the risk source. The "radioactive" capsule thus triggered the most negative associations and therefore caused the most frequent psychosomatic complaints. With respect to risk perception people do not distinguish between the risk level and the object causing the risk. It is not immaterial to the observer whether the identical risk stems from a nuclear power station or from skiing: on the contrary, the risk cannot be fully apprehended until the individual is able to establish a relationship with his ideas and attitudes towards the object causing the risk.

Consequently, the universal assessment factors of risk perception only partially affect the perceived risk level. A different approach has therefore been tried in the research of risk perception which adopts the risk source as such as the key factor of risk perception and draws conclusions about the formation of risk assessment on the basis of associations and ideas (so-called beliefs) about the risk source. Although this so-called "risk attitude approach" has been developed in contrast to the "risk acceptance approach" it can also be interpreted without difficulty as a supplement to the present approaches.

In empirical research the measurement of people's beliefs about each risk source and the identification of typical patterns of perception pose a major problem. Extensive experiments conducted by the "Risk Assessment Group" of the International Atomic Energy Organization in Vienna arrive at the conclusion that people rate their beliefs according to the following criteria ([14] pp. 601–604):

Factor I: psychological risks

- means exposing myself to risk without my consent
- leads to accidents which affect large numbers of people at the same time
- means exposing myself to risk which I cannot control
- is a threat to mankind
- is risky.

Factor II: economic and technical benefits

- increases the standard of living
- increases economic development
- provides good economic value
- increases my nation's prestige
- leads to new forms of industrial development

Factor III: socio-political risks

- leads to rigorous physical security measures
- produces noxious waste products
- leads to the diffusion of knowledge that facilitates the construction of weapons by additional countries
- leads to dependency on small groups of highly specialised experts
- leads to transporting dangerous substances

Factor IV: environmental and physical risks

- does exhaust our natural resources
- increases occupational accidents
- leads to water pollution
- leads to air pollution
- makes economically dependent upon other countries
- leads to a long-term modification of the climate.

Since these factors had been derived from energy risk sources solely, our research group carried out a detailed survey to identify the most important beliefs concerning the consequences of various risk sources. With the aid of a series of statistical methods, the basic patterns of the investigated beliefs were developed (factor analysis) and rendered comparable by aggregation. This evaluation produced a pattern of attributes and thus a rating of risk sources according to the following five aspects:

S1: extent to which a person is directly affected (personal benefits, injuries, comfort, personal well-being, personal freedom, etc.),
S2: effects on economic and social welfare (labor market, social equilibrium, general standard of living, quality of life, etc.),
S3: effects on future conditions (maintanance of economic levels, security of supplies, etc.),
S4: sociopolitical and social values (social justice, democratic rights, equality of distribution of benefits and injuries, etc.),
S5: effects on the person himself and his social environment (health, level of supplies, security etc.).

In order to obtain an overall view of the importance and relationship of the five criteria the average values for the individual factors have been compiled for six sources of risk (Figure 4). The bars extending below the zero line in this figure show negative estimations with respect to the risk under consideration, while those above show a corresponding positive evaluation. A comparison of the bar diagrams for coal and nuclear

