Perception of risk
Studies of risk attitudes, perceptions and definitions

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PERCEPTION OF RISK

STUDIES OF RISK ATTITUDES, PERCEPTIONS AND DEFINITIONS

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Center for Risk Research

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Rosa non vidi mai senza la spina

PREFACE

The thesis consists of papers which in one way or another relate to nuclear power issues. Nuclear power is not, however, the core subject matter of the thesis, risk perception is. Only the fact that an assistant was needed in a project in 1984 steered my attention in this particular direction of risk perception. Additional and unpredictable events, e.g. the Chernobyl accident and studies of public perception of nuclear waste risks, certainly increased my interest in how risks are perceived.

Risk perception research in relation to nuclear power technology offers a number of advantages. For example, nuclear power issues are relatively well-known to most people in Sweden since the 1980 referendum. Thus, subjects usually have an opinion and can motivate it. It is also an emotionally involving issue, which guarantees a wide range of reactions and arguments. Furthermore, the technology itself represents novel technological achievements, produces necessary energy, and involves a component of unpredictability and danger.

Disadvantages of conducting studies within this framework include the risk of letting the genie out of the bottle. Although we encountered only one subject in all studies who threatened to bomb our office, a few wrote that they could not possibly participate in a study which they considered to be so totally pro - or antagonistic to nuclear power. Thus, reactions occasionally seemed to be emotional indeed. The polarization of opinions at the time of the referendum seemed to have left some memories which researchers better approach with caution.

In retrospect, however, my lasting impressions of the work with the studies are those of intensive labor, involving subject matters, and cooperation with positive and inspiring people in my own and in very different areas of employment. Today I am grateful for the opportunity to work in such a highly interesting and important area of research.

There are many persons and several organizations who contributed significantly in realizing the projects on which a major part of this thesis is built, and to whom I am indebted. I start with thanking you all, since I cannot possibly mention all persons individually who in some way contributed to the work. I specifically want to thank the National Institute of Radiation Protection (SSI) and the National Board for Spent Nuclear Fuel (SKN) for the funding of projects which made some of the studies presented here possible, and I want to thank our contact persons at these organizations, Leif Moberg, Ulf Bäverstam and Åke Persson (SSI), and Nils Rydell (SKN), and more recently, Björn Cronhjort (SKN), for their advice and comments in relation to our work. I also want to thank plant managers and union representatives at the concerned nuclear power plants for making the time consuming project of interviewing personnel possible, and I want to thank everyone of the participants for sharing their views with us. I also want to thank my colleagues who helped with the interviews in this project. Furthermore, I want to thank headmasters and teachers at the Stockholm high

schools who took an interest in and made possible our study of adolescents' attitudes and risk perceptions. I also want to thank each and every student who took part in the study, especially for the often highly personal remarks on the nuclear waste issue which gave life to the data.

A large number of people have participated in the mail questionnaire studies. I sincerely thank you for your efforts in reading, digesting and responding to our questions, and I want to underline this, since I have a vague feeling that you possibly do not imagine how important persons you actually are. Thank you also Cecilia Carlsson and Inger Ungmark for helping with collecting and organizing these data.

I also want to thank the persons who helped realize this thesis. The person who first and foremost deserves a thanks is professor Lennart Sjöberg, director of the projects, my co-author on four of the included papers, and today also my husband. Your ability to combine an angel's patience regarding household duties with fierce interest in a great variety of topics has greatly inspired me as well as enabled me to complete this thesis. I am also sincerely grateful to my thesis advisor, professor Karl-Erik Wärneryd, who apart from giving useful advice and comments on my work, also offered what I consider the greatest possible gifts to a doctoral student, namely both trust and freedom. I also want to thank professor Bo Lindell and professor Claes-Robert Julander of my thesis committee, who have made highly relevant and valuable comments on my work. Remaining misunderstandings or errors in the work are entirely my own responsibility. So are the comments or interpretations which explicitly or implicitly express personal theoretical standpoints or remarks.

Last, but not least, I want to thank professor Alain Bultez at the European Institute for Advanced Studies in Management (EIASM) in Brussels, for the invitation to visit the institute in 1990/91 which has made it possible for me to complete several papers and, at last, this thesis.

Britt-Marie Drottz-Sjöberg

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ABSTRACT

The introduction to the papers included in the thesis discusses issues related to risk perception research. Considerations regarding survey methodology and employed concepts are also mentioned. The empirical papers present data from several studies conducted during the 1980's, including interviews with selected groups of respondents and mail questionnaire surveys of selected groups and representative samples of the Swedish population. The studies concerned reactions to the Chernobyl accident, perceptions of nuclear waste risks, perceived job risks at nuclear power plants, and the relationship between risk definitions and risk perception. The main results of the studies show that (a) public reactions to risk (e.g. level of worry after the Chernobyl accident) were related to objective risk levels; (b) on the average, women, and farmers and new parents rated risks related to the Chernobyl accident and to nuclear power higher than men, and adolescents and men without children of their own; (c) risks to one's person were often perceived as smaller than risks to others and risks which concern the society; (d) adolescents often reported lower perceived risk in relation to nuclear power issues compared to adults; (e) students of technology and economics often rated risks lower than students of humanities and social science, whereas the ratings by students of the natural science study program often could be found in between; (f) people differed with regard to how they defined the risk concept, and personal definitions of risk tended to be related to perceived risk, i.e. a definition of risk in terms of mainly a question of the probability of a negative event was often associated with lower risk ratings as compared to a definition of risk which focused on consequences of an adverse event; (g) different rating methods were found to be differently sensitive to employed judgement strategies, indicating different underlying dynamics; (h) level of radiation knowledge correlated negatively with ratings of perceived risk among nuclear power plant personnel, also when controlling for different work conditions. Furthermore, perceived job risk could rather well be accounted for by perceived nuclear risk, frequency of work in controlled sections, perceived general accident risk and amount of received instruction on radiation. Job satisfaction was found more strongly related to perceived conventional job risks than to nuclear risks. The papers are discussed in relation to recent findings and ideas in risk perception research. The importance of risk perception research for decision making and successful solutions to risk communication problems is stressed.

INTRODUCTION

RISK: 15 century: from Italian **risco, rischio** (danger, risk), derived from **rischiare, risicare**. The origin of the word is surprising. It must be traced to Greek **rhiza** (root). The word **rhiza** came to designate, in Greek, all which is extended from a trunk in the manner of a root, and later, in Crete, the beach cliffs, formed by the protruding rocks at the foot of the mountain, rather similar to the roots protruding from the foot of a tree. Thus, from **rhiza** came **rhizikon** (something with a similarity to a cliff and hence presents a danger, a "risk").

Mathieu-Rosay, J. (1985). Dictionnaire Etymologique. Alleur, Belgium: Marabout. (Original in French).

The *Dictionnaire Etymologique* cited above does not give any further time specifications about the word risk. Inherent alarm systems and different kinds of awareness of danger, however, are parts of life itself. Living organisms struggle for survival with available means. Risk awareness and risk minimizing promote survival, and risk perception, in its human form, is therefore presumably of ancient origin.

Although risk and danger have always been a part of life, risk analysis has not. Covello and Mumpower (1985) traced the first simple form of human systematic risk analysis to the Asipu group of the Tigris-Euphrates valley about 3200 B.C. These people provided consultant services regarding "risky, uncertain, or difficult decisions" (p. 103). Input data of likely outcomes was made available by signs from the gods, and analyses and interpretations yielded predictions about the risky future venture in the form of recommendations. A final report "etched upon a clay tablet" (p. 103) was also provided the customer.

The issues of risk and risk analysis have currently become more visible and important. Risk analyses are conducted to foresee and minimize adverse events, if not to prevent them. In an increasingly complex society which requires sophisticated large scale technological solutions to current needs, we cannot disregard the risk aspects involved. If the Asipu consultant gave the wrong recommendation to his client, perhaps a marriage would fail, a battle be lost, a ship never return or a person would loose a fortune. If a modern risk analysis fails to observe or predict building construction weaknesses, toxic substances or the occurrence of natural hazards the consequences may be disastrous on a far greater scale.

Important predictions about the future and risk analyses have always been conducted by specialists employing their natural gifts or acquired skills. The Asipu people, for example, were perceived as especially qualified to interpret the signs from the gods (Covello & Mumpower, 1985), and the oracle at Delphi served a similar function in ancient Greece. Today risk analyses are conducted on the basis of more reliable data and by using scientific knowledge and methodology. Perhaps

a more important difference, however, lies in the fact that scientific knowledge is not absolute and static but develops continuously, and that recommendations can, on that ground, be disputed and distrusted. Scientific progress often highlights our ignorance in the sense that we know increasingly better what we do not yet know.

The risk perception area of research grew from an awareness of discrepancies between estimated objective risks and public reactions to risks. Again, disparate risk estimates and different opinions may always have been at hand, but today they often create problems, since decisions of great importance to many, and with implications for long time periods, must be taken. In the current situation, in societies founded on democratic principles, with an increasingly informed public, different views on risk, acceptable risk, and risk minimizing are therefore destined to create controversy. Our time also offers a much smaller world to us than to previous generations. There are no longer any white spots on the geographical map to explore. On the contrary, the world is overpopulated and we must economize natural resources. Recent developments in information technology furthermore downplay physical distances and provide information constantly.

Covello and Mumpower (1985) mentioned the increase of new risks as one of the differences between the past and the present. These new risks were characterized as "latent, long-term, involuntary, and irreversible" (p. 116). The change of living conditions could perhaps also be described in terms of individuals of the past as being exposed to risks within a society, whereas the present time exposes the societies themselves to risks. I suggest this kind of mental representation of the current situation to be responsible for a major part of the increased interest in e.g. environmental issues, and to play a major role in perception of risk.

New kinds of risks may also be distinguished from old and well-known risks as ***additional*** risks in contrast to voluntary and "necessary-evil" risks. We choose to go down-hill skiing, to smoke or to eat peanut butter. If people "need" the car to go to work, they also accept the risks involved. They may not, however, perceive a need of more recent technological innovations, e.g. computers or nuclear power plants, and they may therefore reject those technologies out of hand, and consider the risks they might imply as additional risks forced upon them to consider. Some people may even argue: If it is so dangerous to drive a car I can do without also worrying about radiation. Risk comparisons, which sometimes intend to illustrate the relative dangers of different phenomena, might therefore not only have reassuring implications: perhaps the highlighting of common and accepted risks, e.g. driving a car, in comparison to new and involuntary risks does not enhance risk acceptance of the new risks, but reduces the available range of an individual's risk acceptance potential.

Another aspect of risk awareness at the present time concerns the invisible nature of an increasing number of harmful agents. Toxic substances in the air, water and soil unobtrusively make their way into our homes and our bodies with largely unknown effects in the long run, possibly causing harm to our physical and psychological beings. Our inherent biological defence and warning systems do not seem designed to cope with this threat of massive invasion, and our own senses can

no longer be trusted to detect them. Beck (1987) wrote: "In the risk society, of which we are now becoming aware, one must unlearn to trust one's senses and the taken-for-granted; one must learn to *mistrust* one's senses in order to survive" (p. 159). I believe this mistrust is awakening. It shows itself in the demand for and creation of new regulatory authorities nationally and internationally at the same time as the work and expertise of these authorities are subjected to heavy scrutiny. A fundamental question seems to be if we can entrust our existence as individuals and societies to these authorities and experts. Do they know all the relevant facts? Will they inform about risks in time? Do they really care about me/ us? It seems as if a growing number of people want to make sure for themselves that they get affirmative answers to all these questions.

Yet another aspect of increased risk awareness and of expression of reactions to potential risks concern knowledge and information. To acquire knowledge or information about potential hazards or about people at risk implies to some extent to take on responsibility for the consequences, should these materialize. The issue of responsibility highlights a range of moral implications, and moral concerns constitute another fertile area of heated controversy. To know about a risk and to refrain from taking action, or neglecting to try to inform others, to offer one's help, to intervene, or to try to influence the outcome is to some people morally reprehensible. At the same time it might be reproachable not to venture or to risk trying a new project or solution to a problem if other and even larger negative effects would result from maintaining status quo. The connection between moral weakness and reluctance to risk was exemplified in a Swedish dictionary explaining "risk" in terms of 'a fear for all risk which develops into spinelessness and inability to take responsibility'. The current availability of information about risks could thus be said to have increased our readiness, as well as our moral obligations to act. The piecemeal constructed risk scenarios based on scarce or incomplete information, however, tend to cause actions to take different, and at times opposing, directions.

The papers of this thesis should be viewed in the context of these considerations. They report individuals' responses to questions about difficult and complex issues, e.g. nuclear power and radioactive waste, and they touch upon areas of fundamental human concern such as trust, involvement, morality and expectations. To measure and investigate perceived risk is to try to catch sentiments existing at a certain time and to try to make them intelligible with respect to that time and with respect to what they may possibly reveal about general human functioning. This is not a task, however, which can be achieved in one work alone or once and for all. Risk perception research is a fairly novel area of research, and thus offers only limited insights into the problems at hand. In addition, times, points of view and societies change, and continue to provide new challenges. The importance of risk perception research keeps pace with the stakes involved in decisions to be made which concern or may have negative effects on members of a society.

Aim and scope of the thesis

The thesis includes six separate papers which all aimed at investigating some aspects of perceived risk. The papers vary, however, regarding focal topic, design and methodology. The variation reflects the many different issues involved in risk perception research, despite the fact that most studies were concerned with attitudes and risk perceptions related to nuclear power. The studies were conducted to achieve goals at different levels of abstraction. The empirical studies were aimed at answering a variety of questions such as how respondents perceive risks associated with nuclear power, nuclear waste and radiation, what aspects or factors influence such risk perceptions and why. The repetition of certain questions and rating tasks in several studies aimed at replication, and thus validation of results.

With respect to different levels of abstraction the "first level" includes the "how" question. Fairly straightforward answers can be obtained from descriptions of subjects' responses from, for example, interviews and mail survey studies. Even allowing for tricky methodological considerations the "how" questions mainly require fair descriptions of results. The next level of analysis, however, immediately introduces considerable complexity. For example, which perspective should be chosen in the attempt to answer the question of what influences risk perception: a sociological, a historical, an anthropological, a genetic or biological, a psychological or an economical? The perspective chosen will strongly influence the choice of questions put to respondents, as well as the interpretation of the results with respect to the "third level" of analysis, i.e. answers to the "why" question.

The studies presented have been conducted within a psychological framework. This means that questionnaires have been constructed to reflect individuals' thoughts and reactions, and that the interpretations of results are based mainly on this kind of reported data. As already noted, studies of risk can be conducted from a great variety of perspectives. Such studies provide additional, and sometimes alternative, suggestions of how to understand and interpret human reactions and actions. It is not possible, however, to consider or review all related research. The papers in the present thesis therefore only aim at contributing some results and interpretations related to perceived risk to the already vast, and rapidly growing, field of risk perception research.

In the following, this introduction first gives a brief background and presentation of the studies and papers included in the thesis. Then follows a section on methodology which presents subjects and sampling procedures, and discusses some methodological considerations related to data quality. Included in this section is also a review of data analyses used in the studies. The third section of this introduction presents summaries of the included papers. The fourth section discusses terminology, and concepts, used in empirical risk research, and clarifies some central constructs used in the papers. The fifth and last section of this introduction presents a discussion of some selected issues relevant to risk perception research, e.g. the relationship between risk levels and perceived risk, attitude change, risk reactions and risk amplification, relationships between

perceived risk and certain demographic variables, as well as worry and anxiety. The optimistic bias, often encountered with respect to personal risk as compared to risk to others, is also discussed, as is the fact that different people actually are exposed or expose themselves to different degrees of risk. The nuclear power framework of the empirical studies highlighted reactions to radiation and to release of radioactive substances and these, often strong, reactions motivated a discussion of the dread of invisible dangers present in our modern society.

Presentation of the papers included in the thesis

After the Chernobyl accident in April 1986 there was a considerable research activity aiming at documenting the accident and reactions to the event both in Sweden and in other countries. The Swedish efforts, within the area of social sciences, included studies of the coverage of the accident in the media (e.g. Anderberg, 1986; Höijer, 1986; Engholm, 1987; Findahl & Lindahl,1987; Nordlund, 1987; Nohrstedt & Lekare, 1987), and opinion polls among the general public (IMU, 1986; Hultåker, 1986). The first two papers of the thesis cover psychological reactions in Sweden to the Chernobyl accident. They are based on results of three studies conducted in 1986. Our aim was to investigate certain groups in the Swedish population and document their reactions to the accident. We wanted to cover as wide a range of reactions as possible, and chose therefore to focus on farmers, pregnant women, adolescents and men without children of their own. The former two groups were included due to the considerable attention directed at radioactive contamination of food products, and the special recommendations to pregnant women. Men without children of their own were included since men often have been found to be less risk sensitive than women, and men without children in the age group of 25-35 were assumed to be even less so. Adolescents were of interest from several points of view; firstly, there were indications, for example from traffic studies, that young people perceive risks as smaller than adults; secondly, they had not participated in the 1980 referendum on domestic use of nuclear power and their nuclear attitude was therefore less well known; and thirdly, because it could be assumed that release of radioactive substances was an event of special concern to the growing generation which had had no influence on prior decisions regarding the nuclear power technology.

We carried out three studies within the project investigating reactions to the Chernobyl accident. The first study was an interview study where about 20 subjects from each of three areas of Sweden, differently affected by the fall-out (the counties of Gävle, Stockholm and Bohuslän), were questioned extensively about their reactions. The study, presented in paper 2 here and conducted in the summer of 1986, was also a pilot investigation of questions and response scales to be used in a subsequent survey study including similar groups of respondents. The results were first presented by Drottz and Sjöberg (1986). A paper in English which presents the results is included in the thesis (Sjöberg & Drottz, 1987) and will be summarized below. See also Table 1.

TABLE 1

Presentation of the data of the five empirical papers of the thesis with respect to kind of study, sample sizes, response rates, time period when the study was conducted, study design and groups of respondents

Presented empirical paper		*Sample size*	*Respondents Freq.*	*%*	*Time period*	*Design and groups*
1. Drottz-Sjöberg & Sjöberg (1990)		*1200*	*737*	*61*	*Sept.-Oct. 1986*	*Survey study; 3*4*100 subjects; representative samples of new parents, farmers, adolescents, and men without custody of children.*
2. Sjöberg & Drottz (1987)	*I.*	-	*59*	-	*June-July, 1986*	*Interview study; convenience samples including farmers, adolescents, pregnant women, men without children; 3 regions.*
	II.	*1200*	*737*	*61*	*Sept.-Oct. 1986*	*Survey study, see paper 1 above.*
	IIIa)	*300*	*148*	*49*	*Sept.- Oct. 1986*	*Panel study; 3*100 subjects; representative samples of 3 regions.*
	IIIb)	*148*	*105*	*71*		*Panel study, see above.*
3. Drottz-Sjöberg & Sjöberg (1991)	*I.*	-	*380*	-	*Nov.-Dec. 1986*	*Survey study; convenience sample of high school students in the study programs of technology, economics, natural science, social science and humanities; 3 schools in Stockholm.*
	II.	*1223*	*590*	*48*	*Feb.-April 1987*	*Survey study; representative sample of the Swedish population.*
4. Sjöberg & Drottz-Sjöberg (in press)		-	*236*	-	*May-August 1984*	*Interview study, including rating tasks; 10 professional groups at Swedish nuclear power plants.*
5. Drottz-Sjöberg (1990)[1]	*I.*	-	*591*	*48*	*See above*	*See paper 3, II.*
	II.	*1000*	*465*	*46*	*April-Oct. 1990*	*Survey study; 2*500 subjects; representative samples.*
	III.	-	*380*	-	*See above*	*See paper 3, I.*
	IV.	-	*243*	-	*Spring 1989*	*Part of a longitudinal project.*
	V.	-	*236*	-	*See above*	*See paper 4.*
	VI.	-	*201*	-	*July, 1990*	*Convenience sample of high achievers.*

[1] *Note. One additional subject have been included in study 5,I.*

The following study (N=737) used representative samples of the populations of farmers from the central data base of Swedish farmers (LRF), and, from the central data base of inhabitants in Sweden (DAFA-SPAR), men without custody of children, adolescents 18-20 years old, and new parents. The latter group replaced pregnant women since there were no official records available of pregnant women. The "new parents" had had a child during the period of the 15th of Mars to the 10th of June in 1986. The age range of adolescents was smaller than we had planned to use, but participation in studies of youngsters under the age of 18 in Sweden requires parental consent, so we had for practical reasons to refrain from contacting younger adolescents. Men without custody of children was intended as a group of bachelors, but we had to settle for men who were not formally "heads of families" in the ages of 25-35 years. The results of the study were first presented by Sjöberg and Drottz (1986a). The paper in English which presents the study is included in the thesis as paper 1 (Drottz-Sjöberg & Sjöberg, 1990). It will be summarized below.

The third part of the project was a panel study, which primarily investigated the stability of the attitude to nuclear power over a time period. Two questionnaires were mailed to respondents in three regions of the country within a time interval of about one month. The results were first presented by Sjöberg and Drottz (1986b), and will be summarized briefly below as part of paper 2 included in the thesis.

The third paper of the thesis investigates adolescents' perceptions of nuclear power and radioactive waste (N=380). The data were collected in late 1986. Results of this study are compared to results of a population study covering the same topics, conducted in the spring of 1987 (Drottz & Sjöberg, 1988; Sjöberg & Drottz, 1988). The adolescent sample was based on last year students of high schools in the county of Stockholm. Participants were students of the study programs of technology, economics, humanities, natural science and social science. Interviews were performed with another small group of students of the same study programs prior to the study in order to test the questionnaire. Spontaneous comments to the studies are available in the reports in Swedish. A previous version of paper 3 in this thesis was presented at the Annual Meeting of the Society for Risk Analysis in Houston, Texas, in the autumn of 1987.

The population study investigating attitudes and risk perceptions of radioactive waste was based on a representative sample of the Swedish population in the age interval of 18-66 years (N=590). It was conducted during the spring of 1987. The questionnaire included several of the questions previously posed to the high school students, and comparisons were subsequently made between the groups. The main purpose of both these studies was to investigate perception of radioactive waste. For a full report of the population study, see Sjöberg and Drottz (1988). Some of the results of this study are used in the thesis, paper 3 (Drottz-Sjöberg & Sjöberg, 1991), to compare attitudes and reactions of adolescents and adults.

The fourth paper of the thesis focuses on nuclear power plant employees' perception of risk in their work environment. These data were collected during the

spring and summer of 1984. It is the only data of the present thesis obtained prior to the Chernobyl accident. The study included 10 groups of employees, who either worked at the plants on a regular basis or who regularly worked with certain tasks at different plants. The main purpose of this study was to investigate risk perceptions of the work environment, including the risk of radiation injury, but the study also included questions about nuclear power attitude, job satisfaction, and investigated the use of various types of scales for rating of risks. Apart from presentations of the study results to the involved parties, the results have been analyzed further and presented in an English version (Sjöberg & Drottz-Sjöberg, in press). This paper is summarized below and included in the thesis as paper 4.

During our work on the various projects we have been aware of the possibility that the risk concept may be differently perceived by different subjects. The fifth paper of the thesis presents a closer look at how subjects construe the concept of risk. It used data from some of the above mentioned studies and from additional sources. Risk definitions have been related to ratings of various kinds of risks (Drottz-Sjöberg, 1990a). The results are summarized below.

The sixth paper of the thesis (Drottz-Sjöberg, in press) discusses some issues and themes related to perceptions of risks in modern society. It widens the scope of issues relevant to risk perception research by also touching upon aspects of costs, morality, risk communication and social implications.

The order of the papers in the thesis is based on their content rather than the temporal sequence in which data were obtained. Thus, studies involving population data or comparisons to such data are presented first, followed by the study of nuclear plant personnel, and the paper on risk definitions. The more popular discussion of risks and risk perception in modern society found in paper 6 rounds off the thesis.

METHODOLOGY

Subjects and sampling procedures

The results of the first paper were based on data from representative samples of 4*3 populations, i.e. farmers, new parents, adolescents and men without children in the regions of Gävle, Bohuslän (except the city of Gothenburg) and the county of Stockholm (excluding the city). The subsequent pooling of subjects was based on the assumption that the same psychological processes contributed to variations between and within groups.

We avoided respondents who lived in large cities since they would contribute an unrepresentative part to our pooled sample. In each population one hundred respondents were drawn from central data bases. Thus each region sample included 400 subjects. The response rate for the pooled sample was 61. The response rate was rather equally distributed across groups and regions.

There were some slight variations in response rate, however. Subjects in the Stockholm area were the least collaborative in this respect (56%), and subjects in

the Gävle region the most (65%). The response rate of the Bohus region was 60. Farmers (64-70%) and parents (55-73%), tended to respond somewhat more often than adolescents (51-66) and men without children (48-56%). Women tended to respond more often than men, 66% vs. 60%, but constituted a smaller proportion of the total sample (27%), due to the choice of groups. (There were 16 anonymous respondents in the sample and two which provided no information on sex. They are not included in the figures above). The proportion of men and women in the pooled sample was assumed to give the results a conservative bias, i.e. men are usually found to rate risks lower than women do, and their larger proportion in the sample was thus expected to lower overall perceived risk.