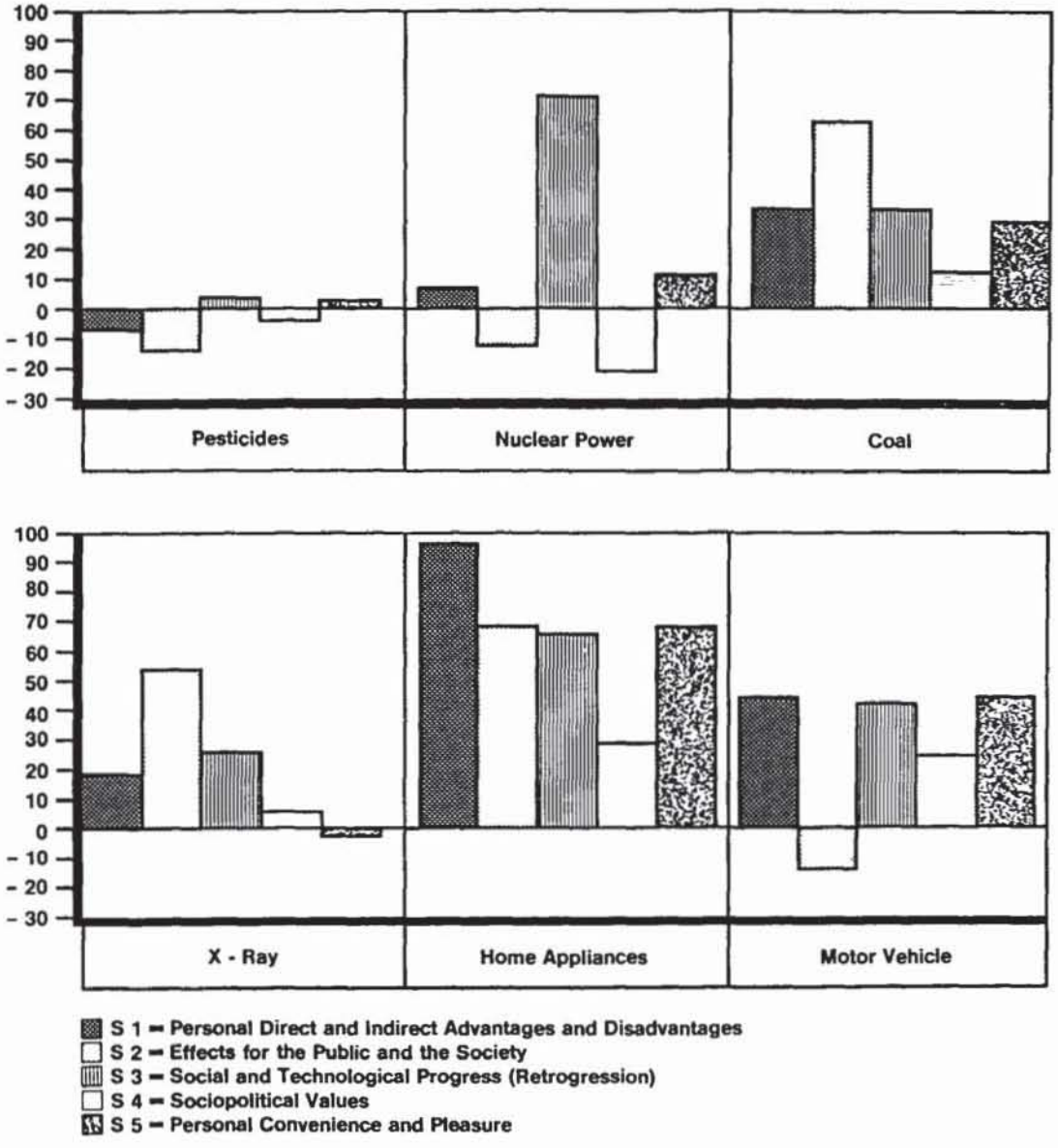

Figure 4: Importance of five belief factors with respect to estimates of the risks of various technologies

energy clearly reveals why nuclear energy suffers from more serious acceptance problems than coal. The public, on average, associates the utilization of nuclear energy with a negative effect on the social welfare and on the realization of social values. The direct and indirect advantages of nuclear power on one's own life, however, are less frequently perceived. The preponderance of the negative aspects can only be compensated by the belief in the future role of nuclear energy for solving the outstanding energy problems. The expectation of the future necessity of nuclear energy prevents a continuously negative attitude to nuclear power. In contrast to this, only positive attitudes are associated with coal and it is precisely the criterion public welfare which achieves the highest value. In other words, acceptance problems are not to be expected for the energy source coal, at least on the part of the majority of the population.

The attitude towards pesticides is particularly ambivalent. While with regard to nuclear energy, extremely negative attitudes compete with some positive aspects, the values for pesticides are distributed around the zero point. This preference for the zero category can be traced back to extreme differences among individuals who adopted partly extremely positive and partly very negative attitudes rather than to an undecided evaluation of the risk by the individuals. The mean values around zero reflect a strongly polarized spectrum of attitudes. With regard to chemical interventions in the food chain a perception process is clearly recognizable which resembles to some extent the nuclear energy situation at the beginning of the public controversy in 1974. These studies offer the political and economic decision-makers the opportunity to avoid, with foresight, an escalation of conflict and to cope well in advance with the problem of chemical additives in the food cycle (cf. [19] pp. 140).

6 Risk and emotions

No area is more subject to speculation than the linking of risk perception with emotionality and/or irrationality. There is no doubt that the area of emotional risk perception offers one of the essential categories of variables in the explanation of perception processes. The possibility of excessive speculation, however, has degraded this approach to a playground of self-appointed psychologists and moralists. Particularly in the dispute about nuclear energy, in which polarization effects have already resulted in a "them and us" confrontation, a raging battle is being fought with psychic stigmatization ([16] pp. 16, [12]).

It would be wrong, however, to throw out the baby with the bathwater. The fact that instinctive or subconscious mechanisms for processing information codetermine the direction of risk assesment and acceptance cannot be denied. However, it is precisely this area which shows a yawning gap: theories on the emotional and subconscious processing of risks which are empirically sound and thematically consistent have not yet been developed.

In fact, virtually no scientific studies exist on the subject of "emotionality and risk perception". At present there are, at the most, several publications on the controversial issue of nuclear energy that attempt to explain the mental reaction to nuclear energy on the basis of psychoanalysis or depth psychology.

In the early phase of the opposition to nuclear energy during the fifties several attempts were made to explain psychoanalytically the opposition to nuclear energy and large-scale technology. In this process mythological fears, the transfer from food intake and discharge to the contamination of food and radioactive waste as well as mechanisms of displacement of fear to cope with nuclear armament are problematized ([32] pp. 161). Most recently, Wünschmann took up these studies once again and applied Jung's archetype theory to the present dispute about solar and nuclear energy [37]. Wünschmann attributes the major causes of the acceptance crisis surrounding nuclear energy to the psychic subconscious mechanisms for coping with the environment. In this connection he proceeds from the following hypothetical variables of influence ([37] p. 25).

Individual consciousness

- embodiment of civilization which forces man into servitude,
- isolation and alienation from nature,
- cultural and metaphysical uprootal,
- suppression of feelings and intellectual isolation,
- lobby, capitalist exploitation,
- dissatisfaction and frustration in occupational life,
- fear of a world based purely on intellect and will,
- uneasiness and distrust vis-à-vis a confusing bureaucracy;

Collective subconsciousness

- archetypal punishment myth,
- paradise archetype,
- sun archetype,
- shade archetype.

When applying these influence factors to the controversy about nuclear energy, Wünschmann arrives at the conclusion that the bomb/power-station association, the perception of the atomic lobby as a monolythic block, the hope for a solar, riskless future and the rejection of anonymous, centralized institutions imply a subconscious opposition of man to nuclear energy.

A similar argument is presented by Tubiana [27, 28] who applies Freud's psychoanalytical categories to the conflict about nuclear energy. Tubiana proceeds from the assumption that human behaviour is mainly determined by dogmas, fear, tradition and myths. He identifies the latent fear of technology, cult of nature, knowledge myth and the fear of adverse environmental conditions as specific mechanisms of displacement. He takes the view that these four mechanisms result in an emotional stress the energy of which is discharged on a symbolic object. Nuclear power stations as symbols of technology, human achievements and unfamiliar types of risk are predestined to be used as a target by irrational and subconscious criticism of difficulties encountered in daily life.

Pahner [15] and Pelicier ([17] pp. 198) have also tried to determine several psychic variables that may influence the attitude towards nuclear energy. In this connection, the opposition is associated with the transfer of personal conflicts to external scapegoats and with the compensation of disorientation no longer bearable in a society based on pluralist values. It goes to the credit of Schrenk also to have pointed out the psychic properties of the proponents of nuclear energy ([21] pp. 87). In particular, he has characterized the identification with technical plants as an ego-stabilizing orientation towards firmly established social structures.

7 Risk perception, value system and communicative context

With the discussion of the subconscious and emotional properties, which are supposed to have a bearing on risk perception, the spectrum of categories of variables was already extended to include factors of influence that do not relate to the quality of the risk or to the cognitive processing of information on risk sources but rather to their emotional perception. The external factors discussed in this connection open up a further level in the explanation of risk perception.

Firstly, it involves the influence of communication on risks and, linked with this, the dependence of one's own attitude formation on one's self-image, on the social structure of values and reference groups. Secondly, it involves social and personal traits which imply a certain reaction to risks. It is quite obvious that these external factors do not necessarily compete with the universalistic risk perception properties or the source-related attitudes but rather run parallel to or precede the majority of them.

When trying to fit these external factors in a social structure two dispositive and two situational properties seem to be important in this connection:

- the overall attitude pattern of an individual,
- the internalized value orientation,
- the influence of reference groups,
- the assessment of the interaction partner or the communicative situation (allocation of credibility, perception of the communicative context, e.g. advertisements or fly-sheets, etc.).

On a more general level all these effects can be traced back to psychic characteristics and properties as well as social and demographic structures.