Three reminders within one month prompted the subjects to respond before a set date in october of 1986. A representative group (N=180) of those who had not responded at this time was drawn, and contacted per telephone for eliciting their reasons. An account of the missing respondents is available in Sjöberg and Drottz (1986a).

The response rate was calculated on the basis of the originally drawn sample, i.e. we did not discount subjects who had moved to unregistered addresses, who were travelling abroad, sick, or deceased, or were otherwise unavailable. Neither did we weigh the telephone contacted nonrespondents in relation to their proportion of the refuser sample drawn if they subsequently returned their questionnaire, which sometimes is a procedure used to achieve a higher response rate. (See Sjöberg and Drottz, 1986b, for a discussion). The calculation of response rate, as based on the originally drawn sample, has been performed in the same manner throughout the studies. The reported response rates thus typically reflect a conservative estimate of "true" response rates. Although it would be possible, and perhaps psychologically more convincing, to report response rates on the basis of a "net sample" (e.g. the total sample excluding respondents with insufficient knowledge of the language, or who have physiological or psychological problems which affect their ability to respond to questions, etc.), our primary concern was to establish a response rate figure which could not be questioned. Against this background we were not overjoyed, but simply content with the response rates achieved. Additional information on nonresponse examinations are available in the Swedish reports. A discussion of data quality follows below.

The sampling procedure of the study of the first paper aimed at reaching target groups of the Swedish population. These groups were assumed to be specifically affected, or unaffected, by the fall-out from the Chernobyl accident. To obtain sufficiently large groups for data analysis of e.g. farmers, new parents, etc., in an ordinary population sample a very large sample is required. Aiming only at certain target groups such a procedure also generates a considerable amount of unwanted data. The presented sampling procedure was therefore used to readily locate the groups of interest, as well as to reduce work load and expenses. Consequently, the study does not aim to reflect the Swedish population at large.

It was of interest, however, to obtain measures for comparisons to population data. For this purpose we included a number of calibration questions from opinion poll studies in our questionnaire. The instructions, the wording and

the scales of these questions were identical between studies. The comparisons showed, firstly, to what extent the mean responses of our total sample corresponded to that of the average population, and secondly, to what extent our respective groups differed from population data. Unfortunately, there was a time factor involved, since we could only compare to already conducted studies. The time interval between our study and the previous two studies by other researchers which we used for comparisons, involved additional information about the Chernobyl accident which might have influenced our subjects. As reported in the paper, we found our respondents, on the average, to be about equally worried as the general population about the accident, but somewhat more pessimistic in their estimates of cancer incidents and possible genetic injury in the population.

The results presented in the second paper involved three studies, of which the survey study has already been presented above. The other two studies were an interview study and a panel study.

The interview study engaged 59 of 60 planed subjects, i.e. 20 persons in each one of the three regions of Gävle, Stockholm and Bohus, including groups of farmers, pregnant women, adolescents and men without children. One pregnant woman declined the interview for personal reasons. The subjects were approached at open maternal clinics, by the help of farmers' organizations, through sport clubs and through youth centers. It was a convenience sample, i.e. those who could be contacted were asked to participate in the study at a certain time and place. Very few declined the offer. Subjects were interviewed either in their homes or at a public place which offered a quiet room for the interview. The interviews were tape recorded and lasted on average 90 minutes (45-240 minutes).

The choice of a convenience sample for the interviews was motivated by our aims of firstly, to approach subjects as soon as possible after the accident, and secondly, to test questions and response scales for use in the survey study. The extensive interviews gave, however, a wealth of information which could not be covered in the survey, and the results were therefore presented in a separate report.

The panel study used two questionnaires distributed with a minimum of three weeks and a maximum of five weeks in between. The tight time schedule was due to a deadline for presenting the results of the project as a whole. The original samples were drawn from three populations, i.e. the regions of Gävle, Bohuslän (excluding Gothenburg and suburbs) and Kopparberg. Each sample was drawn from the published tax-payers' directories of those counties by employing computer generated random tables.

Those who responded to the first and relatively extensive questionnaire within a set time limit (N=148, 49%), were sent the second questionnaire. Totally 105 persons responded to two questionnaires, i.e. 35% of the originally drawn samples and 71% of those who had responded to the first one. Respondents had been informed from the start that they would be contacted again with a second questionnaire, apart from reminders. There were two reminders to the first questionnaire and a telephone call to a group of those who had not yet responded. The second questionnaire was followed by one reminder.

The main aim of the study was to estimate the stability over time of nuclear power attitude. The short time interval did not reflect our desires, but practical considerations. The mean age of respondents was 46 years (22 to 83 years), and they were about 13 years older, on the average, than respondents of the survey study. They had also a somewhat lower education, a fact related to their higher mean age. They furthermore differed from respondents of the survey study in that they considered the issue of nuclear power as more important. This result may be related to the information the respondents received, that they would be asked to respond to two questionnaires. Such an effort requires something more than the usual with respect to respondents' interest in the study. It should therefore be kept in mind that the respondents of the original sample, who completed both questionnaires, very well could represent a selected group with respect to e.g. interest in the issue. The results should therefore not be generalized. It was of interest, however, to examine the stability of attitude and risk perception within the available group of respondents.

The third paper of the thesis presents results based on two studies: an adolescent sample and a representative sample of the Swedish population. The adolescent sample (N=380) consisted of students of three major high schools in the Stockholm area. All three schools offered education within the five major study areas of technology, natural science, social science, economics and humanities apart from several study program variations, e.g. two-year programs, etc.

The study was based on a selection of schools, not on sampling of individuals. The schools were chosen on the basis of their diversified recruitment of students regarding socio-economic background and ability distribution. "Elite" schools and schools in the city were excluded. Among the available schools the choices were determined on the basis of headmasters' consent and time made available for responding to the questionnaire. Students of the five study programs were then approached. Teachers had been contacted in advance (often a teacher of a social science subject area), and had in general terms presented the forthcoming study to the students. During a four week period, the questionnaires were distributed in the classes by an assistant during ordinary class hours. Students present at school that day participated in the study. The questionnaires were collected immediately after each session. No student refrained from participation in the study. Absences were due to either sick leave or leave granted by the school.

The results of the survey study, also presented in the third paper, were based on a representative national sample. A total of 1223 subjects in the age interval of 18-65 were drawn from the DAFA-SPAR central data base and sent a booklet questionnaire. Almost 600 persons had responded (48%) after three reminders.

Those who responded tended to have a somewhat higher education than nonrespondents. The respondent group had a slight over-representation of men (53%). Women tended to choose the "don't know" response alternative in the questionnaire more often than men. Generally, however, the respondents represented a wide range of ages, occupations, education levels and residential regions.

Among the nonrespondents 29% returned a brief checklist on which they had indicated why they had chosen not to participate in the study. The rest of the nonrespondents (22%) did not answer any of our correspondence. A study of the two kinds of nonresponse showed no difference regarding income or residential region, but the latter group more often included men, elderly and single persons. These 10% of the population may well be part of a hard-core group of non-respondents.

Among those who used the checklist to explain their non-participation 57% were women. The most often checked alternative was "I know too little about the issue" (49%). Women marked this alternative significantly more often than men, which was also the case regarding the response alternative "Too difficult questions". Only 9%, however, marked the response alternative "Too many questions". Twenty-six percent of the missing subjects who used the checklist replied that they never responded to questionnaires as a principle, i.e. another possible type of hard-core non-respondents.

The fourth paper reports results based on employees of two Swedish nuclear power plants. Respondents were those within 10 personnel groups who worked at the plant during refueling periods. That is, some were employed by the plant on a permanent basis, others were employed temporarily and by external contractors. Still others were employed by government agencies but worked temporarily at the plants. The study required considerable planning and called for the involvement of managers and unions. Several planning and information meetings were held at the plants. The project also required all involved in the research team to participate in an obligatory introduction course on nuclear power and safety regulations.

Individual subjects were chosen by contact persons at the plants, thus fulfilling a requirement of anonymity of the respondents. Our request was that the respondents should be randomly drawn from lists of available personnel of the selected groups. Very few declined to participate in the study.

The interview lasted about one hour and each person was interviewed individually. The respondents answered a number of questions orally, and completed a knowledge test, as well as rated a series of several separate risk rating lists. Radiation protection personnel completed two knowledge tests. The tests were constructed and the correct answers made available to us by experts at the Swedish Radiation Protection Institute.

The fifth and last empirical paper of this thesis was based on data from several sources, three of which have already been presented above, i.e. the survey study and the study of adolescents presented in paper 3, and the study of nuclear power plant employees presented in paper 4. These respondents had answered questions about how they normally used the term risk. Exactly the same task had also been used in other studies, and those will be presented briefly here.

Firstly, a representative national sample (aged 30-45) participated anonymously in a mail survey study on the AIDS-disease. Two parallel samples of 500 persons were drawn, and 46% responded to an extensive questionnaire, including some highly personal questions. Responses and response distributions of

the same or similar questions were compared to those of representative samples studied by Brorsson (1989), and found to be highly similar. Respondents (N=465) tended to have a higher educational level than the national average. Risk definition questions and ratings of personal risk, risk to people generally, and ratings of the threat to society from a number of events were employed from this study. For a presentation of results of the AIDS-study, see Sjöberg (1990).

Secondly, data from a longitudinal project on study interest (N=243) among college engineers (63% male) and students of psychology (21% male) at the university level was also employed in the fifth paper. Only risk definition questions and ratings of threat to society of this study were used. The data were collected in 1989 and have not yet been published.

Thirdly, a group of respondents (N=201), *viz.* high achieving students of different educational backgrounds, responded to questions about how they employed the term risk on the basis of both the same presentation format as in the previous studies, and a unidimensional rating scale. These data were solely intended for a comparison between ratings of risk definitions using the two different methods, and the convenience sample of this high ability group was therefore rather a strength than a weakness of the design. That is, these students represented a homogeneous group of subjects who could be expected to readily understand their task. Responses should therefore reflect less uncertainty and less procedural errors than what could otherwise be expected.

To conclude this presentation of subjects and sampling procedures a few remarks should be made on data quality and generalization. (1) The studies presented in the thesis are based on a variety of sampling procedures: convenience samples, representative samples of selected groups, selected groups within available schools and nuclear power plants, and representative national samples. The variation of method and design of the studies was due to variation in the aims of the studies, and sometimes also to circumstances unique to each study. (2) The issue of generality of results should be seen in this context. Each study was conducted within the framework of specific requirements and rules applicable to that kind of study. It is thus not appropriate, nor was it our intention, to generalize results based on convenience samples, or specifically sought out groups of subjects, to the general population. Conversely, data from national representative samples could not be used to draw conclusions about specific sub-samples, since they say little about specific target groups, unless there is sufficient material available for their special investigation. However, the use of different kinds of samples and methodologies strengthen the validity of conclusions if results are replicated.

Our response rates, when using representative samples, were in the range 50-60%. These rather modest results are partly due to the chosen manner to calculate the response rate mentioned above, and probably partly due to the subject matter of the studies, which was often regarded as difficult by the participants. Most of the studies were furthermore conducted in the mid 1980s,

shortly after the "disclosure" of the Metropolit project[1]. At this time many researchers encountered increased suspicion in the public towards mail questionnaires. However, response rates in (interview) studies have been declining at least since the 1970s in Sweden, although response rates vary between different kinds of studies (see for example Bergman, Hanve & Rapp, 1978).

Response rates are related to the issue of generalization of results if the intention is, for example, to predict behaviors in the population from which a representative sample was drawn. In this sense, a low response rate threatens the external validity of the results and lessens the predictive power. Groves (1987) wrote: "Errors due to nonobservation (noncoverage, nonresponse, and sampling) are most salient to those for whom external inference to a clearly defined population is important. These tend to be describers, and hence, for example, researchers in government agencies often devote more effort to coverage and nonresponse error than do others" (p. 159). "Describers" in the quotation refer to "those who use survey data to describe populations" (p. 157), whereas in Groves terminology, our use of survey data would fall under the heading of "analysts", i.e. those "who study substantive issues using data" (p. 157). Our main intention was not to describe properties of populations, but to address issues of psychological interest within certain populations or focal groups.

Much research has been done in the area of methodology to pinpoint reasons for nonresponse, the characterization of refusers, and what can be done to improve response rates. A few examples of such research approaches concerning interview as well as mail surveys are mentioned below.

Fox, Crask and Kim (1988) conducted a meta-analysis of mail survey studies with respect to what factors influence response rates. Their analysis showed that university sponsorship, prenotification by letter and stamped return postage yielded the largest increases in response rate, on the average. The effect of a follow-up postcard was also significant and positive regarding response rate. However, the inclusion of a cut-off date for response did not show any significant increase in response rate. The authors estimated that the use of stamped return postage and prenotification by letter would add, on the average, about 14% to the response rate. Scott Armstrong and Lusk (1987) conducted a meta-analysis on the basis of 34 studies to test hypotheses about return postage. They concluded that business reply postage seldom is cost effective because first class postage (including metering, franking and standard stamps) yielded an additional 9% return in mail surveys. The most interesting data to be found in their paper, however, concerned response rates of the studies used in the meta-analysis. All studies were mail surveys which had experimentally varied postage. Response rates of first class postage return envelopes varied between 16.6% and 73.8% over 20 studies, with an unweighted average of 43.2%. The business reply return postage of the same 20 studies showed a response rate varying between 5.6% and 66.3%, with an

[1] This was a project of the Stockholm University, Department of Sociology, which achieved an intensive media coverage for a time period. Critical issues were raised, such as survey methodology, use and registration of data, and information to participants.

unweighted average of 34.0%. The variation of response rates was thus considerable.

Bergman, Hanve and Rapp (1978) presented results of two exploratory interview surveys of persons who had previously refused to participate in a Swedish Survey of Living Conditions (here called the SLC) and the Swedish Labor-Force Surveys (here called the LFS). The authors motivated their study by referring to an observed decline in response rates during the past decade in Sweden as well as in other countries. The nonresponse rate in the county of Stockholm at the time of the SLC survey was reported to be about 23%, and in the LFS panel studies about 6-7%. The authors stated that: "It is thought that some of the reasons for the increasing difficulties in securing peoples' cooperation in surveys are that members of the general public are becoming increasingly concerned about privacy and confidentiality, and about being computer registered..." (p. 341). Thirty refusers were randomly selected from the SLC study and another 30 refusers of the LFS study within the county of Stockholm were approached. The new nonresponse rates were 17% and 43%, respectively. A randomly selected control group of 10 persons was also drawn from each study for comparison. The approached refusers of the SLC study were offered 50 SEK (about $10) as compensation for participation in a 15-30 minutes personal interview. No compensation was offered to the approached refusers of the LFS study. Care was taken to protect the identity of the participants in both studies. An introductory letter had been sent to all persons selected for interviews. Due to the nature of the earlier studies the prior SLC refusers were if possible interviewed in their homes, and the prior LFS study refusers interviewed by telephone. With respect to the former group telephone interviews were conducted if the home interview was not acceptable to the respondent. The authors noted that "With certain exceptions, the telephone interviews were carried out in a more tense atmosphere than the personal interviews" (p. 344).

Examples of reasons to participate and to refuse participation were reported in the paper. The authors concluded that there was a wide variation in feelings with respect to being contacted and asked to participate in a survey. The refuser group was found to be very heterogenous regarding personal characteristics and living conditions. The authors noted, for example, their doubts with respect to trust in confidentiality, doubt of significance of the obtained data, or regarding the aim of the study. They furthermore gave suggestions to ask someone else, or refused out of loyalty to a partner who was negative to the survey. There was also "the panel effect" from repeated contacts by interviewers to persons who were chosen for panel studies (they are asked to participate 8 times, every third month during a 2-year period). Distrust and unwillingness to supply any information about oneself seemed to be the major reasons to refuse, but the authors did not find any "predominant refuser category" (p. 352). Instead they pointed to the many different and interacting reasons of refusal. The persons who previously had participated in the survey studies motivated their participation by referring to "public spirit", interest, social contact or they participated because it was unpleasant to refuse.

Response rates can also sometimes be improved by indirect interviews, i.e. another person than the sampled in the same household answers questions about simple facts which he or she can be supposed to know, for example the employment situation (see Bergman & Thorslund, 1979). The first four months of 1978, after the implementation of new and more restrictive rules regarding indirect interviews, about 10% of all completed interviews in the AKU studies were with another person than the sampled respondent. The average nonresponse rate was 6-7% during the same period. The authors reported variations between regions, age, gender and occupational status, e.g. indirect interviews were more often used for respondents in large cities, the youngest and the oldest age groups, for men and for long-term ill persons, those at institutions or in military service. The authors noted the relationship between nonresponse and indirect interviews, i.e. after the new rules of the mid 1970s, nonresponse rates increased.

Groves (1987) called attention to the often underestimated roles of cost implications of error reduction and the interrelationship between error sources in surveys. All surveys and other research are conducted under cost and time restraints. One can, for example, include additional reminders to increase response rates, or include more indicators to increase construct validity of a measured construct. In the latter case, the attempt to increase construct validity may reduce response rate, since a longer questionnaire discourages more respondents. A short questionnaire, on the other hand, may increase response rate but decrease construct validity. If respondents are totally anonymous, all respondents receive each new reminder (usually with a stamped return envelope) regardless of previous response or nonresponse. This increases the cost, and may also irritate or confuse respondents who have already responded. Groves (1987) concluded that "A solution to the divergence between the results of survey methodology and survey practice requires acknowledgement that surveys are inherent compromises. To become perfect measuring devices they must stop being surveys (as we know them)" (p. 167).

In our surveys, we did not use prenotification letters, but introduced the study, ourselves and the sponsors in a letter included in the first mailing. According to Fox, Crask and Kim (1988) a prenotification letter could have increased response rates. In one study (Sjöberg & Drottz, 1986a) we used a pleasant postcard to remind respondents to mail their response and although response rates did not increase drastically, we received some thankful and encouraging comments by the gesture. The presentation of sponsors for the studies (i.e. Swedish governmental authorities of radiation protection and of spent nuclear fuel), may have influenced response rates. It is difficult to know, however, if such influence would be primarily positive or negative. Some people are genuinely distrusting authorities of all kinds as reported by Bergman, Hanve and Rapp (1978), whereas such references to others mean that the study is important and that responses will be of use to the society. We often used questionnaires in light green or yellow shades since color (often green) has been suggested to increase response rates. All mailed questionnaires were accompanied by stamped return envelopes. When a respondent returned a questionnaire, he or she was omitted from the list of

respondents and not bothered further with reminders. After the completion of the respective studies all respondent lists and mail labels were destroyed.

In one study (Sjöberg & Drottz, 1988) all nonrespondents of a certain date were asked to give their reasons for not participating in the study. The results were mentioned above, and showed that 29% of them readily gave such reasons whereas 22% did not. The questionnaire was rather extensive, but the most frequently given reasons for non-participation were lack of knowledge and too difficult questions. If we had defined the respondents, who reported too little knowledge of the issues to be able to reply to the questionnaire as not belonging to the population, we would have presented a response rate of 56%[2]. Had we instead considered those who returned the checklist (N=359) as respondents who gave a general "don't know" response, we would have registered a response rate of 78%. The example points to the awkwardness of comparing the kind of studies we have conducted to, for example, opinion poll surveys which sometimes ask questions about several sets of unrelated topics in the same survey. A person selected for such a survey and who responds to several sections of a questionnaire would most probably be considered as included in the population and as a respondent. If he or she does not respond to one set or section of the questionnaire included in such surveys due to "no knowledge of the issue" or "don't know", e.g. regarding nuclear waste issues, the only effect would be an average increase of the "don't know" responses, not a drop in over-all response rate. Finally, we did not use any corresponding "indirect interview" techniques as presented by Bergman and Thorslund (1979) since our questions concerned the respondents' personal views.

The response rates of our studies may also be compared to an American telephone interview study regarding the suggested Nevada site for a high-level nuclear waste repository, reported by Kunreuther, Easterling, Desvousges and Slovic (1990). They used a sample based on standard random digit-dialing techniques and got 37.4% completed interviews from 2676 households *when an eligible respondent was reached.* A parallel study yielded 35.1% completed interviews. This implies that persons who were not reached at all were discounted. Still, the results of this otherwise very impressive study was published in one of the leading journals of risk research, *viz. Risk Analysis*. The authors motivated their use of these data: "Because of the modest response rate, the findings may not generalize to the entire population of Nevada. We do feel, however, that the results provide considerable insight into the factors influencing attitudes toward the repository" (p. 473). McClelland, Schulze and Hurd (1990) reported a response rate of 45% of a mail survey of effects of risk beliefs on property values related to a hazardous waste site, after adjusting for bad addresses. Biel and Dahlstrand (1990) reported 54% overall response rate with respect to a mail questionnaire about risk perceptions of a repository for spent nuclear fuel in Sweden. They used four representative samples of four counties.

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[2] That is, 49% of 359 checklist responses gave this reason. 176 persons deleted from the originally drawn sample would make a "net" sample of 1047, and 590 respondents related to this new basis would result in a 56% response rate.

In sum, survey studies vary considerably with respect to response rate. There are a number of interrelated considerations to attend to, which in practice must accommodate the purpose of the study, the available time and the given economical resources. The examples above point to some of these considerations, and show that our response rates do not deviate greatly from studies covering similar risk related topics, and which report response rates using similar methods. Data quality does not rely entirely on response rates, however. And conversely, high response rates do not guarantee the quality of a study. Sources of error are also to be found, apart from e.g. the design of studies, questionnaires and questions, in the processing and comprehension of information and questions by the respondent, in the "perceived quality" of the communication between the respondent and the interviewer or the survey researchers, and in the framework of willingness to comply with the goals and the intentions of a study. (For a discussion of the validity of interview survey data, see Suchman & Jordan, 1990, and the immediately following comments on their paper). It was encouraging to note the conclusion of Bergman, Hanve and Rapp (1978) that no systematic difference could be detected between respondents and refusers in their interview studies. Although these studies were very small, and the authors did not attempt to generalize the results beyond their data, our attempts to compare respondents to nonrespondents have shown similar results. Available data on refusers are naturally very scarce unless specific studies are made of them, e.g. telephone contacts, new studies etc., but certain demographic data might be available if a sample is drawn from a central register of some kind. In totally anonymous studies, only response return points in time can be compared, however (see Sjöberg & Tollgerdt-Andersson, 1991). Our comparisons have shown that higher educated persons tend to respond more often in the studies than persons with lower education. It is not perfectly clear however, how education level is related to attitudes. Higher educated persons generally tend, however, to be more socially well integrated and could thus be expected to be more positive to technological progress and, for example, nuclear power. This would most probably imply a conservative bias in our studies with respect to risk perception.

A general conclusion regarding generalization of empirical data is, however, that one of the better criteria of data quality is to be found in replications of results. The discussion below of the results of the various studies of the thesis highlights two general rules with respect to generalization of results. Firstly, the main rule is that results can only be generalized to the population studied. If a representative sampling procedure is the basis of a study, the results are generalizable to the population at large (given the validity of certain assumptions). If there is no representative sampling, the sample employed, strictly speaking, constitutes it's own population. There is still some utility in such studies, however. For one thing, the results may point to important aspects of the studied phenomena although they do not contribute any suggestions about their distribution in another population. And most importantly, they say something about the sample studied. Psychological research does not generally aim to investigate national populations with respect to their properties. Such an aim is more in line

with sociological research approaches. Psychological research instead aims at investigating relationships between psychological factors, and to relate these to background factors and independent variables. Attempts at generalization of results, however, may be based on e.g. calibration questions, which to some extent say something about the correspondence between results of different populations. Even better, however, is to use the rule of replication within the frame of a cumulative science, and to compare new results to results already available within the research paradigm, and to conduct new studies to test the previous results. The notion of a cumulative science stipulates that knowledge is built piecemeal and continuously over long periods of time. New research results are compared to the existing bulk of knowledge and either make a contribution to this knowledge or are rejected. Thus, secondly, to compare and fit new results to the existing body of already available results is another manner to fit specific results into a wider context. In this process all kinds of studies are useful. Whether they make a significant contribution or not is another issue, not directly connected to the issue of generalization.

Data analyses

Analysis of results in the thesis employ both qualitative and quantitative methods. Qualitative categorizations of responses to open ended questions are presented in the papers and will not be discussed here. The remarks below concern employment of statistical methods when studying subjective phenomena, with a reference to the interpretation of specific statistical analyses.