A number of French studies proceed from the assumption that human behaviour is oriented almost exclusively to the basic direction of the entire attitudinal scope. In this connection, risk perception merely constitutes a by-product of the individual constellation of existing value orientation and attitudes [4]. However, the hypothesis of a deterministic relationship between attitudes in the socio-political field and the standpoint vis-à-vis innovations can hardly be sustained. Particularly the division among the ranks of the political parties caused by the nuclear energy issue and the deviation of this controversial question from the left-right split is sufficient proof of the fact that perception and acceptance of nuclear energy are not determined merely by pre-established assignment mechanisms.

The extent to which value orientation has a part to play is still the subject of controversy. In one of his earlier studies, S. van Buiren ([29] p. 250) presented a direct relationship between growth-oriented values with acceptance of nuclear energy and environmental-oriented values with non-acceptance of nuclear energy. In a Battelle study, dated 1977 [1], it was likewise emphasized that value orientation and attitudes towards specific risk sources (especially nuclear energy) are no longer clearly connected with each other. Similar results were achieved by the "Social Science Research Institute" at the University of Southern California in their comprehensive studies. Interviews with people having different attitudes towards energy systems produced a striking agreement in the weighting of general value orientation (such as health, securing of supplies, economic prosperity, etc.), but distinct differences in the assignment of these values to individual strategies of energy ([25] pp. 11).

In general, it seems to become evident 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.

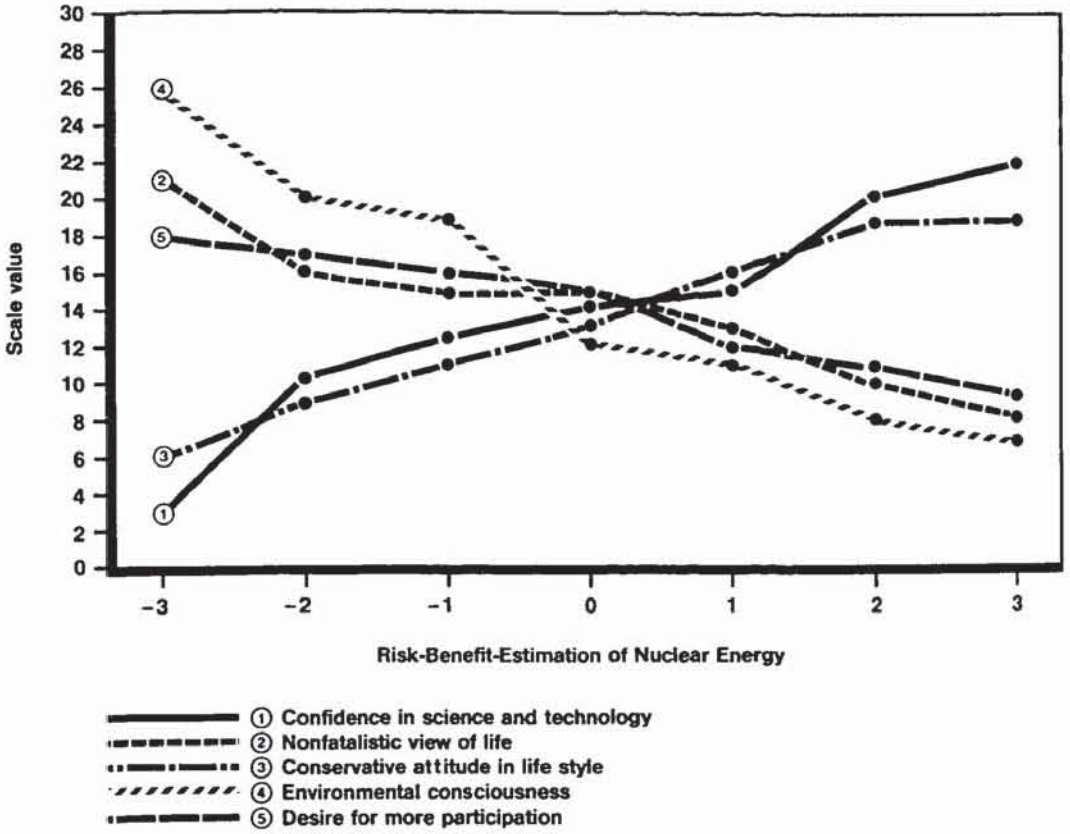

Figure 5: Risk-benefit estimation of nuclear energy as a function of five sociopolitical attitudes.
x-axis: degree of perceived riskiness y-axis: strength of attitude

With respect to nuclear energy a relationship between value orientation and risk assessment was also revealed in our studies. Even if general value orientation – similar to the studies carried out by the Social Science Research Group in Los Angeles – 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 ([20] p. 253). With regard to the perception of the nuclear energy risk we were able to show, for example, that the perceived risk level is particularly influenced by five socio-political attitudes (Figure 5). Low confidence in the 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 socio-political field and those towards nuclear energy.