I leave to the philosophers to investigate and discuss whether human beings can at all be understood and explained. A paramount issue in psychology, the discipline within which this thesis has been conducted, has been to develop and test available methods for the inquiry into properties of the human mind and predictors of human behavior. Empirical evidence has historically been sought parallel with the theoretical modeling, and theories which repeatedly fail to gain empirical support have lost their impact on research. Against this background, the importance of measurement and measurement development becomes obvious. The perhaps most general assumption of all in psychological empirical research is that psychological factors and phenomena can be measured. The focus of much methodological research has therefore been to validate this notion and to investigate and improve the relevance and appropriateness of various methods.

The empirical papers of the present thesis aimed at investigating psychological reactions to certain events and situations, especially how people perceive risk, and relate such measures to each other and to background and situational factors. It should be pointed out in this context that the measurement of psychological factors is based on expressed thoughts and opinions, which are not necessarily synonymous with true experiences. Although the distinction may seem trivial, quite a lot of effort has been invested in relating private experiences to their overt expressions. The checking of a response scale can be seen as such an overt expression; at times seen in terms of behavior, but this issue will not be further

addressed here. The assumed development can be illustrated as a continuous process starting with the experience, over the expression of the experience, to the choice of an appropriate response alternative in a questionnaire. The point to be made here is that the results of the present thesis support the assumption that subjective phenomena can be studied and that results of such investigations present meaningful patterns.

Above I mentioned the unclear relationship between experience and its expression. There also exists a bulk of methodological research aiming at pinpointing the character of the relations between an expressed view, e.g. attitude or reaction, and the actual indication made on a rating scale, or in response to a question. Related to this issue are the large research areas of scaling, and test and item construction. There is also research on bias, i.e. factors influencing the choice of expression, e.g. social desirability, and effects of how, in what order, and in what context questions are presented.

A short discussion of external validity and generalization was given above. Other aspects of quality should also be noted. The reliability of results is closely connected to the employed design and measures of a study. But measures must be both valid and reliable. Both aspects can be tested statistically, although against backgrounds of differing assumptions. To be more specific, the reliability of measures must be assured by means of proper item and scale constructions. The pooling of items should be examined with respect to the resulting reliability of the new measure. One such test of reliability of pooled items is the Cronbach's alpha test. This method has been employed in the thesis for index constructions. The Cronbach alpha is a function of shared variance of items in the index, i.e. to what extent the included variables can be said to measure the same underlying variable or factor.

The validity of an item or a measure rests on its appropriateness and relevance for the studied phenomena. This means that certain precautions should be taken regarding e.g. interdependence between measures, and with respect to influencing and intervening factors. For example, in the study of psychological reactions to radioactive exposure it was essential to measure the independent influence of general risk sensitivity. Subjects' variability regarding reactions to any kind of risk or threat may account for obtained group differences, or may indeed contribute the lions' share to the measured reaction. In short, a rule of thumb for pursuing the often long and cumbersome work of analyzing data is to start with measures which actually measure the focal factors which they were intended to measure in a valid manner.

Below follow some short descriptions of the different methods of analysis used in the thesis, and how the resulting values of such measurement should be interpreted. First, however, a note on statistical significance and power of analysis. It is commonplace in psychological research to use rather small convenience samples, or to test hypotheses within strictly controlled experimental designs on the basis of a small number of subjects. The studies of the present thesis in contrast use some large samples, even when subgroups are analyzed. The large samples facilitate achievement of statistically significant group differences, due to the high

power of the analysis. This means that relatively small consistent variations between groups can render statistical significance at a rather high level. In contrast, small samples require larger group differences to achieve the same level of statistical significance. This is because error variance of means decreases with increasing sample size. (See also Cohen, 1990).

It is important to clearly distinguish between statistical power and statistical significance. In the present thesis, the large sample sizes easily achieve significance levels beyond the 0.0005 level. A control of mean values in these cases almost always corroborates the significance of group differences, which is also usually the case at least at the 0.01 significant level. Differences based on significance values below this level are usually not discussed in the thesis.

Results are almost exclusively analyzed by parametric tests. The choice was based on the intention to analyze data using complex design models not available in non-parametric versions (e.g. 3- or 4-way ANOVA and ANCOVA and multiple regression).

Employed tests of group differences are the *t*-test and the *F*-ratio statistics. The former analysis tests the hypothesis that there is no difference between the mean values of two compared groups on one variable, or with two variables and one sample. The *p*-value obtained estimates the probability that the groups are drawn from the same population.

The *F*-ratio statistics, obtained in the ANOVAs, enable essentially the same kinds of hypothesis tests as the *t*-test, i.e. compare within group variation to between group variations. It is also possible in an ANOVA, however, to test whether there exists a difference between several levels of the independent measure. For example, in a 2*2 factorial design the main effects of both independent variables are tested together with the interaction term. It should be noted that the *F*-ratio is a measure of the overall difference between groups, i.e. it does not give any indication of the form of the differences. For the investigation of the relationships between the dependent and independent variables trend analysis could be employed. Results of trend analyses are not presented in the papers of the thesis. Group differences are instead merely presented, sometimes together with the extreme group means. Group differences in the papers also tended to be large enough to be interpreted from plottings. The specific form of the relationship was furthermore not of focal interest in the studies.

Within the SYSTAT computer program the employed ANOVA analyses corrected for effects of unbalanced designs. A variation of the number of subjects across the cells of the data matrix results in a loss of power, but the unbalanced representation of subjects probably does not *per se* influence the tests of the hypotheses with the present large sample sizes.

An ANCOVA analysis corrects for the influence of a covariate, i.e. a variable supposed to account for part of the variance of the dependent variable. To test whether this is the case, the covariate is entered in the same equation as the target variables and its effect on these variables is estimated.

Friedman's non-parametric two-way analysis of variance was employed to test group differences on the basis of rank ordered data. Chi^2 analyses have been

employed for the testing of differences in response distributions of levels of an independent variable with a nominal, or categorical, dependent variable.

In some cases, e.g. to reduce a large number of questions to a smaller number of measures, factor analysis has been employed. Factor analysis structures the involved items in a number of dimensions which reflect underlying factors. The dimensions can be orthogonal (uncorrelated) or rotated to a non-orthogonal structure. Uncorrelated factor structures have been employed in the analyses, and the obtained factors subjected to reliability tests, using the Cronbach's alpha, when employed as indices in further analyses.

Multiple regression analyses have been employed to estimate the power of prediction of independent variables for the explanation of dependent variables. Beta-weights give an estimate of the strength of this influence of the respective predictors when predictors are approximately uncorrelated. The multiple correlation gives a measure of the extent to which the combined set of used predictors account for the variance in the dependent variable. The presented multiple correlations in the papers are always squared and adjusted for bias, and thus represent an estimate of the expected amount of explained variance.

Principal component analysis was employed to structure large data sets, usually based on interview questions. The method is similar to factor analysis (but makes no assumptions about distribution forms, or common and unique variance), and thus extracts components based on the correlational structure of the input variables.

SUMMARIES OF PAPERS

PAPER 1: *Risk perception and worries after the Chernobyl accident*[3]

The purpose of the study was to investigate effects of the Chernobyl accident on risk perception, nuclear power attitudes and to some extent to measure stress reactions and changes in daily life due to the accident. Four groups of subjects were chosen: farmers, adolescents, new parents and men without custody of children in the three respective regions of Gävle, Stockholm and Bohus. Each group constituted a representative sample of its population. A mail questionnaire was used.

Calibration questions made it possible to compare our results with those obtained by other investigators. They showed our sample to be about equally worried as the population, but somewhat more pessimistic about cancer risks and possible genetic injury due to the accident. About 70% of the respondents in our study and in a somewhat earlier opinion poll reported that they were "very" or

[3] With respect to the published paper it should be noted that it referred to the 27th of April 1986 for detection of an increased level of radiation in Sweden, e.g. at the Forsmark nuclear power plant. The heightened radiation level was registered automatically on April 27, but awareness of the situation is usually dated April 28 (Hibell, 1986; Marshall, 1986; Lundgren, 1987). Figure 1 of the published article also unintentionally displayed numerical values on the Y-axis which did not correspond to the scale used for measuring the question. The mistake was related to the scale range only, and did not affect results. The correct scale is used in the figure of this version.

"rather" worried because of the accident. About 65% chose a negative response category when asked about their attitude to nuclear power. People living in the most affected area (the Gävle region), as well as women and farmers, were significantly more negative to nuclear power than people living in less affected areas. More than half of the respondents indicated that they had become more negative to nuclear power after the accident, and about 70% expected a similar accident to happen again. With respect to a similar accident in Sweden, about 35% held such a prospect as likely.

A list of nine life values was used to measure perceived influence of nuclear power on important life conditions of the respondent and his or her family. Economic standard was judged the most positive in this respect. The most negative influence was perceived on the life values of freedom from worry, physical health and hope for the future. The latter was the most influential life value in predicting overall nuclear power attitude. The ratio of 15 to 1 was found when the number of respondents who judged all life values as negatively influenced by nuclear power was compared to the number of those who judged them all to be positively influenced. The conclusion was that there was a much larger group of decisive opponents than decisive supporters of nuclear power in the sample.

Responses to attitude statements about nuclear power showed that it was seen as a source of cheap energy production with low production costs, but also as a source of risk for people living nearby nuclear plants, and an obstacle to the development of alternative energy sources. Economic considerations, nuclear power as a clean source of energy as long as no accidents occur, and as important for Swedish technological know-how, emerged as important predictors of nuclear power attitude. The combination of such attitude statements and life values for the prediction of nuclear power attitude showed the attitude statements to carry more weight, but also that the life values contributed significantly.

About a third of the subjects reported that they had been exposed to harmful radiation due to the accident to a large or rather large extent. Respondents living in the Gävle area reported about twice as often a high level of personal worry in this respect compared to others. Farmers, women and parents were the most worried subgroups. Risks to people in general in Sweden regarding radiation was perceived as higher than the corresponding risks to one's own person. This response tendency was found also among residents of the Gävle area, i.e. among those who actually lived in one of the most exposed areas of Sweden. The Gävle respondents did not differ from others, however, in ratings of other non-radiation risks. Furthermore, regional differences regarding risks related to nuclear power and radiation could not be explained by general risk aversion (as measured by ratings of ordinary adverse events excluding the radiation aspect). The risk of radiation injury due to the accident was rated among the four most serious risks in a list of eleven, in all the subgroups of the study, except for men without children, who ranked it fifth.

Perceived bodily symptoms attributed to the accident were rare. To have felt off balance was more common, however, and about 16% reported to have been in such a psychological state to a very or rather high degree. Group comparisons showed that residents of the Gävle area, women and farmers reported these

feelings more frequently than others did. The same groups also reported the most changes in daily habits due to the accident, but a relatively large percentage of the sample, about half the respondents of each subgroup, reported to have made no changes at all.

Adolescents were less worried about the accident than other groups. Young women were more worried than young men, but considerably more positive to nuclear power than other women. Adolescents of the Gävle region seemed less affected by the accident than other respondents of the same area, but, for example, young men of the region were more affected by the accident than other young men.

A multiple regression analysis with risk evaluation of nuclear power as the dependent variable, and indices of perceived nuclear power risk, effects of the Chernobyl accident, risk of Swedish nuclear power, perceived injury and general risk aversion as independent variables resulted in a multiple squared correlation of 0.571. The nuclear power risk index obtained the highest beta-value, followed by the risk of Swedish nuclear power and effects of the accident. Perceived injury and general risk perception contributed only marginally to the power of prediction.

In sum, the Chernobyl accident affected a great proportion of the subjects as measured in terms of worry and nuclear power attitude. The latter was predominantly negative. People in the region with the highest exposure to radioactive fall-out were twice as often worried about radiation injury as others. Farmers, parents and women proved, as expected, to react more strongly to the accident than others. The reaction of these groups, as well as those of the others followed, however, the reported level of exposure with respect to the area in which they lived.

The discussion of the results mentioned the discrepancy between the public reaction to a power plant disaster and the official notion of a reliable technology. The increased worry, as reported by the subjects, and the high risk ratings, especially by women, parents and farmers were interpreted from the perspective of these groups' special concern for others, that is, responsibility for care for others and for food production.

PAPER 2: *Psychological reactions to cancer risks after the Chernobyl accident*[4]

The paper summarizes three studies aimed at investigating attitude to nuclear power and risk perception after the Chernobyl accident. (It should be noted that the title of this paper was chosen by the journal and not by the authors). Only the interview study and the panel study will be commented upon here, since the main results of the survey study have already been reported above.

The interview study (N=59) was based on convenience samples of farmers, pregnant women, adolescents and men without children of their own. They were personally interviewed in three regions of Sweden: the regions of Gävle, Stockholm and Bohus. Interview questions were used together with a number of checklists,

[4] Figures 2 and 3 of the published article were accidently interchanged relative their figure captions. The mistake has been corrected in this version.

which the respondent marked personally. The questionnaire used a number of calibration questions to compare results to those of representative samples of the population, since the participants were not randomly chosen. The results of the calibration questions showed overall a reasonable close fit to population data provided by other studies, especially regarding level of worry. Estimates of the number of future cancer cases in the Swedish population due to the accident, however, was more pessimistic than data of the population study, e.g. 37% of the interviewees believed that about 100 persons would get cancer due to the accident, and 25% believed that about 1000 persons would meet this fate, compared to 21% and 15% respectively in population data. Similarly, there were somewhat more pessimistic reports of possible genetic injury due to the accident as compared to population data. This difference between the studies was interpreted as possibly influenced by the increased coverage of the accident in the media during the time interval between the compared studies. Some adjustments of risk estimates were also announced during the early summer by the radiation protection authorities, which might have influenced the opinion in the direction measured in our study.

Perceived worry related to the accident was overall high among all groups of interviewees, and 69% reported that they had been "very" or "rather" worried due to the accident. Two percent were not worried at all, just as many did not know, and 27% were "not especially worried".

Women were more worried than men, and pregnant women more so than other groups, but there was no significant difference between pregnant women and other women. The interview study revealed no significant difference in worry between regions, although a tendency in the expected direction showed that women in the Gävle region were the most worried. Worry was positively related to perceived nuclear power risks, but not to radiation risks of other kinds, e.g. X-rays and sunbathing. Those who worried more tended to report that they had little information on how to behave in the case of an accident. (This comment was very common, however.) They were furthermore often negative to the use of nuclear power and fossil fuels, and more positive to hydro power and alternative sources of energy.

Changes in daily activities were most frequently reported by farmers and pregnant women. Risks of nuclear power, and radiation risks, correlated positively with reports of such changes, especially in the female subgroup.

Comparisons of risk of certain activities before and after the Chernobyl accident generally showed that most activities were perceived as more risky after the event, especially being outdoors. Spearman rank order correlations showed that the greater perceived risk the larger the decrease of activity after the accident.

Attitudes to different energy sources were measured and the results showed the overall most favorable attitudes to apply to hydro power and alternative sources of energy (e.g. wind, sun, and fast-growing forests). There were less favorable attitudes to oil, coal, and nuclear power. Among the compared energy sources hydro power seemed to have all the positive attributes, i.e. it was considered clean, safe, economically advantageous and under domestic control.

With respect to the ability to influence domestic energy policy, personal influence was rated lower than popular influence. Degree of ability to influence

energy policy covaried with age. Among the subgroups farmers were the most optimistic, and pregnant women the most pessimistic.

Ratings of media sources, showed that TV and radio were regarded as the most reliable sources, and evening newspapers the least reliable regarding information on radiation levels and risks. The respondents believed that people would become more safety oriented due to the accident, but the current preparedness to deal with nuclear disasters was perceived as low.

In sum, the interview study provided some information about attitudes, risk perception and worry among various groups of subjects living in areas differently affected by the Chernobyl accident. The study also provided valuable information for the following mail study regarding central issues, questions and scale constructions.

The panel study was designed to measure stability of nuclear power attitude over time. A first and rather extensive questionnaire was mailed to new samples of respondents. After about one month they received a second and shorter questionnaire which mainly repeated some of the questions of the former questionnaire.

The results showed one main difference between the two occasions, i.e. that respondents had become more pessimistic about risks of radiation injury in Sweden. The correlation between responses of the two occasions regarding personal risk of injury was 0.74, and of risk of radiation injury for people in general was 0.68. Attitude to nuclear power on the two respective occasions correlated highly, 0.88, and that was also the case with items measuring perceived risks of domestic nuclear power (0.83). With respect to another item (the importance of the nuclear power issue), however, there was a quite low stability over the short time of one month. (See also the discussion of generalization above).

The result of the panel study was thus that the target item of nuclear power attitude showed considerable stability over the time period measured, a result which was also obtained regarding perceived risk of domestic nuclear power. This testified to the reliability of our attitude scores. Other items seemed more vulnerable to change over time.

The discussion of the interview study noted both the high levels of worry and the frequent reports of not knowing how to behave in the case of a nuclear accident. It was pointed out that many subjects perceived a conflict between economy and safety with respect to use of nuclear energy. The importance in risk perception of the future perspective was evident in this study. The discussion of the panel study mentioned the variations between different correlations measuring change over time, and pointed out that the stability was substantial with respect to the attitude measure, over the measured time period.

PAPER 3: *Adolescents' attitudes to nuclear power and radioactive wastes*

The purpose of the study was to investigate adolescents' perceptions of nuclear waste issues and to compare their attitudes and perceptions to those of an adult representative sample of the population. Questionnaires in the form of small booklets were used. Students of five high school programs participated (N=380), *viz.*

students of technology, natural science, economics, social science and humanities. It was hypothesized that the adolescents would rate risks lower than the adults, and that students of the different study programs would report attitudes and risk perceptions in accordance with their general interest orientations. Especially students of technology and economics were expected to be less negative to nuclear power, and to rate risks of that technology lower than others. It was argued that support for this notion would strengthen an argument that socialization of values in line with future career prospects can be observed prior to the acquisition of actual expert knowledge, and that such a result would weaken the assumption of superior knowledge as being the sole basis for large differences in risk perception, e.g. in the area of nuclear power, between experts and lay people.

The results showed that students were aware of both advantages and disadvantages of nuclear power. Environmental, economic and energy supply issues were the most frequently listed advantages, whereas risks and waste issues were the main reported disadvantages. On the average, all male students, except those of social science, as well as female technologists, agreed to a statement that benefits of nuclear power are larger than risks of radioactive waste.

Men, and students of technology and economics, were most positive to nuclear power; women, and students of social science the least. Mean values of natural science students were found to be in between these groups. A comparison to the adult sample showed adolescents as significantly more positive to nuclear power than the adults. This was the case for both men and women when compared separately.

Various threats to society were rated as more severe by women than by men. One exception was the threat of environmental pollution, which was seen as a major threat in both groups. The nuclear power threat was ranked third by women and sixth by men among seven listed threats. This item obtained the largest difference between the study programs, and the results showed the same trend as mentioned above regarding nuclear power attitude. As with nuclear power attitude, the adolescents again rated the threat to society of nuclear power lower than the adults.

About 65% of the students worried about something in connection with domestic use of nuclear power. Those who worried mentioned risks, accidents, waste and radiation in their motivations. Those students who did not worry said they trusted the security measures surrounding the use of nuclear power. A question of current risk of radiation injury showed than women believed this risk to be greater than men did. The lowest ratings were again made by technology students, and the highest by students of social science.

Personal risks were rated higher if items made a reference to radiation. A nuclear power risk index showed the same trend as above regarding sex and study programs, and correlated strongly with nuclear power attitude. Personal risk used as a covariate in the nuclear power risk rating could not account for the group differences.

It was judged that high level waste should be placed deeper in bedrock than low level waste, sometimes at great depths. The suggested time period during which high level waste from nuclear plants would be harmful to humans ranged

between zero to millions of years. Both adolescents and adults rated their current knowledge of the domestic handling and disposal of nuclear waste as rather low, on the average. Reported personal knowledge did not differ between students of different study programs. Men, however, reported more knowledge than women. A similar sex difference was found in the adult sample.

With respect to ratings of risks of serious accidents involving radioactive waste, the same trend of risk perception as noted above could be discerned regarding the study programs. The main group difference was related to sex, however, and adult and adolescent women gave the highest ratings in the respective studies. All ratings including radioactive waste in accident scenarios were high. Ratings of the influence of nuclear power on life values showed that nuclear power was seen to have an especially negative influence with respect to physical health and hope for the future. On the average, both men and women perceived nuclear power to have a positive influence on economic standard, but only men saw a positive influence of nuclear power on freedom.

Nuclear attitude could be fairly well predicted by the life values. Students of different study programs were divided into two groups and by sex. The results of the prediction equations showed higher R^2 values for men than for women, and that the hope for the future predictor was the most influential for both male and female students of social science, natural science and humanities. The results regarding male technologists and economists showed a greater dispersion of influence from life value predictors.

Several separate multiple regression analyses for predictions of perceptions of risks of nuclear waste showed that eight predictors could account for 30-70% of the variance. Nuclear power attitude, trust and general perceived threat to society were among the predictors contributing significantly in several of the equations. An index of personal risk ratings, excluding items mentioning radioactivity, gave a significant contribution only to the predictions of the two dependent variables which explicitly included radiation.

In sum, the study supported the notion that adolescents report lower perceived risks than adults, and that significant differences can be observed between students of different programs. These differences were in the expected direction, i.e. students specializing in technology and economics were more positive to nuclear power, and perceived less risks of that technology. Especially students of social science differed from these groups, and students of humanities and natural science were often found in between the others. The perceived influence of life values could rather well predict nuclear power attitude. Predictions of nuclear waste risk perceptions obtained the largest contributions from predictors measuring attitude, trust and threat to society. Between 30-70% of the variance of the five dependent variables could be explained by the employed eight predictors.

The discussion of the paper mentioned the possibility that general interest orientation may be a factor to recognize in the explanation of the often noticed discrepancy between public and expert risk perceptions, since value orientations in that direction could be found already among high school students who had chosen study directions in accordance with requirements for a future career as

experts. It was pointed out that students of different study programs did not differ with respect to self-rated knowledge of nuclear waste issues.

The correspondence between risk rating results of this paper and results in the Chernobyl papers was also acknowledged with respect to adolescents' reporting lower risks than adults. Findings of differences regarding objective risk levels between youngsters of different socioeconomic backgrounds and gender were also mentioned. The "hope for the future" predictor again contributed significantly to the explained variance of nuclear power attitude. "Trust" emerged as a significant predictor in all equations predicting perceived risk of nuclear waste.

PAPER 4: *Knowledge and risk perception among nuclear power plant employees*

The study of nuclear power plant employees (N=236) involved ten different groups of employees, and was aimed at investigating perceived risk in the work environment of these personnel groups, relate their level of knowledge about radiation to perceived risk and to investigate the importance of risk perception for job satisfaction. Perceived radiation risk was also to be compared to an expert estimate of radiation exposure. Some attempts were also made to study the role of background data, job tasks and personality for risk perception. Furthermore, subjects personal definition or use of the risk concept was assumed to be related to their perception of risk, and it was of interest to compare risk ratings on the basis of different types of measures.

Both interview questions and rating scales were used in the study to elicit a great variety of data. Three rating scales of risk were included, *viz.* absolute category, comparative category and numerical ratings. Analyses of scale properties of the rating scales showed a strong linear relationship between the risk mean values of the absolute category and comparative category scales. The number rating scale showed a curvilinear trend when plotted against the absolute category mean ratings. All three kinds of ratings tended to produce the same rank order of risk ratings, however, and the curvilinear trend in the latter case was mostly due to the response format of the numerical scale.

Risk ratings analyzed across subjects showed rather low relationships between the two kinds of category judgments and the numerical ratings. This finding could partly be resolved by the use of logarithmic numerical values. Comparative judgments included in themselves the comparison of job environment risk and other risks. When absolute category and number ratings were adjusted for rated job environmental risk their correlations with comparative judgments increased.

The examination of scale properties thus showed that the three different methods of measuring perceived risk agreed rather well on an aggregated level. It was possible however, that the subjects' own definitions of risk, i.e. their judgement strategy, would also play a part in how risks were perceived. The results of an investigation of risk definitions showed firstly, that different and independent groups of respondents could be constructed with respect to how they defined the risk concept. Secondly, it showed that the risk ratings of the groups using different judgement strategies varied over type of rating scale, i.e. in the cases of absolute

category ratings and for numerical ratings (log.) did those who defined risk in terms of mainly consequences of events also give higher risk ratings. Regarding comparative judgments, the group which defined risk as purely a combination of probability and consequences gave the higher risk ratings. It could be shown that these ratings were made in the framework of low perceived job environmental risk. In no instance did subjects who defined risk on the basis of probability rate risks higher than others.

Perceived job risks were, over subjects, to some extent related to radiation knowledge, personality and background data. For example, subjects who had a lower education, and those who had less knowledge of radiation issues generally perceived risks as higher than others; so did those who often worked in controlled areas, and those who had a weak self confidence, or reported somatic anxiety.

Several items included in the employed list were rated as carrying a larger risk than the one perceived in the work environment. Naturally enough, work similar to one's own, but which lacked the aspect of radiation, was judged as less risky. Perceived job risk was fairly well accounted for by the predictors of perceived nuclear risk (more than 30% of the variance), frequency of work in controlled sections, general accident risk and amount of radiation instruction. The last predictor entered the equation with a negative sign, i.e. information and instruction about radiation seemed to influence the subjects to perceive smaller job risks. Amount of instruction had a stronger relationship with perceived risk than had knowledge, indicating that instruction added something beyond increased knowledge, e.g. general attitude.