Concerning other risk sources the relationship between value commitment and risk estimation is even weaker. Only large scale technologies play a role as discriminative factors of value orientation. Still the question remains whether specific value patterns influence the perception of technologies or the other way around. Thus we have to answer the question: Do we confuse cause with effect? For the decision to embark on an alternative way of life and to break away from industrial society by no means precedes the disapproving attitude towards large-scale technologies. On the contrary, the uneasiness about this risk source, the associations linked therewith and the effects they trigger pave the way for a comprehensive reorientation of one's own life. In this connection, certain objects, such as nuclear power stations, assume a symbolic power for the entire movement. The reason why precisely nuclear technology, and not refineries, hifi equipment or refrigerators, has been labelled unacceptable cannot be derived from value orientation alone. Perception-related mechanisms must play a role here that provide a basic reservoir of uneasiness for the value-related process movement via the arousing of scepticism, fear and a general feeling of crisis.

Closely linked with the problem of value orientation is the question of the potential of confidence in social institutions, decision-making bodies and science in general.

Here as well, the chain of effects of risk perception is shortened if the conflict regarding large-scale technologies is seen exclusively as the result of a lack of confidence in the ability of technical or political elites. Indeed, in almost all western industrialized countries an increasing remoteness between the people and their governmental institutions (cf. the survey by Becker et al. [3] p. 30–36) is recognizable. These also include technical and scientific institutions even if the loss of confidence in them remains fairly limited ([7] pp. 195). It would nevertheless be wrong to regard the diverging views held by scientists on the hazards of technical risk sources as the cause of the acceptance problem. The perceived contradictions between experts (and those who regard themselves as such) definitely increase the doubts about the safety of plants and lead to greater distrust in respect to the statements issued by the respective scientific institutions.

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, our empirical studies 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 applies to both proponents and opponents of nuclear energy ([9] pp. 289).

In addition to the credibility of information, the area of communications has also become a theme of social research. In a study on stereotype perception, C. Krebsbach and G. Eisenhart have examined the basis of the nuclear energy dialogue [6]. Proceeding from the concept of symbolic interactionism they have analyzed those structures resulting from the role and person of the interaction-partner as well as from the prestructured interpretation patterns of communicative and situative elements. According to both authors, sterotype expectations replace by and large the readiness to communicate and listen. As a result, they propose to talk about communication more on the metalevel, to determine the open-ended outcome of the discussion (i.e. not to listen to alibis), and to become aware of stereotype perception and reaction patterns.

Apart from direct communication by means of debates and public events, particularly the media have become a popular topic in the discussion of risk perception. Here as well the thesis is often held that biased reporting in the media is a decisive factor in distroted risk perception by the public. The few empirical studies that have been carried out on this subject do not confirm this thesis. An analysis on newspapers carried out by the Battelle Institute in 1978 reveals relatively balanced reporting on the advantages/disadvantages of nuclear energy [30]. The imbalance noted by the opponents to nuclear energy is, in all probability, primarily a product of selective information intake. However, according to some of the results of the Decision Research Group in Oregon the frequent reference to risk sources and/or accidents may influence the availability heuristic, with the result that with frequent reporting, the riskiness of a plant or activity is overrated ([22] pp. 165). So far, the question about the influence of the media has not been answered. In particular studies on the effect of information provided by electronic media are lacking.

When reviewing the literature on the external factors of risk perception it becomes evident that real schools have developed that regard value orientation, credibility of science, the loss of confidence in political institutions or media reporting to be the all-decisive and primary factors of influence. It has not been possible to date to confirm empirically any of these hypotheses. However, the extent to which they have a concrete bearing on the mechanisms of perception and to which they compete with other factors has not yet been clarified. The acceptance of technologies by the public is in itself neither seen as a political problem nor is it determined by values, interests and objectives. Although one has to resist the claim of absolutism regarding the restricted theories on universal risk perception factors, an exclusive concentration on values and interests also will lead us up a blind alley.

8 Conclusions

The discussion of the prerequisites and effects that determine the analysis of type, content and direction of risk perception and the investigation of the specific motives leading to positive or negative attitudes towards new technologies were the subject of this article.