The difference of the geometric mean values of the raw numerical ratings of risk (divided by 100.000) in the own work environment, and risk in a work environment similar to one's own but excluding radiation, gave a value of the additional job risk attributed to radiation. This value of additional risk was compared to radiation experts' estimation of radiation risk for employees at the plants. The comparisons of the results roughly showed them to be similar in magnitude, i.e. 10^{-5} per year.

Job satisfaction could to some extent be predicted by low tension, satisfaction with salary and perception of conventional job risks. Neither general accident risk nor nuclear risk entered into this prediction.

A test given to all subjects of knowledge about radiation relevant issues showed a negatively skewed response distribution, i.e. it turned out to contain fairly easy questions for the groups involved. However, although the mean value was high, there was considerable variation among the professional groups. Radiation protection personnel scored highest on the test, steam generator workers lowest. The relationship between radiation knowledge and perceived job risk was quite strong at the group level, also when controlling for differences in job conditions. Radiation protection personnel were also given a second and more advanced test of their knowledge, resulting in less impressive results.

Sixteen measured risks were tested for group differences on the basis of absolute category judgments, and there were no overall differences apart from perceived job risks. The same risk judgments based on the comparative ratings all

differentiated between groups. Especially steam generator workers judged their job risks as high and gave low ratings of other risks.

The results of the effects on general accident risk on variation in perceived own job risk are discussed in the paper. It seemed as if high perceived job risk resulted in a relative trivialization of other risks, i.e. a possible contrast effect. Personality variables did not contribute to any large extent to the prediction of perceived job risk. There was, however, a stronger relationship between perceived nuclear job risk and personality than between personality and conventional job risks.

In sum, the study showed that different measures of perceived risk might produce somewhat differing data, but that the rank relation between rated items remains robust. The rank order robustness thus contributed to a validation of the scales. The results furthermore pointed to the validity of the semantic content in that the adjusting of the numerical and absolute category scales regarding own work risk resulted in better agreement with comparative ratings.

Perceived job risk could rather well be accounted for by perceived nuclear risk, frequency of work in controlled sections, general accident risk and amount of radiation instruction. The methodology to measure additional risk in an environment including radiation as the difference between own job risk and risk in a similar job excluding the radiation aspect seemed to prove a practicable way to estimate a very small perceived risk. The overall experience of general job risks was related to knowledge of radiation, i.e. those who had better knowledge perceived lower risks. Job satisfaction could be predicted from degree of tension, satisfaction with salary and perceived conventional job risk, whereas nuclear risk did not enter the prediction.

The discussion of the results related to a French study of nuclear power plant personnel, which presented similar results of perceived job environmental risk, differences between participating personnel groups, and the relationship between knowledge and risk perception. The possible implications of different risk definitions were also discussed. The stronger relationship between general job risk and nuclear risk, compared to the former and conventional job risk, was interpreted in terms of general job risks possibly being more sensitive to risk salience than to conventional risks.

PAPER 5: *Risk perception and definitions of risk*

The paper focuses on how subjects in a series of studies have reported that they use the term risk, and relates these risk definitions to actual risk ratings. The paper also presents some researchers' explicitly expressed definitions or preferred use of the concept. It is argued that some of the complexities often encountered in risk communication and in risk perception literature may be related to the different uses and understanding of the risk concept.

The study investigated four suggested definitions of risk, i.e. risk as mainly a question of probability of an event, as a combination of probability and

consequences of an event, as a question of mainly the consequences of an event and that its meaning is entirely due to the kind or the nature of an event.

With respect to the risk definition responses, subjects had first to be categorized into independent groups, due to the methodology used. This was done in two ways. The first categorization was rather strict, excluding the fourth definition and uncertain responses, whereas the second categorization included also these aspects.

A series of risks were considered. There were items rated with respect to personal risk, regarding risk to others or to people in general, and items which were rated with respect to the threat to society. These kinds of ratings were considered as ratings of risks from different perspectives.

There were also different kinds of risks involved, and in this context they could be classified in two main groups: ordinary possible adverse events, and events or situations including radiation.

The main results showed that subjects who used a definition of risk which focused on consequences of an event gave higher risk ratings than subjects who reported that they defined risk in terms of the probability of an event. This tendency was clearly discernable in data from several studies, although it was not always significant. Sex differences played a certain role in the results since women generally rated risks higher than men did, and also tended to focus on a consequence definition of risk. However, in spite of the often very substantial sex differences in the ratings, the risk definition trend prevailed in each sex group.

Apart from the results especially related to the risk definitions, the paper presented results which showed that risks rated from another perspective than the personal were rated higher. That is, risks to people generally and to society were perceived as higher than when rated as risks to the own person. A third main result was the considerable difference between perceived risk of ordinary events or situations, and events which included some aspect of radiation. The latter ratings were considerably higher, although effects of rating perspective and used definition of risk still prevailed.

When reports of risk definitions were compared using a unidimensional scale and the four risk definitions mentioned above, it could be shown that the unidimensional scale did not capture all the possible response variations which were expressed by the other methodology. There was, for example, a strong tendency of the unidimensional methodology to incorporate the otherwise reported uncertain responses in the middle response category of the scale, in this case the least extreme response alternative, defining risk as a combination of probability and consequences of an event.

The results were discussed in a wider context of social phenomena with relevance for risk perception, risk acceptance and risk communication, e.g. the NIMBY phenomenon, which is characterized by local opposition to the siting of risky technologies. The lower personal risk ratings compared to the same risks rated for people generally were interpreted as the latter reflecting concern about a community or having a more generalized basis than the former. It was pointed out that aspects related to moral standards, future generations and perceived

personal significance may play a part in risk ratings generally, as well as account for some differences with respect to rated personal risk and risk for others.

The use of different methods to measure risk definitions was discussed, and it was pointed out that information may be lost in using a unidimensional scale for this purpose. The results which showed different preferences with respect to personal use of the risk concept were suggested as of possible relevance to the differences of risk ratings obtained between experts and lay people. The interest in further investigations regarding risk perception as related to events with low probability and high consequences versus events with high probability and low consequences was pointed out. Some research findings were mentioned which suggested a possible shift of risk definitions in such differently framed situations.

PAPER 6: *Risk: conceptions, reactions and communication*

The paper discussed risks and risk perception in modern society, as well as the complexity and importance of the issues in a rapidly changing world. For example, the huge human and economic costs of mistakes and accidents were exemplified. It was pointed out that there exists a great variation of perceived net benefits of modern technologies including some negative expectations, but that discoveries and new technologies often are embraced with overall positive expectations. It was also suggested that failure to keep up with such expectations can violate public trust in corporations and authorities. Trust, and the importance of morality and values in risk perception and in risk acceptability was highlighted.

It was argued that it is essential to establish and restore trust in modern technology and in specialists by means of rigorous safety standards and a keenly alive dialogue between experts and the public. The importance of choice of terminology and the expression of shared values was emphasized in this context.

Feelings of fear and dread were related to personal inability to influence developments, and to detect harmful agents in the environment, and thus to the diminished ability to defend oneself and others with respect to health and life. The consideration of well-being of future generations related to perceived risk and the conception of a meaningful life was discussed. It is finally predicted that the future will see more vigorously enforced joint attempts to prevent and handle human and ecological disasters.

The results and interpretations of the presented papers will be further discussed below in a more general research framework. Prior to that discussion, however, a discussion of use of language in empirical psychological research is included, which also gives special attention to some central concepts used in the thesis.

The results and interpretations of the presented papers will be further discussed below in a more general research framework. Prior to that discussion, however, a discussion of use of language in empirical psychological research is included, which also gives special attention to some central concepts used in the thesis.

TERMS AND CONCEPTS

'The fuzzy utterance results from fuzzy thinking' is a popular saying in Swedish which requests the employment of both brain cells and unambiguous language in communication. There are more aspects to communication and clear language, however, than is conveyed in this saying. I will discuss below some questions of terminology and use of language in which answers to the more intricate details should be sought among experts of philosophy and semantics. My intention is, however, to discuss some of the problems involved in using language, which should both be intelligible in ordinary communication and correct with respect to research aims. In the discourse some of the central concepts of the thesis will be discussed.

Two aspects can be discerned as influencing the clarity and meaning of language. Firstly, there is the aspect of *which* parties are involved in communication. It can be illustrated as varying along a dimension of similarity with respect to personal experience and knowledge background. Secondly, there is the contextual influence on the determination of meaning[5]. This is an aspect which brings in a variation between ambiguity (e.g. in everyday language) and specificity (professional and scientific language).

Parties in a communication process can use verbal or written language which contains terms with either the same or different meanings. The former case involves few difficulties. In the latter case, however, the parties may either know and accept that the same word has different meanings or misunderstand each other. Misunderstandings may be followed by attempts to bridge the differences by using explicit definitions of meaning, or by borrowing meaning content from each other during the discourse. The result is increased communicative ability in the given context, but the process may also change the meanings originally associated with the terms. An example of the dispersions of meaning associated with certain words in different contexts is the meaning(s) of "energy" in everyday language and in the terminology of engineers. Hansson (1987) wrote about the different meanings of words in different contexts:

> "... This double use is of no disadvantage if it is commonly understood that the word has two meanings, none of which should replace the other. Thus no geneticist would criticize a person who said that he had inherited a sum of money, or claim that "inheritance" means only genetic transference..." (p. 3-4).

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[5] Those who have read a transcript of an ordinary conversation between two people have presumably noticed the passages of seemingly sheer nonsense utterances. In listening to the conversation, however, even silence becomes meaningful. This is due to the simple fact that oral and personal communication includes an abundance of cues to the correct interpretation of what is said, e.g. cues from the voice, the facial expression and the bodily posture, etc. Written communication excludes such cues, and relies heavily on the semantic meaning of concepts and the clarity of formulations. (See also Drottz, 1985).

In discussing terminology it is important to distinguish between the constructs "term" and "concept", which in everyday language both signify "word", but which also carry the disparate meanings of "simple construct" vs. "complex" or "aggregated construct". "Terms", as the word is used here, are employed in everyday language on the basis of their generally accepted meaning(s), whereas "concepts" are employed to communicate a theoretically defined meaning[6]. An example is the different connotations of "opinion" and "attitude". Both terms simply mean "point of view" in everyday language. The concept of "attitude", however, in e.g. scientific psychology denotes certain theoretical constructs. These constructs or theoretical models, (there are several of them), may include prescribed relationships to other constructs, or they may denote a certain assumed configuration of basic components which constitute the concept. To confuse matters further, it is possible to use in the same discourse the concept of "attitude" both in a more general sense, e.g. "attitude research", and in a specific sense which exactly defines the intended meaning, e.g. "the Fishbein-Ajzen attitude model".

In the practical empirical work of research in psychology intelligible communication requires both the use of commonly understood language and the preservation of the intended scientific content meaning of the used or studied concepts. Some tricky concepts and considerations will be mentioned below. I will start with an example of a particularly relevant term and concept related to the present thesis, *viz.* risk.

"Risk" is an old and common word in many languages (e.g. the French *risque*; damage, bold venture. See also the citation in the beginning of the introduction). It's everyday meaning denotes uncertainty associated with danger regarding a future, or an imagined, event. If something is "risky" or "not without its risk", the implication is thus that it involves the components of uncertainty and some degree of danger. Certain negative events cannot be described as risks because they lack the component of uncertainty. Growing older is one example. However, there may be risks associated with aging. Compare the distinction between "a risk" and "a risk associated with". "Risk" should therefore be distinguished from events with certain outcomes, and "risky" conditions involve danger. It is also interesting to note the connotations of the verb "to risk" to include "to dare" and "to venture", words which have a positive connotation.

Lindell and Sjöberg (1989) used Webster's Dictionary in distinguishing between four meanings of "risk" and I quote:

> "(1) the possibility of loss, injury, disadvantage or destruction; (2) someone or something that creates or suggests a hazard or adverse chance: a dangerous element or factor - often used with qualifiers to indicate the

[6] The distinction is, of course, very rough. There are certainly a large number of "concepts" used in everyday language. For example, "house" and "bird" are concepts subsuming a variety of specific cases. My distinction between "simple" and "compound" constructs is only aimed to distinguish between the use of words in the everyday vague meaning and the specific professional or scientific meaning.

degree or kind of hazard; (3)(a)1: the chance of loss or the perils to the subject matter of insurance covered by a contract; (2) the degree of probability of such loss; (b) amount at risk; (c) a person or thing judged as a hazard to an insurer; (d) an insurance hazard from a specified cause or source; (4) the product of the amount that may be lost and the probability of loosing it - compare expectation" (p. 4435).

These meanings suggest that risk can be construed as either the *mere possibility* of an adverse event, the *cause* of an event, the *magnitude* of the consequence, as someone or something *judged as a hazard* and as the *conceptualization* of a procedure for the estimation of a quantity. The authors noted that in the generic sense "risk" includes a variety of concepts which together constitute the risk concept.

The future orientation is obvious in these meanings of risk. It is possible, however, to discuss risk from a historical perspective, e.g. "he took a risk" or "they miscalculated the risk of encountering icebergs" although we now know the outcome. Those utterances reflect an implicit assumption that the statements should be understood from the point of view of those involved. And from that perspective the actions involved uncertainty about outcomes in the future.

As can be seen in the citation above, one meaning of risk includes someone or something creating a hazard. Does this definition make criminal elements or automobiles to be "risks"? Is a nuclear installation a risk even if nothing harmful ever happens there, or should it in this case be referred to as a "hazard", or a "possible hazard", since accidents have happened elsewhere? Is being a possible hazard synonymous with being a risk, or being a possible risk? What does a "possible risk" mean if "risk" is defined a "possible loss"? The dictionary examples do not specify what meaning should be excluded from the "risk" concept, and a variety of disparate responses to these questions can be found in the rhetoric of e.g. political argumentation. There simply does not exist a universally "true" risk concept. As mentioned above it is a compound concept. The commonly used term "risk" belongs to a domain of concepts which depend on other concepts and perceptions for their definition. In this sense it may be compared to the concepts of fairness, happiness and beauty. The point to be made here is that "risk" certainly may be used with clearly defined and specific meanings, but that the "true" meaning undeniably is elusive. The meanings or definitions of "risk" reflect semantic consensus of how to perceive phenomena which exist solely as products extracted from our mental representations of the world. This means that without subjective apprehension and evaluation of phenomena, risk would not exist.

The notion above on perceived subjective phenomena conveys the meaning of "perceived risk". Slovic (1987) used "intuitive risk judgments" to denote risk perceptions. The phenomenon of risk requires subjective apprehension and evaluation. It may certainly be real, but it cannot exist without an apprehending subject and it cannot be observed in the same sense as material objects. However, it can be estimated, and it can be subjectively perceived or construed. It is perceptions of risk which are reflected in the results of this thesis. As with beauty,

perceived risk lies in the eyes of the beholder. And as in fashion, there may exist general agreement about what is appropriate to consider as a risk, but different times show considerable change of preferences. Preoccupations of our time concern good health and high economic standard, whereas other times confronted the unmasked reality of sheer survival. This is also a reality which faces a large part of humanity in other parts of the world in our time, however, and this fact exemplifies very clearly that perception of risks is content dependent.

Hansson (1987) discussed risk as intimately connected with the societal decision process. The choice of a risk evaluation model is thus also a choice of what aspects will be accounted for and discounted of. With respect to *risk comparisons* he stated the existence of several rational comparison methods. Although they are all rational, they differ with regard to evaluative perspective.

The extent to which risk perceptions are objectively true I consider a metaphysical question. This stand does not exclude, or diminish the importance of, comparisons between estimated objective risk and perceptions of the same risk. Neither is the issue uninteresting or meaningless, since "meaning" constitutes the very fundament on which a subjective existence is built.

A short note should be made in this context of the "risk" concept being used somewhat differently in different areas of research. For example, the risks related to business management and entrepreneurship are sometimes addressed in terms of financial risks, social risks and emotional risks. The terms risk propensity or risk proneness, risk seeking and risk aversion are often used in the context of economic risk taking, including risk taking as measured in game theory (see Wärneryd, 1988; Lopes, 1987). The terms denote meanings specific to the context, e.g. risk propensity could be readily interpreted as willingness to engage in risky economic endeavors; risk seeking and risk aversion are often defined on the basis of theoretical constructs, and the measurement of what objective, or subjective, odds are found adequate or acceptable. It should be noted that "risk aversion" is not synonymous with risk attitude, but has a specific meaning related to risk acceptance; that is, risk acceptance in the sense of accepting a choice option. In relation to this framework, March and Sevón (1988) discussed decision making and attitudes towards risk within the business firm, and related managerial risk taking to the different utility functions of gains and losses (See also Kahneman & Tversky, 1984; Tversky & Kahneman, 1986). They stated that "riskiness is a feature of decision problems" (p. 379).

Wärneryd (1988) used the concept "perception of risk" against a background of subjective experiences of risk and individual behavior, and related research findings to attribution theory and prospect theory. It can be seen that also in this research area risk is related to uncertainty, but additional distinctions are made. The interpretation of one's own and other's risk taking in this sense is not addressed in the present thesis.

Let me return to the use of concepts in language and to the earlier outlined frame of reference of risk perception research. It was obvious from above that risk involves an aspect of danger. The next paragraphs address its relationship with the concept of "hazard".

Orr and Fogle (1988) traced the word "hazard" to the Arabic "az-zahr", which means "the die", and they referred to two meanings of the word used in Webster's Dictionary: "(1) a game of chance like craps played with dice and (2) an adverse chance, as of being lost, injured or defeated" (p. 1). The authors continued: "Many people understand a hazard to be a condition that tends to create or increase the chance of loss" (p. 1). This meaning seems straightforward and, disregarding hazard gambling in this context, "hazard" hence denotes the possibility of a negative outcome. The relationships between "risk" and "hazard" as they can be derived from some of the examples taken from the citations above therefore become: (1) "risk" as "the possibility of loss" overlaps with the definition of "hazard" as "an adverse chance", and (2) risk as "someone or something that creates or suggests a hazard" relates to "hazard" as a cause to its effect, but since one connotation of "hazard" was "a condition that tends to create or increase the chance of loss" the relationship between risk and hazard may also be understood in terms of both of them being conditions which include possible adverse events. That is, if a "condition" can be synonymous with "someone or something that creates or suggests a hazard".

In sum, there are overlapping meanings with respect to the words "risk" and "hazard". This does not imply, however, that the words are fully synonymous, although they may sometimes be used so in everyday language. The word "risk" has a more diversified number of connotations. An example of one which does not overlap "hazard" is "risk" defined as the conceptualization of a procedure to estimate a quantity.

I will here briefly mention the possibility of a total break-down in communication and in theoretical constructions if concepts like "risk", "hazard", "hazard causes", "hazard likelihood", "risk probability", "possible risk", etc. are used interchangeably or too freely. A rule of thumb would be to define concepts rigorously, which often means very narrowly, but one problem here is that truly precise concepts are not available. Very specific meanings can, of course, be construed. The problem with this attempt at solution is that the construed concepts in themselves often must build on other vaguely defined concepts. The approach in the empirical parts of the thesis has instead been to use another heuristic. It can shortly be described as "stick to common and readily understood concepts, and specify instructions to subjects". This rule assumes that terms and concepts are interpreted in accordance with their normal semantic meaning in everyday language. In the case of "risk" it is obvious that different content meanings can be employed by subjects, and one of the papers in the thesis actually presents results which support the notion that this is the case. These results would hardly have been obtained with the use of imposed definitions of risk, or in fact, another simpler methodology.

To conclude, a variety of concepts are available in the domain of risk ratings. The choice of theoretical construct of risk which one wants to measure includes a series of considerations. Should, for example, a concept be readily understood by its common sense meaning or should it be strictly defined and described extensively? In the first case one is confronted with the dilemma of not knowing

what meaning the subjects utilized in their ratings. This, of course, is exactly the motivation of paper 5 in the thesis. In the second case the dilemma of subjects actually understanding the intended meaning arises, together with uncertainty about their ability to understand correctly, and their willingness to use the concept. For example, despite explanations of how to understand and use the expected value construct subjects may refuse to employ it.

Other concepts used in the thesis which require some comment are "threat", "catastrophe", "disaster", and with respect to the latter two concepts, the distinction between man-made and natural accidental events. Again I must make the reservation that my discussion of the use of concepts to be found in the thesis only touch upon their face value, and excludes attempts to delineate their profoundly complex nature.

The term "threat" was used in its ordinary everyday meaning of "possible danger". "Threat" was preferred to "risk" because it was a more natural way in the Swedish language to express the intention of what subjects were supposed to rate on the provided scales. The subjects were asked to give their perceptions of the danger facing society at large from e.g. violence, the AIDS disease, nuclear power and environmental pollution. The ratings included the perceptions of impersonal agents influencing a collective entity in a negative manner. To use "risk" in this context would have required the more awkward instruction to the subjects to rate their perceptions of e.g. "the risk of negative influence" on society; an expression which still not adequately accounts for the emotional component involved in "threat".

These "threat" ratings were in some analyses compared to "risk" ratings related to the own person and to people generally. One could argue that such comparisons would have been more adequate had subjects also rated the "threat" to their own person or to people generally, or vice versa. This is probably not the case, however, and the motivation again rests on the meaning content of terms and concepts. To rate a "threat" to one's own person is to complete a rating task within a more alarming context than to rate the "risk" that something negative will happen. A "threat" to a person is thus much more emotionally loaded than a "risk" a person confronts, cf. "the risk of injury" and "the threat of injury". Conversely, a risk to society, in natural language, implies to some extent a doomsday's scenario focusing on a society at risk rather than subjected to a degree of danger. These considerations constitute the background to the choice to include both "threat" and "risk" ratings in the questionnaires used in the empirical studies.

The issue of the relation between agent and victim becomes central when scrutinizing the concepts of natural versus man-made disaster. Let me first say that "disaster" and "catastrophe" are used synonymously in the thesis. The concepts are partly overlapping in their general meaning of "severe accident". The "accident" interpretation of these concepts in turn informs about the unexpected or unintended nature of the negative events. The distinction between natural and man-made (sometimes technological) disasters is not the unexpectedness of accidents, however, but rather their source and the perceived responsibility for their occurrence. The agent is either Nature itself, e.g. in the forms of tornados,

blizzards or earth quakes, or takes the form of failure or break-down of human constructions, e.g. accidents involving dam constructions, chemical or nuclear installations, etc. (See also Baum, 1987, for a discussion of the definition of "disaster").

The more common employment of "disaster" and "catastrophe" lies in a wider, societal perspective. Otherwise we use the more precise expression of "personal catastrophe". The expression "personal disaster" is seldom used, however, although it might refer to a socially less well adjusted personality. "Catastrophes" or "disasters" usually imply severe damage or loss in either magnitude of consequences or with respect to the importance of the loss. The damage and loss can refer to human death and suffering, economical ruin, and the destruction of nature or natural resources, as well as technical and social infrastructures.

The imprecise quality of the distinction between natural and man-made catastrophes becomes obvious in the Swedish expression of famine, i.e. "hunger catastrophe", where cause and responsibility can be attributed to either weather, e.g. draught, or ineffective social organization, or perhaps to the combination of both. Another phenomenon which is difficult to categorize is an epidemic, which similarly can be the result of either unknown agents (the AIDS disease) which could not be predicted, or human neglect of health standards (e.g. salmonella) which could have been avoided. The use of the distinction between natural and man-made disasters in the thesis thus rests on perceptions of what caused them and what or who is seen as responsible for the negative event. The difference between personal and collective catastrophes should be kept in mind in discussions of risk perception and worry. It seems as we perceive events differently when it comes to events related to oneself personally versus to people generally, or to the society at large. Also, the degree of involvement varies across different events or objects. We think of societal risks and potential catastrophes as more or less related to personal life, and we discount or exaggerate events which are closely connected to personal life or life-style.

We can be "concerned" and "worried" about the development of events. The use of "worry" in the thesis always refers to emotional involvement, including anxiety. "Concern" on the other hand, is used more loosely, and can imply both "worried about" and "take seriously". The most frequently used meaning in the thesis is the latter. This meaning does not require anxiety or any emotional involvement. This means, for example, that a person can respond that he or she is concerned about the societal use of nuclear power, but not the least worried with respect to the operation of nuclear power plants. Such a person may instead worry about fossil fuel pollution, and see a solution to this problem in the increased use of nuclear power. In the questionnaires we therefore asked subjects about their "worry" and about their perceived "threat" when we wanted to measure emotional involvement to avoid the interpretation problems associated with "concern".