When reducing the conflicts about risk sources to a common denominator, the dispute over the introduction of new risks may be interpreted as a reflection on the justifiability of social actions which, trusting in the

calculations of the degree of insecurity (probability) tolerate the possibility of far-reaching (and possibly devastating) consequences in order to strive for certain social objectives. These actions are linked with the hope or conviction that it will be possible to avoid the most improbable worst case with the aid of science and technology as well as social control. The question of justifiability touches on the following problem areas:

1. the significance and expressive power of probabilistic models for political decision-making,
2. the question of the degree to which benefits and damage may be collectivized (between individuals, over generations),
3. the optimal rules of selection for options with similar expected losses, but different composition with regard to probability and the extent of possible consequences,
4. the legitimacy of overt and latent objectives which guide the decision making process (values, attitudes),
5. the significance and credibility of scientific expertise,
6. the form and procedure of decision-making (issue of participation).

When looking once again at the most important results of empirical analyses of risk perception it becomes evident that these six problem areas touch on the focal aspects of risk source estimation. The individual level involved the absorption and processing of probabilistic information, the different judgements of disaster potentials, the benefit/damage distribution effects as well as personal controllability and familiarity with central patterns in the evaluation of risks. In addition, the confidence in science and technology, the decision-making mode as well as social values and attitude patterns play a significant role in the social and political debate.

The heterogenity of the opponents to innovations is due to the multidimensionality of risk perception. Opponents or proponents of different risk sources can differ in their basic value orientation (but need not), in their attribution of general values to specific objects, in the perception of probability as a guideline for acceptance, in their relationship to scientific expertise or in their trust in respect to political controlling or decision making agents. Last but not least, specific concern for qualitative characteristics (like voluntariness or personal control) plays a decisive role in explaining different results of perceiving any risk source among individuals or social groups.

What conclusions can be drawn from the results of perception research?

Primarily it should have become evident that the artificially constructed contrast between an allegedly rational expert judgement and an allegedly irrational layman judgement will miss the point and therefore obscure rather than explain the background to the present controversy about technology and risk.

The technical calculation of risk dimensions should undoubtedly be regarded as an integral part of any decision on risk sources and at the same time as an ideal tool for continously improving the population's safety. This point, however, is not a controversial issue among the public! To make such calculations the sole criterion of "acceptability" and/or "desirability" of technologies or other civilizational risk sources is in contradiction to the intuitive view of risk acceptance and is also unreasonable from a political and social standpoint.

When reflecting on the six levels that contribute to the creation of conflict during decision-making on the acceptance of risks, it becomes evident that all models of conflict solution based on technical information or PR concepts make little sense. What is required is a qualitative extension of the traditional judgement of technological consequences to an analysis of social options, which comprise not only technology or an alternative risk source, but also the social change with its target implications linked therewith. It is of decisive importance for the making of decisions on risk sources that the implementation of a risk source is linked with certain social objectives, ideas and possibly even conceptions of the world which will act as a motor for the envisaged social change. Therefore, it is absolutely necessary that the desired and feared effects be regarded not only as quantitative physical changes but also as reference points within a social context (e.g. atomic state, calory state or computer society).

Since the diverging views about the employment of risk sources range from basic philosophical viewpoints (such as the significance to be attached to probability statements) to symbolic and instrumental expectations a decision cannot, as experience has shown, be justified by a majority vote. This is so not only because of the many-sidedness and existential significance of risk-taking but also because of the decision-makers' loss of legitimacy – pervading the entire spectrum of political activities – and the increasing reluctance of the citizen simply to tolerate environmental changes.

Decisions must therefore be given a new basis of legitimacy. On the one hand, it would seem to be necessary to investigate the different levels of risk perception also with the aid of functionally diverging procedures of decision. On the other hand, it is important that the decision-making process becomes more democratic, i.e. that the parties involved are able to integrate their own preferences within the decision-making process.

The objective of a new decision-making process for risks aided by technology and civilization is self-evident: one task is to maintain, also in the future, the functionability of a highly differentiated society based on the division of labor and the other task is to retain the

public's need for safety, a sense of security, codetermination and ethical self-legitimization as political objectives. This aim requires more than just altered structures to deal with the political solution of conflict. In a pluralist society a basic system of common convictions and objectives is also necessary to serve as collective political guidelines. Such a basic system can only be developed when man's relationship with technology, risks and their justifiability has been clarified. If we intend to master the future we require, according to the philosopher Hans Jonas in his book on the principle of responsibility, a philosophy of technology and risk. However, such a philosophy has yet to be developed.

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