Finally a few comments on the "attitude" concept. McGuire (1985) reviewed attitude research, and distinguished between "working definitions" and "conceptual definitions" of the attitude construct. The "working definitions" are readily described, and I use McGuire's text for this purpose:

> In most empirical studies specific attitudes are defined at least implicitly as responses that locate "objects of thought" on "dimensions of judgement"... Objects of thought are foci of interest such as self, mother, equality, etc. Some are concrete (a familiar person, a specific sorrowful experience); others are more complex or abstract (humanity, evil) or are semantic compounds (the goodness of humanity, a whole's being greater than the sum of its parts). Anything that the person distinguishes from at least one other thing on at least one dimension of judgement is an object of thought for that person. Dimensions of judgement are axes of meaning on which the person locates objects of thought when constructing meaning..." (p. 239)

There is less consensus on conceptual definitions of attitudes, not to mention the complex grounds of disagreement. It is generally understood, however, "that attitudes have a directive function in that their selectivity channels activity into certain types of responses and toward certain objects" (McGuire, 1985, p. 240). It is also agreed that attitudes are acquired from experience. A great number of models have tried to capture the structure of attitudes, e.g. additive and multiplicative models, and in the latter case e.g. expectancy-value models, which decomposes the attitude into characteristics which are judged with respect to their probability and desirability. The "beliefs" and "values" are thus seen as components of the attitude here. Other models may see the attitude as composed of cognitive, affective and conative components, and there are multiple manners of how components are interrelated and combined. (See McGuire, 1985, for a review). The description of the "attitude" concept used in the thesis is well accounted for by the "working definition" given above, since we had no intention to analyze the attitude concept *per se*, only to measure attitudes.

To conclude this section of the paper I would like to summarize the discussion above by pointing to (1) the intention in the empirical research of the thesis to employ a commonly available language, and in this context to adjust the common meaning of terms and concepts to also reflect the theoretical constructs that were to be measured. (2) I have touched upon the depths of psycholinguistic and philosophical dilemmas when it comes to understanding language, and the implications the inherent meanings and contextual frames might have on what is understood. In that context I expressed my personal conviction that the experienced world ultimately is based on apprehension and perception of meaning. (3) I have also described the intended meaning of some concepts used in the thesis, and here pointed to the compound nature of the "risk" concept. (4) Finally, I have stressed the "perception" or the "subjective experience" aspect of risk perception research.

GENERAL DISCUSSION

Mankind is often distinguished from lower animals and from machines on the basis of enjoying both intelligence and empathic ability. We have specific derogatory expressions for describing those who lack either or both of these qualities. Feeling and thinking resources are thus both naturally occurring and expected properties of human functioning. They are also intricately intertwined. To perceive something is also to perceive something within a certain frame of reference. When we perceive an object or a phenomenon we are also able to say if we liked or disliked it. There need not be any rational or contemplated ground for such a preference (Zajonc, 1980). Similarly, we may have, or we may create, an attitude to a phenomenon which we either do not know anything about, or which only exists in our imagination.

Risk perception research has its historical roots in the detected discrepancy of estimated, or expected, risk levels of especially novel technologies, and the public perception of their risks. Starr (1969) set out to answer the question "How safe is safe enough?" and examined the relationship between technological risks and social benefits in a "revealed preference" approach. He pointed to the voluntariness and the magnitude of consequences dimensions in risk acceptance. The risk perception literature has since then developed both in scope and depth. Risk perception research is often motivated as aiming to guide policy and decision making by the examination of how people evaluate and judge hazardous activities and technologies (Slovic, 1987). A number of factors, social as well as individual and intrapsychic, have been related to perceived risk, and to its behavioral and emotional consequences. In this general discussion I will foremost point to some research relevant to the area and of importance for interpretation of the results in the thesis. I have selected only a few topics for discussion, although very much more could be said, and has been said, about the subject area. I have also often chosen to use the most recently published results to exemplify my discussion, although two decades of intensive research and debate certainly offers much more.

I first address the relationship between perceived risk and objective risk level; I continue with a discussion of correlates of perceived risk; the optimistic bias related to personal risk and how it might be related to variations of individuals' actual risk levels; I exemplify risk taking dimensions and discuss the morality aspect involved in risk perception. I conclude that perceptions of risk are psychological facts, and although they may not correspond neatly with actual risk levels, neither are they constructs of distorted or irrational minds. Perceptions of risk function as heuristic tools for personal decision making in the small and in the large. They constitute guidelines in the face of possible danger and harm, and they are real, no matter how misguided, to the extent that they are recognized and acted upon. In the special case of increased worry and risk perception related to possible radioactive contamination, I suggest that the reaction should be understood in terms of the realization that human senses no longer suffice to detect danger, and the vulnerability and fundamental threat this condition poses to individuals.

Let me start this discussion by addressing one of the perhaps most interesting question of all: the relationship between perceived risk and objective or estimated risk level. Most risk perception research is cross-sectional, and thus provides "snap-shot" overall pictures of a situation at a given point in time. Loewenstein and Mather (1990), however, presented time series data on public concern about a series of phenomena or events, *viz.* the AIDS disease, crime, inflation, suicide, etc. They studied (a) how accurately risk perceptions corresponded to actual changes over time, (b) what mediating psychological factors influenced the relationship between objective and subjective risk, (c) the "panic" aspect of risk perception, i.e. the "exaggerated response to an emergent or worsening problem (such as herpes in 1985) followed by a virtual collapse of concern" (p. 156), and why some risks seem prone to such panics and others not. (For a review of panic disorders, in the biological and psychological sense, see McNally, 1990).

They found that "concern" (in their terminology) and actual problem levels were rather highly correlated ($r=0.55$ on the average over nine different problems, all but two with correlations exceeding 0.38). Correlations between change variables ("period-by-period") were much lower ($r=0.25$ on the average, with only unemployment and inflation rates yielding high correlations (0.72 and 0.59, respectively). These results implied that risk perceptions, as measured in opinion polls, were more in accordance with overall levels than with changes measured at separate time periods. With respect to mediating psychological factors, the authors tested the influence of adaptation and surprise. They argued that adaptation processes may influence risk perception in such a way that earlier experiences decrease later concern, and that deviations from expectations create surprise. The authors assumed that if surprise is involved in risk perception, concern would be a decreasing function of prior expectations. Although they found some support for this hypothesis, they could not find support for the adaptation hypothesis in data. Instead the results indicated that "concern is not immediately fully aroused by an increase in the level of a problem, but bubbles up slowly" (p. 170). They denoted this finding "partial adjustment" and interpreted it against a background of an information time lag in reports about risks, and the possibility that expectations may be regressive. That is, they cited research on intuitive extrapolation and the results that people often expect random variables to return toward prior levels. "Panic" reactions in this context were described as "sudden surges of concern" (p. 171) out of line with both prior and later levels of concern. The authors distinguished between distal and proximate causes in their discussion, and suggested that *familiarity* is one distal cause of panics, whereas intense and vivid media coverage may be a proximate cause.

These results thus showed that although the relationship between change in perceived risks (i.e. "concern") and change in problem severity level at specific moments in time hardly coincided, the levels of concern and actual problem levels correlated substantially "in the large" with respect to several problems, with an average of 0.55 over nine different problems. The results of the present thesis regarding the Chernobyl accident and the reactions of respondents living in more

affected areas of Sweden with respect to fallout which showed them to report significantly higher levels of worry than others are in accordance with this general conclusion. It should also be noted that our and others' studies could measure high levels of concern also during the summer and autumn of 1986. The panel study showed, furthermore, that attitude to nuclear power was rather stable during a time period of about a month, while perceptions of radiation risks grew more pessimistic.

Attitudes also change over time, however. Nuclear power attitudes have been monitored for quite some time, and opinion poll results show that the most negative attitudes could be measured a short time after the Chernobyl accident, that they stayed on a low level for a while and then gradually changed in a more pro-nuclear direction. This attitude development has been reviewed in Sweden by Westerståhl and Johansson (1987), and by Biel, Svenson and Dangården (1989). It is not a locally unique phenomenon with respect to Sweden, however, and other studies indicate that the attitude change in Sweden was rather modest in comparison to other countries.

For example, Hohenemser and Renn (1989) compared reactions in several countries to the Chernobyl accident. They reported firstly, that opinions in different countries were by no means uniform before the accident, and secondly, that opinions to nuclear power immediately after the accident varied greatly in magnitude across countries. They mentioned that countries like Finland, Greece and Yugoslavia experienced an increase in opposition to nuclear power of about 30%, and that France and the USA saw an increase in opposition of 12% and 6% respectively. In the case of Yugoslavia, opposition had increased from 42% to 78% three months after the accident. A year later the level was still 24% higher than before the accident. Furthermore, Hohenemser and Renn (1989) investigated the relationship between estimated radiation exposure and public opinion, and found a positive relationship between the average radiation dose in a country and observed shift in public opinion. Although data showed a considerable scatter, the relationship was statistically significant. They concluded that:

> "The high correlation at a national level between increased opposition to nuclear power and the actual average radiation dose following the Chernobyl accident indicates that, in spite of the confusion and the controversy about the seriousness of the threat, most citizens were capable of forming relatively accurate assessments, which were in part expressed in public opinion shifts. In saying this, it is not implied that people reacted directly to fallout levels but rather processed information from different sources and took into account expected biases" (p. 10).

The authors furthermore reflected upon why opposition to nuclear power at least a year after the accident had decreased, but not reached the pre-accident level. They used an analysis of the TMI accident to relate findings of that accident to the one at Chernobyl. Three types of respondents had been identified in the

former analysis to describe responses to a nuclear accident: (a) those previously undecided who form an opinion and cling to it, (b) previously positive subjects who temporarily become more negative, if they are not affected personally, and (c) previously negative subjects who have their negative attitude reinforced. Thus, the authors hypothesized that countries with a larger undecided population prior to the accident would demonstrate the largest initial increase in opposition to nuclear power. And conversely, that countries which prior to the accident had a large proportion of highly committed subjects already before the accident would show the largest return toward opinion levels as they were prior to the accident. They found both suggestions to conform with available data. Renn (1990) related this behavior to the "inoculation effect" of attitude formation and commitment[7]. Thus the example shows, firstly, that risk perceptions to a certain extent reflected the actual risk after the accident, with respect to level of public reactions and measured fall-out, and secondly, that attitudes change on the basis of new information, but that the stability of the influence may be due to the degree of prior commitment to a belief. In the case of strong commitment to a belief or point of view, the held belief furthermore influences the way subsequent information is integrated (Slovic, 1987).

Both examples above indicate that subjective perceptions of risk fairly well can reflect the objective severity level of a problem or event, but that one should expect a time lag and that the overall correspondence is better measured over longer time periods than at specific moments in time on the basis of cross-sectional data. Certain risks become more emphasized than others. The reason for this is not fully understood, but seem to include voluminous information about the risk, as well as unclear or disputed information, and rumors. An attempt to shed light on the phenomenon has been denoted the "social amplification of risk" (Kasperson, Renn, Slovic, Brown, Emel, Goble, Kasperson & Ratick, 1988; Kasperson, Emel, Goble, Hohenemser, Kasperson & Renn, 1989). It is suggested to occur by the transfer of information about the risk through individual and social "amplification stations", and by social response mechanisms. It may result in behavioral changes and further social impact, e.g. the creation of new social groups, and stigmatization of certain geographical areas.

Perceived risk as presented in the thesis was related to certain demographic and psychological variables, e.g. gender, age, occupation, knowledge and interest orientation, as well as attitudes, emotional reactions and behavioral changes. I will make some comments on how to interpret such relationships in the discussion below.

The results of all studies showed that whenever gender differences occurred, women rated risks higher than did men. In most comparisons the gender difference

[7] Renn (1990) gave the following explanation to the "inoculation effect": "This effect makes individuals with a positive attitude feel almost immunized against negative incidents, while an uncommitted person may use the incident as an incentive to take a side in the debate. The metaphor of inoculation refers to the preparedness of the immunity system to cope with a class of bacteria or virus" (p. 156-157).

was evident and highly significant. There were instances, however, where such differences did not occur. Examples are perceptions of personal risk to fall and to drown, and the perceived threat to society from environmental pollution. The studies did not intend to explain why or how the gender differences occurred but some suggestions have been discussed in the separate papers.

The gender difference is well documented in the risk perception literature, and in literature on emotion and mood as well. It is generally the case that strong emotions have a relatively short duration (Wallbott & Scherer, 1986), and that everyday mood usually is experienced in a mildly positive direction (Sjöberg, 1981,1989). Negative expectations and perceived lack of control seem to play an important role in affecting the mood state in a negative direction. Sjöberg and Magneberg (1990) found that women, on the average, experienced a more positive mood state than men, and Sjöberg, Olsson and Salay (1983) showed that they displayed larger mood variations than men. Sjöberg (1985) found that women were particularly badly off on the eve before an important exam. Thus gender differences with respect to risk perception and ratings of risk and worry may be related to emotional and mood factors, as well as to differences regarding perceived responsibilities as discussed in the papers of the thesis, and probably also to perceptions of personal control over events. I will return to the issue of perceived personal risk below in addressing the "optimistic bias".

The age factor was mainly investigated in the study which included comparisons between adolescent and adult samples. These comparisons were motivated on the ground that other research has reported that adolescents, and especially younger men, rate risks lower than other subjects. This notion was again supported in the results presented in the thesis. Tränkle, Gelau and Metker (1990) have reported, for example, that young male drivers seemed to rate traffic situations which did not explicitly display danger signals as lower in risk. The authors furthermore suggested that differences in self-estimation were not the only, or the most important, aspect of gender and age differences in traffic risk perception. For example, middle-aged male drivers rated themselves as better drivers than younger male drivers did, but the former group also rated risks higher than the latter group.

The young men thus seemed to perceive risks as lower in spite of their relatively less favorable rating of themselves as drivers. It is interesting to note the authors suggested explanation that they seemed to interpret traffic situations only as they were actually presented, not recognizing the dangers they *might* suggest. Perhaps such suggestions or images only present themselves with increasing experience of real danger and with personal maturity, which the middle-aged men's ratings indicated. I would like to suggest that the "immunity shield" against harm and danger is more robust, as well as more transparent, in younger ages if children and adolescents are fortunate enough to enjoy protected lives. With age and experience, I would suggest, life itself generates an increasing vulnerability, and the life situation, including other people, becomes less generally trustworthy and positively predictable.

An adolescent sample was included in some studies presented in the thesis on the basis (among others) that they were assumed to report lower perceived risk. This was not the only possible hypothesis, however, and especially not in a context of nuclear power issues. An alternative hypothesis would have been that adolescents rate risks of nuclear power higher than adults, since quite a number of surveys and other kinds of studies have shown young children and adolescents to be very concerned about nuclear weapons, and since perceived relationships between civil and military use of nuclear energy have been reported to exist in the public (Slovic, 1987; Eiser, Hannover, Mann, Morin, van der Pligt & Webley, 1990).

Goldberg et al. (1985), for example, reported several studies which all indicated that adolescents (over 12 years) to a large extent list nuclear war among their three greatest worries. In a Finnish study (students of 12-18 years) by Solantaus, Rimpela and Taipale in 1984, 79% of the students listed nuclear war as their greatest worry, and showed that although the expressed worry decreased with age, 45% of the 18 years old expressed the same greatest worry. A Californian study, reported by Goldberg et al., showed that "nuclear war" was ranked second after "death of parent".

One can but speculate about the reasons for the different findings of the relatively low risk ratings with respect to nuclear power and the high reported levels of worry regarding nuclear weapons and war mentioned above. One possible suggestion would be, of course, that although adolescents' report high levels of worry, adults' ratings would still exceed these. I have not been able to locate any study which could shed light on this, not entirely improbable, suggestion. Increased independence and control over one's own adult life as compared to the characteristic dependency during childhood and adolescence suggest the reversed pattern, however. Other possible explanations would be that worry may be expressed in spite of relatively low ratings of likelihood, or perceived risks, of negative events. This interpretation is in accordance with findings which indicate that cognitive suppression of mental contents is more effective than emotional repression. For example, Sjöberg and Jansson (1982) showed that people could both rate low risks of radon in their homes and feel worried about it.

Worry, as well as risk perception, is often strongly related to perceived personal control. Personal control, in turn, is positively related to mood (Sjöberg & Magneberg, 1990) and negatively related to perceived helplessness (Seligman, 1975). Goldberg et al. (1985) reported that perceived threat of nuclear war among adolescents were *not* related to feelings of helplessness. Instead the young persons who reported that they very often thought about the possibility of nuclear war and felt anxious and fearful about it ("the daily fear group") also more often reported that they themselves, as well as others, could have an influence on the issue. A group from the other extreme, i.e. those who said they did not at all think about the threat of nuclear war and who reported no fear or anxiety associated with the issue also expressed the most helplessness with respect to trust in their own and others' ability to have some influence. This group also showed the least interest in planning their own job careers. Goldberg et al. furthermore showed that the group

of youngsters who often thought about the nuclear war threat also discussed the issue more with their family, friends and at school. The authors speculated that either this group, which expressed more fear and anxiety, is more able to tolerate the anxiety associated with thinking about nuclear war, or it is "more aware of efforts for change that are being made and feel that change is possible" (p. 511).

The suggestions may be related to the beliefs and risk ratings of nuclear power in the different high school student groups reported in the thesis. That is, students of technology and economics might have experienced a greater trust in the development of science more generally in spite of admitting no greater personal knowledge than other students of e.g. nuclear waste issues. A comparison of students of natural science, social science and humanities (Drottz-Sjöberg, 1990b) showed, for example, that students of natural science were the most positive to new technology.

The examples above also show that trust in others and in one's own ability to exert influence seemed to be of importance for expressions of fear about nuclear threat. Some results presented in the thesis show that almost all adolescents could mention both positive and negative aspects of nuclear power. They still differed significantly, however, with respect to attitude and risk perception of this issue. There are obviously other influential factors which determine what aspects will be stressed or become the most influential for the expressed attitude and risk rating. Other results presented in the thesis indicated that adolescents of different gender and different study programs emphasized both different and a different number of life values when it came to prediction of nuclear power attitude. Predictions of nuclear waste perceptions showed that the "trust" predictor entered all the equations. Interpretations of these findings included in the thesis suggest that the students embraced different value systems, and that trust was an important indicator of perceived risk. Kunreuther, Easterling, Desvousges and Slovic (1990) similarly showed that acceptance of a nuclear repository was influenced by perceived risk to future generations, and confidence in the federal government.

The study of adolescents included in the present thesis showed a positive correlation of 0.53 between nuclear power attitude and worry about something related to nuclear power. Worry was furthermore a significantly contributing predictor of nuclear waste risk perception in this study, when dependent variables included the aspect of radiation, and when the dependent variable measured satisfaction with current solution of the nuclear waste issue.

The Chernobyl studies showed that worry was positively related to perceived nuclear power risk, but not to non-nuclear sources of radiation. Worry was overall high after the accident. Women reported more worry than men. Among the specifically chosen groups, farmers, pregnant women and parents were more worried than adolescents and men without children of their own. Farmers and pregnant women reported more changes in their daily activities than adolescents and men without children. Such changes covaried with perceived risk of nuclear power and radiation risk. Radiation injury risk was rated among the highest in a list of different kinds of risk. Perceived risk of the accident was related to larger

decrease of activity after the accident as compared to activity prior to the event. People experienced concern about the present state of preparedness regarding nuclear accidents, and a large proportion reported that they did not know how to behave after the accident. Furthermore, perceived nuclear risk accounted for a large proportion of the variance of general job risk.

Thus, again, the aspect of personal control and perceived helplessness in the wake of the accident seemed to express itself in experiences of worry and in high risk ratings. The worry seemed focused on radiation and the possibility of radioactive contamination, which is not very astonishing since radiation involves aspects of *dread* (Fischhoff, Slovic, Lichtenstein, Read and Combs, 1978), e.g. a relatively new and unknown phenomenon at a massive scale, undetectable by human senses, and uncontrollable with respect to personal efforts in the long run.

I suggest that the increased level of worry after the Chernobyl accident was an effect of the event and not an opportunity for frustrated people to express their inherent anxiety. I make this point plainly since attempts at explaining reactions to the accident have at times moved in a direction of viewing high levels of worry following a negative event in terms of a high pressure outlet of phobic fears and other mental problems. It could, from this perspective, be argued that persons who perceive some risks as high have a disposition to see a wide range of situations as threatening. The contrast would be that high worry or risk ratings are due to temporary and transitory anxiety.

It is well known that an individual may be a risk taker in relation to some activity, but that there is no personality trait which distinguishes between individuals who take risks and who do not take risks across all kinds of situations. (See also Wärneryd, 1988). Furthermore, De Man, Simpson-Housley and Curtis (1984) investigated the relationship between trait-anxiety and state-anxiety and perceptions of potential nuclear disaster. They found that only state-anxiety was related to expectation of an accident and estimation of damage. They concluded that "once a stimulus situation is appraised as threatening an A-state reaction will be evoked" (p. 794). Thus, they found no strong relationship between high scores on a trait-anxiety test and strong beliefs in the likelihood of future nuclear accidents, or regarding anticipated damage in case of an accident. State-anxiety effects were indeed 3-4 times larger than trait-anxiety effects. The previously discussed papers on the relationship between perceived and estimated objective risk also support the notion that increased levels of concern, worry, or perceived risk, correspond to changes in the real world. People do differ, however, with respect to both risk perception and risk taking, and there seems to exist a rather peculiar apprehension of radiation, specifically when associated with nuclear energy. People also differ with respect to how they perceive or rate risks to themselves and risks to others. I will address these issues below.

Optimistic bias, with respect to personal risk, has often been observed in traffic research (DeJoy, 1989; Sivak, Soler & Tränkle, 1989). Subjects thus often rate themselves as better drivers, and less likely to be involved in a traffic accident, than an average driver. DeJoy (1989) found optimism strongly related to perceived controllability, and that global optimism increased with driving experience. The

optimistic bias seems more general than that, however. Weinstein (1989) reported on the "consistent, optimistic bias that exists concerning personal risks" (p. 1232). He also asserted that the bias includes positive events (e.g. financial success, long life, etc.) and that pessimistic biases are rare. (These assertions agree with the finding of an overall mildly positive mood state in everyday life as reported above). Weinstein mentioned that biases may occur due to comparisons with incorrect norms (e.g. high risk groups), or by allowing a positive interpretation of a situation (e.g. less likely to occur to oneself than to others) or by downplaying the risk, including taking irrelevant action to counter a risk. Optimistic biases were reported to be higher if there exists high personal control, little personal experience, expectancies of early signs of vulnerability or low ratings of probability. Weinstein provided three possible explanations to the optimistic bias: that it shields us from the fear of being harmed, our desire to enhance feelings of self-worth and competence, and simply cognitive errors. He advocated the explanation that the optimistic bias serves a self-protective function. He pointed to the strong correlation to controllability, and gave the example of the social devaluation of victimized persons found in situations over which they were perceived to have personal control.

The optimistic bias thus seems to facilitate enjoyment of life or at least enhances a more positive perception of it. It may become a formidable obstacle, however, in reaching target groups with information about personal risks. Information attempts formulated in terms of increased safety, e.g. use of safety belts, as well as attempts advising the desirability to reduce risk, e.g. smoking and drinking, both face the challenge to reach through the personal shield of immunity.

Levenson (1990) suggested that there are many kinds of risk taking and that these may have very different sources and consequences. He used measures of substance abuse inclination, emotional arousability, conformity, moral reasoning, empathy, sensation seeking and psychopathology to investigate risk taking of subjects of three all-male groups: (1) antisocial risk takers (criminal long-term drug abusers committed to treatment), (2) adventurous risk takers (rock climbers) and (3) heroes or prosocial risk takers (decorated policemen and firemen). He found that the drug-unit sample scored higher than others on measures of psychopathology and antisocial behavior (e.g. emotionality, disinhibition, depression, substance abuse inclination etc.) and had lower empathy scores. Rock climbers scored higher on adventure and experience seeking and thrill compared to heroes, but these groups did not differ with respect to moral reasoning or independence/conformity measures. Heroes differed from others primarily on the ground of low scores on sensation seeking. Related to the two dimensions of "Anti-social" and "Anti-structural"[8], the drug-unit sample was found to be low on the anti-structural dimension and high on the anti-social dimension, whereas rock climbers exhibited the reversed pattern and heroes were found low on both

[8] Explained as "a tendency to regard conventional norms as provisional not because of an antisocial posture but because of experience seeking or developmental aspirations toward self-actualization".

dimensions. With respect to the latter group the author noted that: "The fact that the heroes, although they literally risked their lives in the performance of their duties, were not characterized by either dimension, suggests that the reason for prosocial risk taking may be very different from those for risk or sensation seeking" (p. 1079). And he suggested altruism as one such motive. Levenson also distinguished between different types of social risk taking, i.e. the violation of norms for personal gain and in the service of positive social change.

The example suggests that the concepts of "risk taking" and "risk takers" should be further divided into more precisely defined characteristics. The most interesting aspect of the example is, however, that it points to the importance of moral norms, social posture and influence of self-interest on the characterization of different risk taking groups. In relation to risk ratings including others, this implies that other considerations than those made with respect to personal risk become involved. Related to the optimistic bias discussed above the example also shows the relevance of different estimations of risk for oneself and for others, if the risk rated involves aspects of skill and knowledge. A rock climber, for example, would certainly agree to a certain personal risk involved in the activity, but asked about "people in general" climbing the same rock, he or she would probably perceive an average risk level of a completely different magnitude. It would be difficult to refer such a difference of ratings purely to the optimistic bias. Policemen and firemen are similarly trained, and equipped, to deal with dangerous situations of their occupations. They may still experience risk, and worry about some scenarios, but they know, and rightly so, that they are better prepared than others to deal with the situations.

Brewer (1990), for example, investigated experiences of being a living target as a member of the RUC police force in Belfast, Northern Ireland. He reported the discourse in discussing the paramilitary threat as related to "skills, fatalism and routinization vocabularies" (p. 661). The skill discourse was related to training, common sense in behavior, and constant vigilance. Fatalism was detected in expressions such as "if your number comes, your number comes"[9] or "if they're going to get you, they're going to get you". In this discourse related to real danger with a high probability of harm and death (i.e. the 1977 death rate in the RUC forces was 213 per 100.000 members as compared to a risk for police officers of about 16 in the U.S.A., p. 658), Brewer mentioned that it was not uncommon to compare occupational risk with conventional risk in attempts to keep the reality at bay. Subjects could say, for example, "the way I look at it is, you could just as easily be killed crossing the road" (p. 664). The routinization vocabulary emphasizes routine and describes risks as ordinary parts of the job. The discourse includes the taken-for-granted nature of the risk, and that risks could not or should not be contemplated constantly. Such inclinations would undermine the ability to do the job or threaten personal sanity. Certain instances did, however, sharply display the real danger of the work, and emotions forced their way to consciousness: "You just don't think about it. The only time you think about it is

[9] Note the use of the "chance" or "hazard" reference in relation to a negative event.

when a friend or someone you knew well gets killed. There are times when you think, God I'm genuinely at risk" (p. 663).

The examples thus show that different risk estimates can be based on the grounds that people have special competence influencing the real risk they face, and that different people actually face different degrees of risk. Being a living target or working closely with hazardous materials or radiation should be expected to result in higher risk ratings than ratings from persons who do not face the same situation. Protest activities against industrial installations in the neighborhood could also be interpreted in this perspective. Thus, protesters do not accept an overall increase of the local risk level, no matter if accidents or pollution are improbable or if they do not threaten themselves directly. The mere possibility of stigmatization of the local vicinity or the home community could be an additional reason (Roberts, 1987; Petterson, 1988; Mitchell, Payne & Dunlap, 1989; McClelland, Schulze & Hurd, 1990).

There is also a morality aspect involved in risk perception and risk rating. For example, Levenson (1990) distinguished between social risk taking for personal gain and in the service of positive social change. In some situations it might be morally justifiable, or indeed requested, to engage in risky behavior (e.g. to save someone drowning), whereas it is seen as immoral to expose others to the same risk as one is willing to take oneself (e.g. drunken driving). Bord and O'Connor (1990) studied women's reactions to food irradiation. They used variables measuring to what extent the respondent intended to try irradiated food in the home, comfort in serving it to family members and reaction to a hypothetically suggested ban of irradiated food on the market. They found, for example, that the women were more comfortable with eating irradiated food themselves than serving it to members of the family.

In the thesis, risk ratings of items which mentioned radioactivity or radiation exceeded ratings of more conventional, but objectively more risky activities or events. The aversion of radiation related to nuclear power was also expressed in suggestions of how deep in bedrock nuclear waste should be placed, etc. People rated the risks to others as higher than to themselves also when radiation was involved. I suggest these results should be interpreted in the light of the discussion above of both the optimistic bias attached to oneself and the morality aspect which implies that you should not expose people to danger. "People" in such moral reasoning related to radiation seems to include strangers and yet not born people of future generations.

Finally, there is yet another basis for differences in risk ratings and it was the main focus in one of the papers of the thesis. It concerns the definition of risk and implies that risk ratings tend to increase the more emphasis is put on consequences of adverse events. The notion has been extensively discussed in the paper, and I will therefore here only add that it is possible that quite a number of risk definitions are used by the same person in relation to different situations or events. This assertion has not been tested in the thesis, and therefore requires new research efforts. The implication of a variety of risk definitions in relation to different problems and events, however, would be that risk perception research

faces a massive task in relating such definitions to already existing results on risk perception. It would be of special interest here to examine whether people define risk differently when the risk concerns one's own person, as compared to close family, people generally, and the society.

To conclude, I have presented support for an assertion that perceived risks to a certain extent reflect actual risk levels, although they do not correspond closely to objective or estimated risk levels. Perceived risks may express exaggerations as well as underestimations in comparison to the objective risk. Amount of information, its vividness and perceived personal relevance have been mentioned to contribute to risk estimations. Similarly, certain characteristics of an event or technology may be important. The psychological reactions to the Chernobyl accident were interpreted as reactions to an existing threat. Evaluations of events and circumstances, including the perception of risk, represent continuous mental activity to guide decision making and behavior. The interpretation of stimuli from the outside world, as well as from the inner world, constitute integrated aspects of our representation of *THE* world. Human beings are not infallible, however, and do not know everything of importance to them. We counter our weaknesses by striving for control, by avoiding danger and harm, try to have a positively tuned mind, and by striving for consensus about behavioral and ethical issues in our group to minimize social conflict. Our ability to fend for ourselves fails us completely, however, when we face dangers undetectable to our senses; dangers of which we have inadequate knowledge or no existing protection. Such events or situations, and even thoughts about them, may create feelings of dread, fear and anxiety, since they remind us of our vulnerability.

Risk perception research does not challenge the fact that there exist real dangers to consider, and it does not attempt to counter such real dangers by suggesting e.g. psychological solutions. To understand more about how risks are perceived, however, enables us to create and provide more adequate information, to respond more appropriately to others' reactions, and to understand more about human beings.

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RISK PERCEPTION AND WORRIES AFTER THE CHERNOBYL ACCIDENT

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RISK PERCEPTION AND WORRIES AFTER THE CHERNOBYL ACCIDENT*

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ABSTRACT

This is a study of reactions in selected groups of the Swedish population to the Chernobyl accident. Data were collected in September 1986, from 3 regions in the country which had been exposed in various degrees to radioactive fallout. In each region samples of farmers, adolescents, persons who had had a child just before or after the accident, and men who were not registered as legal custodians of children, were approached with a mail questionnaire. It was found that attitudes to nuclear power were predominantly negative, that the risks associated with radiation and nuclear power were rated among the worst risks, and that residents of the most exposed region (Gävle) reported being worried about injury from radiation twice as often as others. A sub-group of decisive opponents of nuclear power was identified. It was 15 times larger than the corresponding sub-group of decisive proponents. New parents and farmers were quite negative to nuclear power, a finding discussed in relation to their responsibilities for food production and care for others.

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INTRODUCTION

Modern society offers a large variety of both benefits and potential risks due to technological development. The production of energy in nuclear power plants is but one example. Benefits are easy to welcome and get used to, whereas estimates of risks and potential catastrophes are hard to understand and to digest. How do people react when potential risks actually develop into accidents? Can we keep a cool head and accurately estimate the probability of being hurt or injured when a nuclear power plant goes astray? The present paper is an account of how people in Sweden reacted to the Chernobyl accident.

There has been extensive research on risk perception. There are, of course, different kinds of risks as well as different reactions to risks. Researchers have tried to trace some of the sources of risk attitudes (Sjöberg, 1987) and concluded that people react more strongly to risks they consider unjust (Sjöberg & Winroth, 1986; Rayner & Cantor, 1987; Sjöberg & Drottz, 1988c), less known, forced upon them against their will (Fischhoff *et al.*, 1978) and beyond their control (Prince-Embury & Rooney, 1987).

In spite of considerable efforts, risk perceptions are still incompletely understood. Experts tend to differ greatly in how they view risks, compared with the general public (Slovic, Fischhoff, Lichtenstein, 1979). The US Environmental Protection Agency conducted a study in which experts' judgments of environmental risks were compared to laymen's judgments of the same risk. The two sets of judgments were virtually unrelated (United States Environmental Protection Agency, 1987). Many experts argue that people exaggerate nuclear power risks, and it is often argued that the public is too little concerned with other risks, such as radon in their homes (Johnson & Luken, 1987; Sandman *et al.*, 1987). Attitudes are frequently found to be largely dependent on how risks are conceived, but why some people deny risks and others are hyper-vigilant to them (Fisher *et al.*, 1988) is unknown. Denial of risks has been thoroughly documented in the field of somatic health however (Weinstein, 1984). The communication of facts about risks is indeed difficult, among other things because credibility is hard to establish in situations where experts openly disagree. Another reason may be that people simply do not care to attend to attempts at information, as documented by Stütz (1987) in the case of the attempt by Swedish authorities to inform the public about radiation risks in the fall of 1986.

The Chernobyl accident was preceded in Sweden by much discussion of nuclear power during the seventies. The issue influenced the political life of the country to a great extent and contributed to the fall of at least two administrations (in 1976 and 1978). The TMI accident in 1979 further highlighted the nuclear power issue. The Swedish referendum of March 23, 1980, was a response to that accident. The outcome of the referendum was a defeat of the most antinuclear standpoint. This policy programme opposed completion of additional reactors and called for a swift dismantling of the Swedish nuclear programme. The adopted policy recommended that previous plans of expansion were to be realized but that

nuclear power should be wholly discontinued at the latest in the year 2010. For a more complete account of Swedish nuclear policy, see Carter (1987), chapter 9.

The referendum was the dramatic climax of an extended period of intense public concern in Sweden about the issue of nuclear power. Subsequently, interest levelled off and opposition to nuclear power weakened. The National Bureau of Statistics in Sweden conducts regular surveys of what the Swedish population is worried about. During the period between the 1980 referendum and the spring of 1986 they reported the most frequently mentioned source of worry to be that of environmental problems (Pressmeddelande, 1986). The general picture was that people frequently worried about various issues and threats, women more so than men. Thus, although concern about nuclear power had faded, strong worries about the environmental problems in general had not.

The Chernobyl accident changed the situation profoundly, Sweden being one of the countries in Western Europe to be hit most severely by fallout from the accident in the Soviet Union. The accident, which occurred on April 26 1986, caused measurable radioactive fall-out in most parts of Sweden. High levels of radioactivity were first detected on April 27 at the Forsmark nuclear power plant north of Stockholm. After considerable initial turbulence and thorough investigations it was concluded that the increased level of radioactivity originated from outside the plant. Although large parts of Sweden were threatened by the fallout, some parts were more affected than others due to the weather situation at the time of the accident. Thus, the parts of Sweden north and north-west of Stockholm received more fallout than southern regions.

Disasters and catastrophic events like the Chernobyl accident can be expected to increase emotional stress reactions (Sjöberg, 1986). Indirect and unobtrusive indicators of stress would be, for example, consumption of prescription drugs and alcohol. We attempted to get some information about such indirect indicators. Our inquiries about alcohol sales revealed an over-all 10% increase of sales in June of 1986 but no general changes in May, nor any variation of sales change across the districts chosen for comparisons.

The reported increase in alcohol sales is not easily related to the Chernobyl accident due to a lack of sufficiently precise data and a number of alternative explanations such as changes in the weather. Tendencies towards raised levels of stress and worry could be also inferred from newspaper reports in 1986 that people avoided certain kinds of food and, much later, from an increase in abortions in 1986 (Socialstyrelsen, 1988).

Our approach relied mainly on the use of direct measures of attitudes and risk perceptions rather than unobtrusive indicators. We focused on attitudes as revealed in evaluative global judgments, and on judgments of beliefs and values connected with important aspects of the attitude object.

Attitudes are developed partly in response to information and mass media coverage. Media often increases the awareness of risks, and public opinion reflects the perceived saliency of specific risks. A few words about the information situation subsequent to the accident are therefore in order.

The mass media in Sweden carried extensive information about the accident in the late spring (10-25% of the total news time on radio and television). The predominant trend of the material was negative to nuclear power and possibly to some extent anxiety provoking. There were exceptions, of course, to this trend, but it was clearly evident in all investigated media (Anderberg, 1986; Findahl & Lindahl, 1987; Engholm, 1987; Nordlund, 1987; Nohrstedt & Lekare, 1987). Another rather interesting trend in news reporting was pointed out by Nohrstedt and Lekare (1987): there was little or no criticism of the Swedish authorities in the early reporting but critical voices became more common later on.

Summing up, the purpose of the study reported here was to investigate the effects of the Chernobyl accident on risk perception, nuclear power attitudes and stress reactions. The main question of the project was how the Chernobyl accident had affected attitudes and, to some extent, well-being. In this paper we focus on the main survey investigation. Other sources report an extensive interview study (Drottz & Sjöberg, 1986), and a panel survey study which followed the development of attitudes for one month (Sjöberg & Drottz, 1987), as well as a critical discussion of the procedures used by polling institutes in this field (Sjöberg & Drottz, 1986a).

METHOD

Selection of subjects

The selection was based on the intention to investigate groups of the population who were assumed to be vulnerable to the accident and the resulting fallout in varying degrees.

We could reach registered farmers, but since data on pregnancy are not generally available in Sweden we had to settle for a group of parents of recently born children. A comparison group was defined as men without children of their own. A fourth group of adolescents was selected because it was a group not already extensively surveyed with regard to nuclear attitudes and risk perception. Thus the four groups of subjects were:

(1) farmers;
(2) adolescents aged 18-20;
(3) parents of children born just before or after the Chernobyl accident; and
(4) men aged 25-35 who were not registered as legal custodians of children in their own household.

Four groups of 100 subjects randomly chosen from each of three parts of Sweden participated in the study. The three parts of Sweden were:

(1) the county of Gävleborg (the most exposed area, about 200 km north of Stockholm);

(2) the county of Stockholm, excluding the central city; and
(3) the county of Bohus, excluding the city of Göteborg (the least exposed area, on the west coast of Sweden, approximately 450 km south-west of Stockholm).

The resulting total of 1200 questionnaires were mailed in early September 1986. The last responses, after three reminders, were received on October 3. At that time 737 respondents (61%) had completed the questionnaire and another 15% had given their reasons why they chose not to participate in the study.

The response rate was somewhat higher in the Gävle area (65%), as well as among women (66%). Farmers and parents were most likely to respond (67% and 65% respectively). Adolescents and men without children of their own were somewhat less likely to respond (57% and 51% respectively).

Almost 75% of the respondents were men. Females constituted 9% of the farmer group, 50% of the parents, and 45% of the adolescents. The mean age of the respondents was 32 years (range 18-71 years). Sixty-six percent of the respondents were married or lived with a partner. Fifty-seven percent of the respondents had completed upper secondary school or a still higher education. About 40% lived in the countryside, 17% in a large city and others in small cities or in an urban area. The distance to the closest nuclear power station (as reported by the subjects) ranged between 5 and 700 km (M=137 km).

Questionnaire design

The ten-page questionnaire contained questions about attitudes to nuclear power, how important the respondent found the issue to be, whether his or her attitude had changed after the Chernobyl accident and whether the respondent perceived any differences between Swedish and foreign nuclear power concerning risks. There were some calibration questions in the questionnaire, asking for extent of personal worry due to the accident, future cancer rates due to the accident and whether the accident could have caused genetic injury. The calibration questions were included in order to make it possible to compare our respondents with those participating in other surveys.

There were also questions about feeling physically ill and emotionally malfunctioning due to the accident and whether the respondent had made any changes in his or her life and everyday habits as a result of the accident. A section of risk ratings followed. The respondents rated the probability of new, similar accidents and the risks of actually being exposed to dangerous ionized radiation, for themselves and for people in Sweden generally. Next, subjects estimated the risks of serious reactor accidents in the future and rated a number of 'everyday' risks. The latter ratings were included to make possible comparisons between perceptions of nuclear risks and other kinds of risks and to get a measure of general risk aversiveness.

One set of questions asked the respondents to estimate to what extent, and in what direction, existing nuclear power influenced living conditions in relation to

each of nine life values. The listed life values were physical health, economical standard, freedom, a happy and harmonious life, freedom from worries, an exciting life, a comfortable life, the possibility to influence one's own life and hope for the future. Other questions asked whether a dismantling of nuclear power plants would affect the material standard of living in Sweden and, if so, whether the respondent was willing to lower his or her standard of living to achieve a faster than planned dismantling of nuclear power.

RESULTS

We refrain in this section from reporting specific details about a large number of statistical tests. The differences discussed were statistically significant, in most cases highly so, partly because the sample sizes in most analyses were of an order of magnitude larger than in usual psychological research. Details are available in Sjöberg and Drottz (1986b).

Calibration questions

The calibration questions were used to relate our set of data to representative samples of the Swedish population obtained by an opinion poll institute and another unpublished survey. These data were collected somewhat earlier in 1986 than ours.

One calibration question asked what degree of worry the Chernobyl accident had caused the respondent. We note that our data were quite close to the population sample in this respect (the data on overall worry in Table 1). Other calibration questions asked for estimations of how many persons in Sweden would develop cancer due to the Chernobyl accident and whether the fallout over Sweden could have caused genetic injuries. The results of the calibration questions in those respects showed our sample to be more pessimistic and uncertain than the population samples. The results could reflect a shift in estimates of health consequences over time, due to the increased media coverage at this time and the upward trend in preliminary risk estimates by the National Institute for Radiation Protection. (Our data were obtained 6 weeks after the opinion poll and about two months after the survey sample asking about genetic injury).

TABLE 1

A comparison of overall worry reported by respondents in our survey study and in an opinion poll. The table gives the proportion of respondents selecting each response alternative

	Proportion of responses	
Response alternative	*Survey study*[a]	*Population*[b]
Very worried	*0.30*	*0.25*
Rather worried	*0.42*	*0.46*
Not especially worried	*0.23*	*0.24*
Not worried at all	*0.03*	*0.04*
Don't know	*0.02*	*0.01*

[a] *The entries are based on 723 respondents.*
[b] *The entries are based on 601 respondents.*

Attitudes to nuclear power

A seven-point scale was used to measure the global attitude to nuclear power. The scale ranged from 'completely negative', through 'neither positive nor negative' to 'completely positive'.

The reported attitude to Swedish nuclear power at the time of the survey study was predominantly negative. About 65% chose a negative response alternative. People living in the most affected area (the region of Gävle) were, as expected, more negative than others. Women were more negative than men, and farmers were the most negative subgroup.

Women found the issue of Swedish nuclear power more important than men did. The subgroups of farmers, parents and people in the Gävle district rated the issue as important. Asked about attitude change due to the accident, more than half of the respondents reported becoming more negative to Swedish nuclear power after the Chernobyl accident. The effect among women was again greater than among men.

The results furthermore showed pronounced expectations of new nuclear power accidents like the one in Chernobyl. More than 70% of the respondents found it very or rather likely that another accident like the Chernobyl accident would happen again. About 35% held such beliefs about a similar accident in Sweden, and about the same proportion of subjects estimated that a serious reactor accident would happen in Sweden before the year 2010. (Table 2). Less than 20% of the respondents judged Swedish preparation for nuclear accident to be very or rather good.

TABLE 2
Proportions of affirmative responses to questions about possible new nuclear accidents

Event	*n*	*Very likely*	*Rather likely*	*Missing*[a]
New accident disregarding country and place	*736*	*0.39*	*0.32*	*11*
Accident in Sweden	*736*	*0.14*	*0.23*	*12*
Reactor accident in Sweden before year 2010	*736*	*0.14*	*0.21*	*10*

[a] *'Missing' summarizes percentages of answers of 'don't know', 'no response alternative suits me' and strictly missing data.*

Two lists of ratings were used to determine the components of the nuclear power attitude. One of the lists concerned how nuclear power was perceived to influence important life conditions of the respondents and his or her family. The listed attributes were denoted basic life values.

The aspect of economical standard was found the most positively judged aspect related to nuclear power. The most negatively judged aspects were effects on worries, physical health, and hope for the future. The mentioned life values, excluding freedom from worries and adding 'freedom', all contributed significantly ($p<0.05$) to the prediction of the overall nuclear power attitude. Hope for the future was the most important aspect. The corrected multiple correlation (squared) for the prediction of nuclear power attitude from life values was 0.403.

A grouping of respondents into three categories; (a) subjects who judged nuclear power negative in relation to *all* listed life values, (b) subjects who judged nuclear power positive in relation to *all* listed life values, and (c) others, showed a proportion of 15% definitely negative subjects to 1% definitely positive subjects. The results thus showed a much larger group of decisive antagonists than of decisive supporters of nuclear power. Subgroup analysis showed that about 20% of the respondents in the Gävle area belonged to the decisively negative category.

The life values were generally perceived as relevant to the nuclear power issue. There was a lower proportion of the answer 'not relevant' for life values perceived as negatively influenced by nuclear power. For example, only 20% of the subjects perceived 'hope for the future' to be an irrelevant aspect, compared with 57% regarding the life value of 'a stimulating life'.

A second list which contained 15 positive and negative attitude statements of the Likert type regarding nuclear power generally resulted in agreement with negative statements and, with a few exceptions, rejection of positive ones. Respondents thus agreed to statements that nuclear power increases the risks of spreading nuclear weapons, can imply great risks for people living near a power plant, can have serious consequences if power plants were to be subjected to sabotage, that it delays the development of alternative sources of energy, etc. The

respondents, however, rated the aspects of cheap energy production and low production costs as advantages of nuclear power.

A multiple regression analysis of the items resulted in 10 statements giving significant contributions to the overall nuclear power attitude. The corrected multiple correlation (squared) was 0.579. Beta-weights showed that economical considerations (cheap energy production, low costs, positive influence on employment) and aspects of nuclear power as a clean source of energy as long as there are no accidents and as a 'tested technology', important for a high Swedish standard of technological know-how, emerged as important predictors of the overall nuclear attitude.

We hence found two sets of variables predicting the general nuclear attitude fairly well: life values and attitude statements. To combine them, we computed mean values in each set separately and then correlated them with the nuclear power attitude. The obtained corrected multiple correlation (squared) was 0.551, thus not exceeding the corrected multiple correlation of the separate attitude items alone. The beta-weight for the statement set was 0.56 and for the set of life values 0.24. Although the set of statements had added more power to the prognosis, 4% explained variance could be attributed to the life value set, which was a significant contribution.

An additional stepwise regression analysis again used all statements and life value items. The 'hope for the future' item gained the highest beta-weight (0.25) followed by the statement that nuclear power is necessary to retain Swedish technological know-how on a high level (0.19). The corrected multiple correlation for these two items alone was 0.471.

Emotional and behavioural reactions

Questions about perceived risk of injury, stress, worry and behavioural change due to the Chernobyl accident were included in the questionnaire. There were questions about perceived risk of injury caused by radiation, perceived bodily symptoms, whether one was feeling off balance and whether one had made decisive changes in life or in regard to daily habits due to the accident.

Starting with responses concerning perceived injury, i.e. of having been personally exposed to harmful radiation due to the accident, the results showed that about a third of the respondents reported such concerns to a large or a rather large degree. Parents, women and farmers were the most worried subgroups. Residents of the Gävle area reported approximately twice the personal worry of residents in other investigated areas (the 'very high' and 'rather high' response alternatives). We know from other responses that personal concern emerged primarily from consumption of certain food products and having spent time out doors.

Subjects were generally more optimistic about personal risk in relation to radiation than they were judging radiation risks for people in Sweden generally. About 50% of the respondents rated the risk of harmful exposure to radiation for

people generally as very or rather large. The corresponding figure for perceived personal risk included less than 30% of the respondents. This result was true also for respondents in the Gävle region, although they actually lived in one of the most exposed areas. Following the overall pattern of the data, persons living in the Gävle area and women gave the highest risk ratings also in this respect.

The mean ratings for the seriousness of various risks are given in Table 3. Nuclear power and radiation risks were rated as quite severe. The risk of injury due to the Chernobyl accident was rated among the four highest risks by three of our four groups, and in the overall averages it ranked fourth. The level of risk ratings observed here for nuclear power and radiation clearly surpass by orders of magnitude, the views held by experts and government authorities.

Persons living in the Gävle area did not differ from respondents of other parts of Sweden when it came to rating non-radiation risks. Ratings of risks related to nuclear power and radiation, however, showed inhabitants of Gävle giving higher estimates. These regional differences could not be explained by differences in general aversiveness to risks.

TABLE 3
Mean ratings[a] of the seriousness of various personal risks

Risk type	*Total group*	*Farmers*	*Adolescents*	*Parents*	*Men, non-parents*
Drowning	*1.60*	*1.56*	*1.62*	*1.61*	*1.64*
Lightning	*1.03*	*1.29*	*0.86*	*1.03*	*0.89*
Fire	*1.80*	*1.89*	*1.66*	*1.90*	*1.69*
Air crash	*1.37*	*1.32*	*1.41*	*1.41*	*1.32*
Heart infarct	*2.35(3)[b]*	*2.81(2)*	*1.83*	*2.37(3)*	*2.31(3)*
Physical abuse	*2.21*	*1.93*	*2.38(2)*	*2.29*	*2.26(4)*
Traffic accident	*2.52(2)*	*2.13*	*2.57(1)*	*2.70(1)*	*2.73(1)*
Work injury	*2.60(1)*	*3.28(1)*	*2.18(4)*	*2.29*	*2.59(2)*
Natural radiation	*1.64*	*1.89*	*1.40*	*1.72*	*1.45*
Swedish nuclear power	*2.18*	*2.44(3)*	*1.79*	*2.35(4)*	*2.07*
The Chernobyl accident	*2.32(4)*	*2.40(4)*	*2.23(3)*	*2.45(2)*	*2.14*

[a] *Ratings were made on a category scale from 0 to 5, where 0 denoted no risk at all and 5 a very large risk.*
[b] *Ranks are given in each column for the 4 risks rated as most serious.*

Perception of bodily symptoms attributed to the radiation following the accident were overall rare in the data. Around 1% responded that they had experienced physical symptoms to a large or rather large extent. About 7% chose

the response alternatives of 'rather low extent' and 'neither large nor small extent' of such symptoms. (Table 4). Feelings of being psychologically off balance were more frequent. About 16% of the respondents agreed to have felt off balance to a very or rather high degree after the accident, women more so than men and people in the area of Gävle and farmers more often than others. Adolescents reported less psychological impact of the accident.

We asked two direct questions about behavioural changes. One question asked about *decisive* life changes due to the accident. The question was motivated by media reports about people wanting to sell their homes (if they could) or wanting to leave the area for the time being. A following question asked about changes of habits and everyday life after the accident. Table 5 summarizes the results. Although the reported changes of life and of everyday habits followed an expected pattern, the most striking result is the large proportion of people who do not mention any changes in their lives at all.

TABLE 4

Percentages of responses[a] indicating (a) some bodily symptoms and (b) reports of feeling off balance due to the radiation situation following the Chernobyl accident

Subject category	Very and rather high extent		Neither high nor low extent		Rather low extent		n	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
Total[b]	1.2	16.5	3.4	6.3	3.4	11.2	614	650
Men	0.6	14.4	3.1	5.7	3.1	11.2	452	474
Women	2.5	22.1	4.3	8.0	4.3	11.4	162	176
Gävle	1.9	26.3	3.4	6.7	5.3	14.2	207	225
Stockholm	0.0	12.2	3.7	5.6	3.2	8.6	188	197
Bohus	1.0	10.2	3.4	7.0	2.0	11.2	205	214
Farmers	1.9	25.7	5.0	7.8	5.0	16.2	161	179
Adolescents	0.0	6.6	3.9	3.9	2.0	9.2	153	153
Parents	1.2	20.0	1.8	8.0	4.3	8.0	164	175
Men without children	0.8	10.9	3.3	5.5	2.5	12.5	121	128

[a] *Proportions of responses, i.e. excluding the answers 'don't know', 'no response alternative suits me' and strictly missing data.*

[b] *The 'total' category includes 16 anonymous responses not categorized in subcategories except for sex.*

The group of adolescents was generally less worried about the accident than other groups in our sample, and less worried compared with population data.

There were considerable gender differences also in the adolescent group, in the expected direction, but young women were more positive to nuclear power than other women. These differences between women could be explained by differences in judgments of nuclear power risks.

TABLE 5
Percentages of responses about (a) decisive life changes and (b) changes of habits in everyday life after the Chernobyl accident

	Very large[a] and some changes		*Fairly few changes*		*No changes at all*		*n*	
Category	*(a)*	*(b)*	*(a)*	*(b)*	*(a)*	*(b)*	*(a)*	*(b)*
Total	*14.1*	*20.5*	*16.9*	*20.8*	*69.0*	*58.8*	*693*	*713*
Men	*12.2*	*17.7*	*16.0*	*20.0*	*71.8*	*62.4*	*507*	*521*
Women	*19.4*	*28.1*	*19.4*	*22.9*	*61.3*	*49.0*	*186*	*192*
Gävle	*22.5*	*33.0*	*25.4*	*23.8*	*52.1*	*43.1*	*240*	*248*
Stockholm	*8.9*	*16.0*	*12.1*	*19.3*	*79.0*	*64.7*	*214*	*218*
Bohus	*9.9*	*10.4*	*11.7*	*18.6*	*78.5*	*71.0*	*223*	*231*
Farmers	*16.0*	*23.2*	*15.4*	*21.1*	*68.6*	*55.7*	*188*	*194*
Adolescents	*8.8*	*13.9*	*12.6*	*15.1*	*78.6*	*71.1*	*159*	*166*
Parents	*18.8*	*29.0*	*21.9*	*23.2*	*59.4*	*47.9*	*187*	*190*
Men without children	*11.2*	*12.4*	*16.2*	*23.3*	*72.5*	*64.4*	*142*	*146*

[a] *Regarding (a) 'decisive life changes' we used a five-point scale and the following response alternatives have been summarized under this heading: 'yes, to a very large extent', 'yes, to a rather large extent' and 'neither to a large nor a small extent'. The heading also includes response alternatives of (b) 'changes of habits': 'yes, very large changes' and 'yes, some changes' (a four-point scale was used).*

The results further indicated that young men in the Gävle area were more negatively affected by the accident than other young men. Although the adolescent group in Gävle seemed to be least affected of the Gävle groups, they showed concern to the same extent as the respondents in other areas. Figure 1 shows reported influence of the Chernobyl accident, i.e. change of habits, in the sample subgroups in the studied areas of Sweden.

The figure shows that the Gävle groups give the overall highest values of perceived influence, and also that the groups differed more in the Gävle region than elsewhere. In other words, those who were affected most strongly (farmers and parents) reacted especially strongly in the Gävle region.

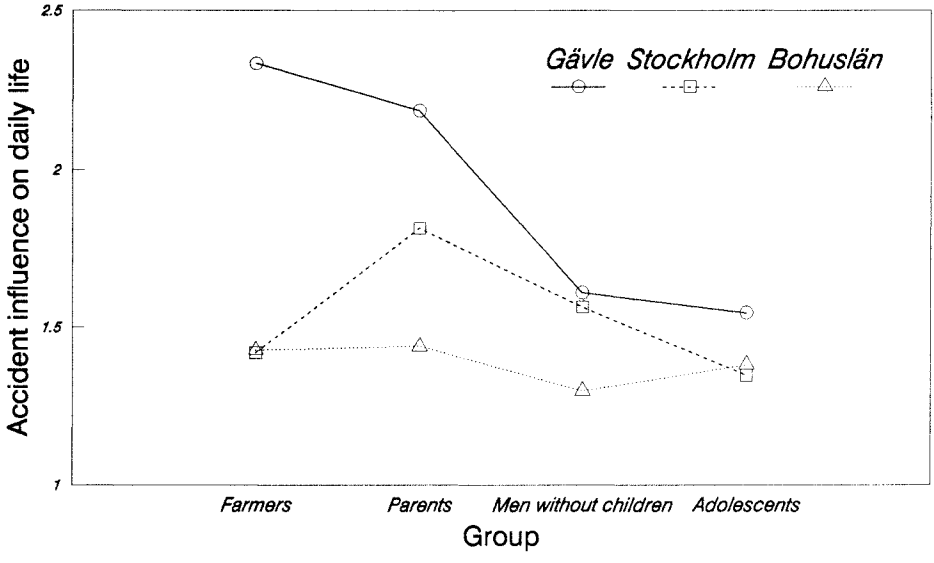

FIGURE 1. Perceived influence on daily life from the Chernobyl accident, in different groups and regions.

Indices and relationships

Three indices were constructed based on factor analysis. One index, a *nuclear power risk* factor, contained high loadings on variables of ratings of risks concerning nuclear power and future nuclear power accidents (Cronbach's alpha 0.911).

A second factor was measured by an index of *evaluation of nuclear power.* It was based on ratings of general attitude to nuclear power, the mean value of statements about nuclear power as well as the mean value of life value items. There was also a question included about effects on material standard given an early dismantling of Swedish nuclear power plants (Cronbach's alpha 0.769).

Factor three was denoted *effects of the Chernobyl accident.* It contained the ratings of feeling off balance, changes of life and habits due to the accident, and perceptions of being subjected to harmful radiation and risks concerning Swedish nuclear power (Cronbach's alpha 0.787).

Another two indices were constructed on an apriori basis. Index four constituted a measure of *perceived injury.* It contained ten risk ratings of having been injured by radiation due to the accident in everyday situations. (Cronbach's alpha 0.956). An index of *general risk perception* was also constructed based on nine risk estimates of injury in normal life (flight and traffic accidents, drowning, heart attack, etc.), excluding radiation risks (Cronbach's alpha 0.805).

There were strong correlations among the indices, especially between nuclear attitude and perceived risk. The correlations between variables related to the

nuclear attitude, i.e. the evaluation of nuclear power, and variables concerning risks with nuclear power were especially high. (Table 6).

Note that the indices related to the Chernobyl accident (number 1, 3 and 4) correlate rather strongly with the evaluation of nuclear power. A multiple regression analysis using the evaluation of nuclear power as the dependent variable related to the other indices and the risk judgement of Swedish nuclear power as independent variables resulted in a multiple correlation (squared) of 0.571. The index of perceived nuclear power risks obtained the highest beta-weight (-0.44), followed by the risk of Swedish nuclear power (0.28), and the index of effects of the Chernobyl accident (-0.13). The index of perceived injury contributed only marginally (0.05) to the prediction, as did general risk perception (0.07).

TABLE 6

Correlations between indices of perceived injury, general risk perception, evaluation of nuclear power, effects of the Chernobyl accident and nuclear power risks

Index	*1*	*2*	*3*	*4*	*5*
1 Nuclear power risks	*1.00*				
2 Evaluation of nuclear power	*-0.72*	*1.00*			
3 Effects of the Chernobyl accident	*0.65*	*-0.53*	*1.00*		
4 Perceived injury	*0.61*	*-0.41*	*0.62*	*1.00*	
5 General risk perception	*0.42*	*-0.21*	*0.23*	*0.36*	*1.00*

Analysis of the index of general risk perception showed significant differences between men and women, and between the groups in the sample. There were no significant differences, however, between regions, and no interaction effects.

Further analysis of the indices concerning independent variables (sex, region and group) were based on analysis of covariance, controlling for the influence of general risk perception. The results generally showed that people in the Gävle region were more negative in their evaluation of nuclear power, perceived greater risks from nuclear power and radiation, were more concerned about exposure to radiation, and introduced more change in their everyday lives. Women were throughout the material more worried and more negative to nuclear power and related risks than men. The ratings of the various groups differed somewhat between analyses. Frequently farmers and parents were the most concerned groups, but there were exceptions. The strong expression of a negative evaluation of nuclear power in the Gävle region, for example, was mostly due to ratings among its farmers and adolescents compared with groups of other regions. Furthermore, the index measuring perceived risk of injury, did not reveal any significant differences between the groups.

DISCUSSION

The main results of the study can be summarized in the successful predictions of large differences of nuclear power attitudes, risk perceptions related to radiation and perceived effects of the Chernobyl accident. The overall attitude to nuclear power had decreased drastically and the risks of this technology were by many respondents considered among the most threatening of all risks, a judgment disagreeing with the most common expert notions on the safety of nuclear technology.

The evaluation of nuclear power could primarily be accounted for by risk perceptions and perceived effects of the accident, results well in accordance with other research on nuclear power attitudes (e.g. Van der Pligt, 1985). Attitude statements and life values could independently be used in the prediction of nuclear power attitude and attitude change.

In spite of this generally negative image of nuclear power it should be stressed that most respondents agreed that this technology has important economic benefits. There is an obvious conflict between economic benefits and risks.

The emerging picture of the effects of the Chernobyl accident in our data involves a much more negative attitude towards nuclear power and strongly increased worries and concern with the risks of this technology. Later developments (Biel *et al.*, 1989) have shown that nuclear power attitudes of the Swedish population have rather quickly reverted to the previous, weakly pro-nuclear level. There are indications that people differentiate between domestic and foreign nuclear power and that they are more favourable to the domestic technology. However, we noted in our study that there was one group of people who were very decisively anti-nuclear, although no corresponding large group of people deeply committed to a pro-nuclear standpoint could be discerned.

Similar distrust of nuclear power was documented as an effect of the TMI accident. A study of the effects of the TMI accident (Hughey & Sundstrom, 1988) in a distant community (Trousdale County, Tennessee) 18 months after the accident showed that about 25% of the respondents reported that they had been 'very much' or 'a lot' influenced by the accident. Such influence was strongly related to attitudes towards the building of a local nuclear plant.

Manifest stress reactions of bodily symptoms were rare in our data but nevertheless experienced by a small group of respondents who attributed their discomforts to the accident. Emotional reactions were generally more common. People in the Gävle area reported about twice as often worry about radiation than people in other regions. They also reported having introduced more changes in their daily lives.

We found that young men aged 18-20 were the least risk-aversive group. The finding can be related to male attitude stereotype specifically pronounced at an age of intense sex identification (Wilson & Daly, 1985), but that, of course, does not account for the attitudes of the females in the adolescent group. Future research should invest more effort in the risk perception development during childhood and

adolescence, and particularly address gender differences (Sjöberg & Torell, 1988). Studies of children's worries often point to anxiety of nuclear war and our data suggest that the worry about proliferation of nuclear weapons is related to the nuclear power attitude also within a predominantly adult sample. Eiser *et al.* (1990) found that attitudes to various civil and military uses of nuclear power correlated.

Women report more worry than men do. This is a common result in risk perception studies and in population polls (Brody, 1984). We are inclined to believe in fundamental hereditary causes of such sex differences. Genetic predispositions of aggressiveness and caretaking ought to be traceable in data of experiences and behavior. But of course we also agree that there is much more to it. Höijer (1987) assumed, for example, that men and women focus on and absorb different aspects of available information about radiation.

Interest tends to be related to knowledge, and therefore one can expect a negative correlation between knowledge and judgment of risk. Other factors contribute to such a relationship, such as socio-economic status (Sjöberg & Drottz, 1988a) or the real level of risk one is exposed to, e.g. in the work environment (Sjöberg & Drottz, 1988b).

Eiser *et al.* (1990) found that degree of 'involvement' could be related to coping style. We found that women reported more changes of daily habits than men did, and that some worries about possible exposure to harmful radiation emerged from food consumption.

Food preparation is a traditional female area of duty. Food production is the responsibility and income source of farmers. Faced with the radiation situation after the Chernobyl accident these groups of respondents reported high levels of concern. Surely there are other additional sources to rely on for possible explanations of sex and group differences. We believe, however, that the high level of worry after the accident in Chernobyl partly can be traced to the invisible and enduring character of ionized radiation. You can protect yourself from a temporarily increased level of radiation, but how do you protect yourself, your family and generations yet to come from its possible long term effects? The salience of the 'hope for the future' life value in the results might reflect such concerns. The subgroups of our sample who reported high levels of worry and of perceived risks, apart from subjects in the specifically exposed region, fit nicely into a category of subjects more related than others to food production, human reproduction and care. The problem of risk perception as related to one's responsibility - or lack of it - for the lives of others, be it in a professional or a personal relation, is a topic of interest for future research, taking us from the present individual level of functioning to the study of organizational processes (Clarke, 1988).

The question of the cognitive vs affective nature of attitudes and preferences is frequently raised in contemporary psychology (Zajonc, 1980). Most current attitude models are predominantly cognitive, in spite of the fact that much work has shown that attitudes are only partly explicable of the basis of beliefs and values (McGuire, 1985) and that there seem to be qualitative differences between affective and cognitive judgments (Sjöberg *et al.*, 1987). Yet, an implicit assumption

in attempts of communicating risks about various hazards is the assumption of rational thought and consequent rational behaviour. In the case of the Chernobyl accident authoritative estimates of health risks did not accord with the public reactions. Similar discrepancies between expert and layman estimates and reactions can be found in estimates of risk and risk perception concerning nuclear waste (Sjöberg & Drottz, 1988a). Risk communication attempts have so far largely failed to induce safety increasing behaviour, e.g. in the case of indoor radon (Johnson & Luken, 1987; Johnson *et al.*, 1988). Risk attitudes may or may not be predominantly cognitive, but even if they are cognitive, and we certainly still have to define the crucial aspects of information that determine them. We therefore suggest that future research also considers life values and life goals.

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PSYCHOLOGICAL REACTIONS TO CANCER RISKS AFTER THE CHERNOBYL ACCIDENT

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PSYCHOLOGICAL REACTIONS TO CANCER RISKS AFTER THE CHERNOBYL ACCIDENT*

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ABSTRACT

This is a report on an investigation of people's reactions to the Chernobyl accident. Interviews and mail surveys were conducted in July-September 1986 with pregnant women, parents of newborn children, farmers, adolescents and men who were not parents, in various areas of Sweden, differing as to the amount of Chernobyl fallout they had received. The accident had probably doubled the number of people who were negative to nuclear power in the most affected area. Radiation risks were highly salient in most groups. Areas differed in the expected direction, people in the more exposed areas being more concerned. Women were more worried and more negative to nuclear power than men while adolescents appeared to be the group least affected by the accident. Farmers were also strongly opposed to nuclear power and concerned about its risks. Nuclear attitude could be well accounted for by attitude statements and rated basic life values. It was quite stable over a 1 month period.

Key words: *Risk perception, Attitude, Cancer risks, Nuclear power, Chernobyl accident.*

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INTRODUCTION

Questions concerning health risk in modern society have become very acute during the last decade or two. People sometimes react very strongly to risks that they consider as unacceptable, especially if the risks have been more or less forced upon them against their will, or at least without their prior consent. The prevalence of strong protests is probably a reason why there is at present so much attention directed at questions concerning risks.

There are, of course, many kinds of risks and reactions to risks. There is also, as a rule, variation in opinions about what constitutes rational action. It is likely that experts and government officers often have quite a different view of risks to other people or the general public opinion. Researchers have attempted to trace some of the sources of the prevalent risk attitudes, see e.g. Sjöberg[1] for a review of the field.

The National Bureau of Statistics has conducted regularly repeated surveys of what the Swedish population is worried about[2]. In the 1980-86 period the most frequently mentioned source of worry was that of environmental problems. The general picture is that people frequently are worried about various threats. Women were reported throughout to be more worried than men, a finding well in line with internationally reported data.

The concern of the present paper is public opinion and nuclear power. In Sweden there was much discussion of nuclear power during the 70s and the issue was decisive for the fall of at least two administrations (in 1976 and 1978). A referendum on the issue of domestic nuclear power was held on 23 March, 1980. (The referendum was a direct response to the Harrisburg accident a year earlier.) The outcome of the referendum was a defeat of the most anti-nuclear standpoint which opposed completion of additional reactors and called for a swift dismantling of the Swedish nuclear program. The two winning options recommended that previous plans of expansion were to be realized but that nuclear power should be wholly discontinued at the latest about the year 2010.

The referendum was the dramatic climax of an extended period of intense public concern in Sweden with the issue of nuclear power. Subsequently, interest waned and opposition appeared to weaken. The Chernobyl accident changed all that, of course.

The purpose of the studies reported here was to investigate attitudes to nuclear power subsequent to the Chernobyl accident, if and how attitudes have changed, and how permanent the changes can be assumed to be. These attitudes have developed partly in response to mass media coverage of the accident. Hence, a few words about what is known about the information given by the Swedish media subsequent to the accident are in order.

The mass media in Sweden carried extensive information about the accident prior to our data collection. A number of studies have been conducted on the contents of the media information. Findahl and Lindahl[3] surveyed the contents of the major news programs of the Swedish television and national radio. Local newspapers published in the Uppsala-Gävle region (the part of the country where

the highest levels of radiation were reported) were investigated by Anderberg[4], Nohrstedt and Lekare[5] and Engholm[6]. In addition, the news reports issued by the local radio station in Uppsala were studied by Nordlund[7]. These studies were all confined to the time elapsing from the accident to the beginning of June 1986. We know of no studies of mass media contents in later periods with special relation to the Chernobyl accident, nor have we found any studies covering the major newspapers published in Stockholm, Göteborg and Malmö. The papers investigated in the cited reports were all quite small and are probably read only in limited areas. People often combine them with one of the major Stockholm dailies. But, of course, the main news medium in Sweden is the national television, closely followed by morning newspapers and the radio[8].

Briefly summarizing this work it can be especially noted that the media coverage was extensive (10-25% of the total news time on radio and television) and that the dominating trend of the material published was negative to nuclear power and possibly to some extent anxiety provocative. There were exceptions, of course, to the trend, but it was clearly evident in all investigated media. Journalists seem still to have exercised a certain restraint, at least in the beginning of the period. A striking episode recounted by Nordlund[7] was when the local radio station in Uppsala refrained from reporting that some 'experts on radioactivity' fled from Uppsala with their families.

There was also a rather interesting trend in news reporting[5]. In the first phase there was little or no criticism of the Swedish authorities but later critical voices became more and more common. It is likely that many people found it hard to understand the messages issued by the National Institute for Radiation Protection which stated, at the same time, that the fallout received in Sweden was harmless, but that certain activities were discouraged and that milk cows were to be kept in barns and prevented from grazing. The 'grazing prohibition', and a recommendation that farmers use protective clothing, caused much anger and irritation among farmers.

The cited reports amply document that, beginning on 28 April, 1986, the Swedish population was exposed to a large amount of information which was negative to nuclear power and probably anxiety provocative when it came to personal health and safety.

The general purpose of studying attitudes needs to be further specified. Attitudes have different kinds of effects on behavior and they can be studied in several ways. Attitudes should also be distinguished from emotional reactions. Emotional reactions constitute an important topic of research in themselves. Previous work on emotional reactions to disaster has demonstrated strong stress reactions[9] and it could be expected that similar reactions would be noticeable in the Swedish population after the Chernobyl accident.

An indirect indicant of stress is the amount of alcohol consumption. There was an over-all increase in alcohol consumption about a month after the accident (about 10%). It is hard to know, of course, if the reason is to be sought in stress reactions to the accident. There was another shattering event, the assassination of Prime Minister Olof Palme just 2 months before the Chernobyl accident, and that

event was surely as salient to the Swedes as the accident. Newspapers have also reported that there was an increase in sick-listing and abortions, that people were unwilling to consume certain food items and that several thousands of Swedes even made inquiries about emigrating to New Zealand! A clear drop in the tourist trade was felt, and people changed some food habits and refrained from such outdoor activities as fishing and hunting[10].

It is because indirect indicants such as the consumption of alcohol and tranquilizers yield data which are so hard to interpret that it is advantageous to obtain attitude data. Another reason is that even if a type of risk related behavior is exhibited by a large number of people they can be only a tiny fraction of the population. E. g. if some 5000 persons seriously considered emigrating to New Zealand they could scarcely be detected in a normally sized opinion study based on a sample of about 1000 persons.

The present work builds upon three data sets: an interview study and two mail questionnaire studies. The purpose of the interview study was to deal with a rather large number of topics extensively and to be the basis of further work. The questionnaire studies did not utilize nationally representative samples. Several other groups were doing studies of that kind (to be mentioned briefly in the Discussion section) so we concentrated on some special groups which we felt were potentially of special interest, either because we expected that they would be especially troubled by the accident (farmers, parents of newborn children) or because there was a lack of previous work on a special and interesting group (youth). As a possible contrast we included a group of middle-aged men who were not registered as heads of families.

We were furthermore concerned with how stable and profound any changes of nuclear power attitudes were. We therefore conducted a panel study with a limited sample. The participants in the panel were asked to report their attitudes twice with a certain time interval in between.

THE INTERVIEW STUDY

The interview study was conducted in order to obtain extensive information regarding a large number of issues of potential interest when it came to attitudes to the nuclear power program subsequent to the Chernobyl accident. The present summary can give only a selection of results. The reader is referred to Drottz and Sjöberg[11] for a more detailed account.

Method

Time of study and selection of subjects. The interviews were mostly carried out during the latter part of July 1986, most often in the homes of the participants. Four youngsters in the Stockholm group were interviewed in the end of August. Since July is a common vacation month in Sweden there were some problems in recruiting interviewees.

We recruited persons in the following four categories: farmers, pregnant women, youths and men who were not parents. Farmers were of interest because the accident had the effect of directing much attention to their problems. To name an example, cattle were recommended by the National Institute for Radiation Protection to be kept indoors for parts of the spring. Pregnant women were often considered to be a special risk group because embryos were mentioned as being more vulnerable to radiation exposure than children and adults. Adolescents were of interest because, among other things, they had been too young to participate in the 1980 referendum. Voting in Sweden requires one to be aged 18 and participants in our group of youths were, at the most, 20 yr of age in 1986. The fourth group, men in the age range 25-35 yr who were not parents, was expected to be the least risk sensitive group. There were 15 members of each group with the exception of the pregnant women who were 14 in all. The number of men was 32 and the women were 27.

The participants were selected in an informal manner and do not constitute a random sample. As a rule we found that persons who were approached about participating in the study did so if it was practically feasible for them. In order to investigate the degree of representativeness of our groups we compared them to national data on certain calibration questions which were obtained from other investigators.

Place of data collection. Fallout from the accident was distributed over Sweden in a very uneven manner. We selected people from three areas: Gävle, in the center of maximum radiation, Stockholm on the east coast south of Gävle and the county of Bohus on the west coast of Sweden where a much lower level of fallout was registered.

Design of interviews. The interviews began with a number of background questions and eight calibration questions. Then followed a section on radiation, where we asked for judgements of the risk of being hurt in each of 18 different situations, such as having an X-ray examination, eating freshwater fish, etc. The second checklist asked for judgements of how often the subject had been engaged in various activities following the accident, as compared to the 6 months before it. Examples of activities were being outdoors, eating game, etc. The third list asked the subject to rate the risk that he or she had actually been injured by the radiation caused by the accident.

Next followed a section on attitudes to the Swedish nuclear power program, any changes in personal attitude to nuclear power since the time of the referendum, and consequences for Sweden of abolishing nuclear power. The participants were also asked to judge the probability of a serious reactor accident in Sweden and abroad, risks connected to the handling of radioactive wastes, the readiness in Sweden to deal with such accidents, and to what extent people have an influence on Sweden's energy policy.

In a subsequent section subjects were asked to compare different sources of energy when it came to domestic large scale use (coal, oil, hydro power and

alternative sources*). We also asked about what sacrifices the subject was willing to make in order to abolish nuclear power in Sweden before 2010.

Questions about anxiety and worry followed next. Degree of worry, what was the content of anxious thoughts, if the subject talked to other persons about his or her worry, bodily symptoms of worry, loss of emotional stability and recurrent thoughts and dreams connected to the accident were all covered.

Estimates of the risks of the type of accident exemplified by Chernobyl occurring again, regardless of where and including Sweden, were then asked for. We asked if the subject believed that the general sensitivity to risks of radiation would be affected by the accident.

The final sections asked the subject to state whether any fundamental values of life were affected by the development of the Swedish nuclear program and which sources of information regarding the accident they had utilized and what their attitude was to each of the sources, as well as their opinion of expertise in the matter. The interviews were tape recorded and took, on average, 90 min.

In order to describe the trends in a comprehensive manner we constructed several indices on the basis of groups of questions which showed considerable within-group correlation.

Results

Calibration questions. There were eight questions which made it possible to obtain a direct comparison with population data. Our informal sample of 59 persons showed, in some respects, a remarkable similarity with such data, see e.g. the data on overall worry in Table 1. (The table also gives comparable data from the other two studies).

The interview subjects were somewhat more pessimistic than the population in general when it came to an estimate of the number of persons in Sweden who were likely to get cancer because of the accident, see Table 2. They were also more pessimistic on a question about genetic injuries due to the accident.

TABLE 1

A comparison of overall worry reported by our interview, survey and panel subjects and in a population poll (n=601)(IMU, 1986). The table gives the proportion of persons selecting each response alternative

Response alternative	*Interview*	*Survey*	*Panel*	*Population*
Very worried	*0.25*	*0.30*	*0.33*	*0.25*
Rather worried	*0.44*	*0.42*	*0.39*	*0.46*
Not especially worried	*0.27*	*0.23*	*0.20*	*0.24*
Not worried at all	*0.02*	*0.03*	*0.04*	*0.04*
Don't know	*0.02*	*0.02*	*0.03*	*0.01*

* Wind and sun, peat, energy crops and rapidly growing forests.

It can furthermore be noted that the interview subjects were somewhat more interested in the issues raised by the accident than were the population in general.

We conclude that the group was not very different from the general population when it came to emotional reactions but that they may have been somewhat more involved and also more pessimistic about the health consequences of the population. Both of these differences may have been due to the fact that our data were collected about 6 weeks later than the poll*.

TABLE 2

A comparison of the number of persons likely to get cancer because of the Chernobyl accident reported by our interview, survey and panel subjects and in a population poll (n=601)(IMU, 1986). The table gives the proportion of persons selecting each response alternative

Response alternative	*Interview*	*Survey*	*Panel*	*Population*
Nobody	*0.00*	*0.03*	*0.07*	*0.09*
Approx. 10	*0.14*	*0.06*	*0.04*	*0.24*
Approx. 100	*0.37*	*0.15*	*0.19*	*0.21*
Approx. 1000	*0.25*	*0.15*	*0.15*	*0.15*
Approx. 10,000	*0.12*	*0.08*	*0.05*	*0.06*
Approx. 100,000	*0.02*	*0.04*	*0.02*	*0.02*
Don't know	*0.10*	*0.49*	*0.47*	*0.24*

Anxiety and worry. When it came to overall level of worry it was found that about two-thirds reported that they were 'very' or 'somewhat' worried, a rather large number. Women tended to be more worried than men and farmers, and pregnant women, as expected, were more worried than others. Pregnant and non-pregnant women did not differ in terms of worry. There were no overall differences among areas, a more surprising finding, but for women there was a difference in the expected direction, women in Gävle being most worried. Worry correlated with the judgement of nuclear power risks ($r=0.58$, $P<0.001$), but not with the judgement of radiation risks of other types.

Those who reported more worry tended to state that they had little information about what to do in case of an accident. Also, they were more negative to nuclear power and to the use of oil, and positive to alternative sources of energy.

* The radiation agency had adjusted its preliminary risk estimate upwards to some extent. In addition, the media coverage may have contributed to an ever increasing saliency of the issues.

Risk perception. We formed an index as a measure of the overall judgement of radiation risks in every-day situations, and one for perceived or assumed injury due to the Chernobyl accident. It was found that persons living on the west coast of Sweden had a tendency to rate both types of risks as lower than those residing in Gävle and Stockholm.

Several questions concerned changes in daily activities. They differed among areas, being most pronounced in Gävle. Farmers and pregnant women had made most changes. There were strong correlations between perceived risks of radiation and nuclear power and changes in daily habits, especially in the female group.

There was an interesting pattern of findings when it came to the rated change in risk level of certain activities subsequent to the accident, and reported own activity level (see Table 3).

In most activities, there was a report trend for a decreased activity. (A natural exception being activities outdoors, due to the seasonal change.) Furthermore, most activities were judged to be more risky after the accident than before it. However, there were some exceptions, such as eating beef and game.

We have computed Spearman rank order correlations between the values given in Table 3, across the nine activities (see Table 4). The difference between risk level before and after the accident has also been entered as a variable.

TABLE 3

Mean reported activity in certain situation, 'normal' risk perceptions and such perceptions following the Chernobyl accident, and correlations between level of activity and estimated radiation risk following the accident

		Risk perception		
Activity	*Change after the accident*[1]	*Normal*	*After accident*[2]	*Correlation change-risk after accident*
Being outdoors	3.20	1.00	1.58	-0.04
Drinking own water	2.93	0.86	1.03	-0.33*
Drinking municipal water	3.02	0.85	1.02	-0.18
Eating dairy produce	2.84	1.00	1.19	-0.42***
Eating vegetables	2.81	1.29	1.42	-0.37**
Eating freshwater fish	2.79	1.78	1.36	-0.14
Eating berries, mushrooms, fruit	2.67	1.48	1.60	-0.38**
Eating beef	2.92	1.27	1.11	-0.48***
Eating game	2.87	1.52	1.28	-0.26

[1] *<3 means less than before the accident, 3=no change, and >3 means that the activity was more common after than before the accident.*

[2] *Both kinds of risk judgement employed scales with six steps where 0=no risk at all and 5= a very large risk.*

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

It is interesting to note that decrease of activity occurs mostly with activities that, in themselves, and even before the accident, were regarded as most risky. Negative correlations between activity and risk level, indicating a prevalence of high risk and decreased activity, occurred mostly for activities which tended to increase following the accident (or decrease less than other activities).

TABLE 4
Spearman rank order correlations between variables in Table 3, augmented with the difference between risk before and after the accident

	Mean activity	*Correlation*	*Risk before*	*Risk after*	*Difference*
Mean activity	*1.000*				
Correlation	*0.367*	*1.000*			
Risk before	*-0.745*	*0.008*	*1.000*		
Risk after	*-0.500*	*0.133*	*0.603*	*1.000*	
Difference	*0.577*	*0.084*	*-0.807*	*-0.092*	*1.000*

The relationship reveals, however, that the average between-activity trend tends to coincide with the within-activity trend, suggesting that the factors accounting for variability in mean levels between activities are partly the same as those giving rise to individual differences in judgements of a given risk.

We had two types of risk questions: risk of nuclear power in general, and the risk of having been personally injured by the accident. The former group of questions did not differentiate groups and areas, but the latter did.

We also asked about personal variation of involvement in the issue of nuclear power. We found that those who had a more varying degree of involvement also were more negative to nuclear power and rated its risk level as higher. Perhaps they were more involved, on the average, and found it difficult to keep up their high level of involvement, especially since the development was against their own opinion prior to the accident.

Attitudes to various sources of energy. We scored the ratings of the various sources of energy firstly in an overall index of how favorably they were rated. Hydro power and alternative sources were judged positively while nuclear power, oil and, most of all, coal, were judged negatively. The evaluation of nuclear power differed among groups, farmers being most negative and young men who were not parents most positive. A closer look at the various aspects in which sources of energy were judged showed that risk aspects were dominating when it came to nuclear power, and safety in the case of alternative sources. Oil was associated with environmental damage and dependency with regard to foreign suppliers, and hydro power

appeared to have all the advantages: clean, safe, economically advantageous and under domestic control.

Who were most optimistic about the possibility of having an influence on Sweden's energy policy? Most of all farmers, and the older the respondent was the more optimistic was he or she in this respect. Pregnant women were most pessimistic about their chance of having some political influence. Quite naturally, *personal* influence was regarded as smaller than popular influence on the political process. The present group was, on the whole, rather optimistic about popular influence on energy policy.

Most respondents had had early information about the accident. They were actively following news about the incident, mostly on TV and radio. TV and radio were rated as the most reliable sources of information, evening newspapers as least reliable. Experts and representatives of the government authorities were regarded as quite reliable, experts perhaps slightly more so.

Most of the subjects believed that a rapid deployment of Swedish nuclear power would have negative effects on the standard of living in the country as a whole. They were, however, a bit more optimistic about effects on their personal standard of living. Men expected that abolishment of nuclear power would have negative economic effects more frequently than women. The respondents exhibited some willingness of personal economic sacrifices in order to contribute to the abolishment of nuclear power, but they were pessimistic about the willingness of other people to do the same. Those who were more worried about the risks of radiation were also more willing to make some sacrifices to get rid of the risk, not surprisingly.

When it came to the basic life values which could be affected by the abolishment of nuclear power it was found that most respondents perceived a conflict between the achievement of some safety and decreased worry about risks on the one hand, the risk of economic losses on the other.

A large majority believed that an accident like Chernobyl would happen again. The risks were mainly associated with nuclear power in general, and secondly with reactors in Eastern nations. A majority held it to be not unlikely that a serious accident could happen in Sweden. There was a belief that Swedes would, in the future, become more safety oriented. Finally, preparedness to deal with nuclear disasters was regarded as low.

Discussion

The results of the interview study showed that there was a high degree of worry and anxiety in the group, as many as 25% said they were very worried about the consequences of the accident. The respondents appeared to have been more worried than they had to be in the opinion of the majority of experts. They were also interested in getting information about the accident. More than half of the subjects believed that the radiation from Chernobyl could have caused genetic injuries. Lack of personal control over these events was perceived as quite unpleasant.

As expected from previous research, women were more worried than men. People living in the east of Sweden were more worried, quite naturally, than those in the west. It is also noteworthy that about 90% did not feel that they had obtained sufficient information about what to do in case of a nuclear accident.

The conflict between economics and safety was clearly perceived by most subjects, who also rejected fossil fuels such as oil and, in particular, coal. The negative attitude to coal is especially interesting, since the present plans in Sweden appear to call for replacing nuclear power with coal, at least to some extent.

The subjects judged the risk that they themselves had suffered some injury from the accident as small but possible. They avoided some activities they believed to be risky and they followed the news with a positive, but not unlimited, confidence in the information they obtained. They were a bit uncertain about who were the most competent experts in the area. They were surprised that Sweden could be reached by fallout from an accident in the Soviet Union, and they held it as likely that new accidents would happen, including in Sweden. This is a surprise shared also by many experts and administrators and there was clearly no planning for the event*.

We conclude from the interview study than an especially important aspect is the conception of the future, involving personal and social ability to control potentially disastrous events. People asked themselves: Can there be a new accident? How can I protect myself from radiation? Where can I get reliable information?

THE SURVEY STUDY

Following the interview study we performed two studies with mail questionnaires. The most extensive one was the survey study treated in the present section, and it is followed by an account of the smaller panel study.

The purpose of the survey study was to follow up on the interview data obtained in the first study with more extensive and reliable data from several random samples of groups corresponding to those in the interview study. The questions were selected from those that had turned out to be most promising in the interview study. The selection was necessary because of space and time limitations of the questionnaire. A more detailed account is given in Sjöberg and Drottz[12].

Farmers and adolescents could readily be reached by means of accessible official data files, pregnant women could not. We therefore included a group of parents of recently born children. Men without children of their own were also a somewhat difficult group to locate but we settled on the definition 'men who were not registered as head of families for children in their own household'. It is

* Employees at the Forsmark reactor, where unusually high levels of radiation were first discovered on April 28 were directed to stay outdoors, thus exposing them to more radiation than if they had stayed indoors.

reasonable to assume that men who are parents tend to be registered as head of families, but it need not always be the case. Also, some of these men could have children they were not living with and they could live with children who had another father. In spite of these complications, however, we found that this group of men lived in households with much fewer children, on the average, than other men in our study did.

Method

Subjects. There were four groups of subjects, namely
(1) Farmers.
(2) Adolescents aged 18-20.
(3) Parents of children born just before or after the accident.
(4) Men aged 25-35 who were not registered as heads of families of children in their own household.

Each group was studied in each of three areas:
(1) The county of Gävleborg (the most exposed area).
(2) The county of Stockholm (excluding the central city).
(3) The county of Bohus (excluding Göteborg).

About 75% of the respondents were men. There were 100 persons, randomly selected, in each of the 12 subgroups, thus a total of 1200.

Questionnaire design. The questionnaire started with some questions asking the subject to judge his or her attitude to nuclear power in general, how important the question is, comparisons between Swedish and foreign nuclear power, etc. Then followed questions about the risks of nuclear power, if the subject considered him or herself likely to be injured by the Chernobyl accident, and ratings of a number of 'everyday' risks in order to make it possible to compare perceptions of nuclear power risks with other kinds of risks. There were also some calibration questions, just as in the interview study.

The questionnaires were mailed in the beginning of September 1986. After three reminders, we had obtained by the closing date of 3 October 1986, 737 (61%) completed (more or less) questionnaires and responses from another 15% saying that they for various reasons were unwilling to complete the questionnaire.

Results

Beginning with the calibration questions we note that our data were quite close to those obtained earlier in 1986 by IMU (see Table 1) when it came to worry. However, when it came to cancer frequency and genetic injuries due to the accident our present subjects were more pessimistic than the data obtained earlier by IMU and about the same time by Hultåker[13]. The survey respondents resembled, in this respect, the participants in the interview study. The respondents

were more pessimistic than the general population about the effects of the accident and they were, on average, more negative to nuclear power. They were also much less inclined to state an opinion, as demonstrated by the very large number of people who checked 'don't know', but that may be an effect of the use of a mail questionnaire in our survey (and panel) studies.

As to global evaluation of nuclear power, 65% were negative. Women were more negative than men. People in Gävle were more negative than those in Stockholm and on the west coast. Farmers and parents of recently born children were also negative while adolescents were more positive, as were men without children of their own, see Figs. 1-3.

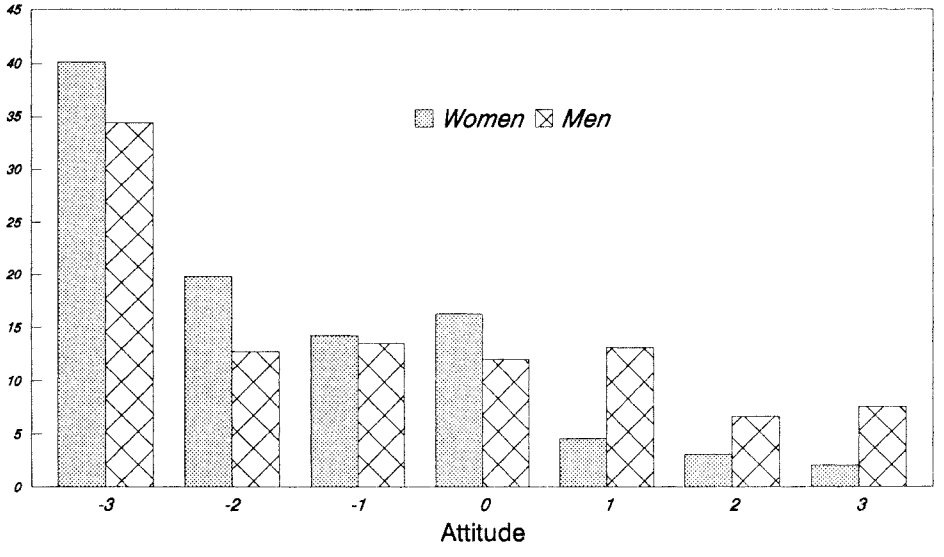

FIGURE 1. Distributions of attitude to nuclear power; men and women.

Figures 1-3 give a picture of the data as a whole. The amount of difference between various groups in their tendency to choose the more negative response alternatives was about 10-15%, but these differences increased when the questions concerned more personal aspects, such as the risk of personal injury due to the accident. Worry about having been personally injured was indicated by some 40% of the Gävleborg respondents, twice as many as found in the other two groups. It therefore seems that the accident doubled the number of people seriously worried by nuclear power.

The question of nuclear power was considered to be quite important, especially in the most negative groups. Some 60% stated that the accident had made them more negative to nuclear power, 40% felt they had not changed their attitude and almost nobody had become more positive. Women responded more often than men that they had become more negative.

Swedish nuclear power was generally considered to be safer than foreign, but in some female groups the two kinds of technology (Swedish and foreign) were considered equally dangerous.

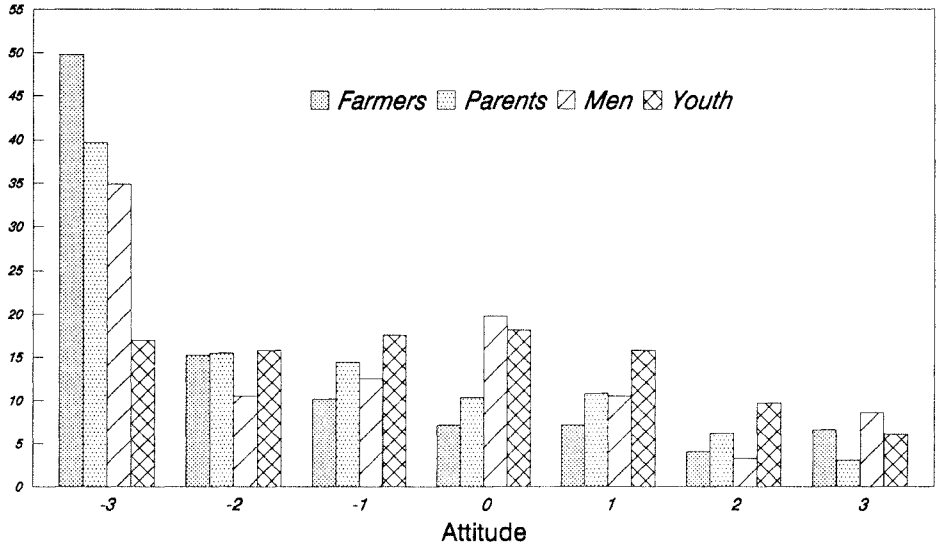

FIGURE 2. Distributions of attitude to nuclear power; four different groups.

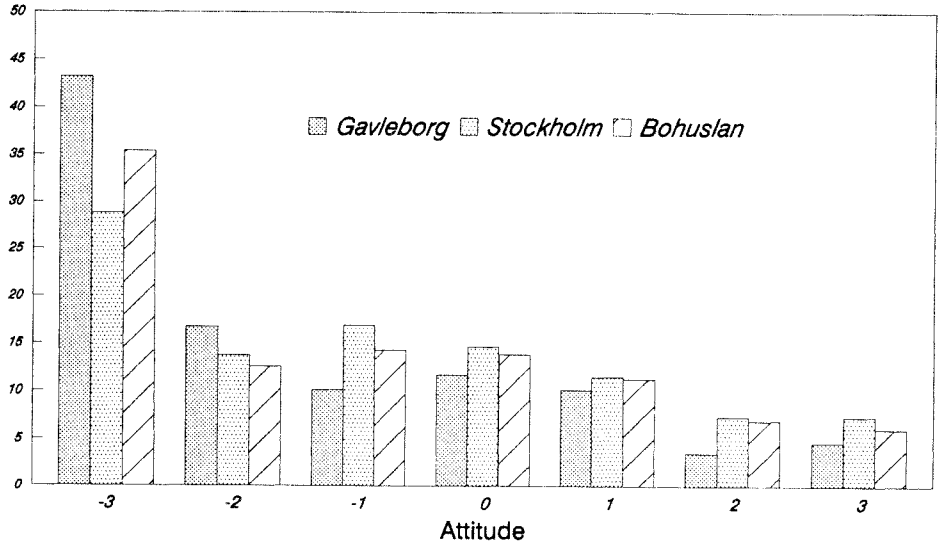

FIGURE 3. Distributions of attitude to nuclear power; three parts of Sweden.

There were statistically few bodily symptoms reported as due to the accident (<5%)* but psychological effects (such as loss of poise) were much more common (about 25%). The latter figure was about 30% for women and for inhabitants of Gävleborg county.

Many people, about 80% in all, believed that new accidents would happen but only half (40%) believed that such accidents would occur in Sweden.

When it came to radiation risks about 50% were of the opinion that there are very large or rather large risks of radiation for people in Sweden in general. They were more optimistic about personal risks. The greatest source of worry was associated with having eaten berries, mushrooms, vegetables and game.

About half of the sample stated that the risks of nuclear power were very large or rather large. The risks from foreign nuclear power were considered to be even larger. Swedish preparedness to deal with accidents was considered to be low, especially by farmers.

Judgements were made of nuclear power in relation to basic life values. In all respects, with one exception, it was found that the judgement was negative. The most pronounced negative rating was given the dimension 'hope for the future'. The exception was that of economic aspects. More conventional attitude statements concerning nuclear power correlated more highly with a global attitude measure, but the life value ratings contributed significantly beyond the predictability afforded by the attitude statements.

There were nine basic life values investigated here. We scored the respondents with regard to how many life values they had rated negatively or positively and divided the sample into three sub-groups: those who gave only negative ratings, those who gave only positive ratings and a group which gave some negative and some positive ratings. The totally negative group constituted 15% of the sample while the totally positive group was only 1%. The rest were variable in their attitudes.

The nuclear power attitude was investigated in more detail by means of regression analysis. First, we entered the mean attitude statements and the mean value ratings as predictors, employing the global rating of attitude to nuclear power as dependent variable. The squared multiple correlation was estimated to be 0.551 (corrected for bias). The beta weights were 0.56 and 0.24 for attitude statements and value dimensions, respectively. Second, we performed a stepwise regression with all of the separate attitude statements and value dimensions as predictors. The highest beta weight (0.25) was obtained by the value dimension 'Hope for the future', the second highest (0.19) by the attitude statement 'Nuclear power is necessary to preserve Swedish technological know-how at a high level'. By including other value dimensions and attitude statements it was possible to account for virtually all of the true variance of the attitude to nuclear power.

* The figures given for both bodily and psychological symptoms include those respondents who did not check the alternatives "no, very little" or "no, not at all".

There were also a few questions about iodine pills. Only very few persons had acquired and consumed such pills*.

Another interesting set of results was produced by the general risk ratings. Three of the groups (all except men who were not head of families) judged radiation from the Chernobyl accident to be among their four most dangerous risks, in a group of eleven risks (see Fig. 4). In addition, farmers and parents of newborn children judged the Swedish nuclear program to be among the four worst risks. Other risks that were ranked highly were occupational injuries, traffic accidents, assault and heart infarction. Inhabitants of Gävle rated the risks connected with nuclear power higher than other groups but did not differ from other groups when rating other kinds of risks.

There were quite considerable sex differences in risk perception and attitudes to nuclear power. We found that the perceived risks of nuclear power could explain the sex differences to a considerable extent, but not entirely.

Finally, we were surprised to find that adolescents constituted the group with the least negative attitudes to nuclear power. This was particularly true of young boys, young girls were less positive, but the young female group was still higher in attitude than other women.

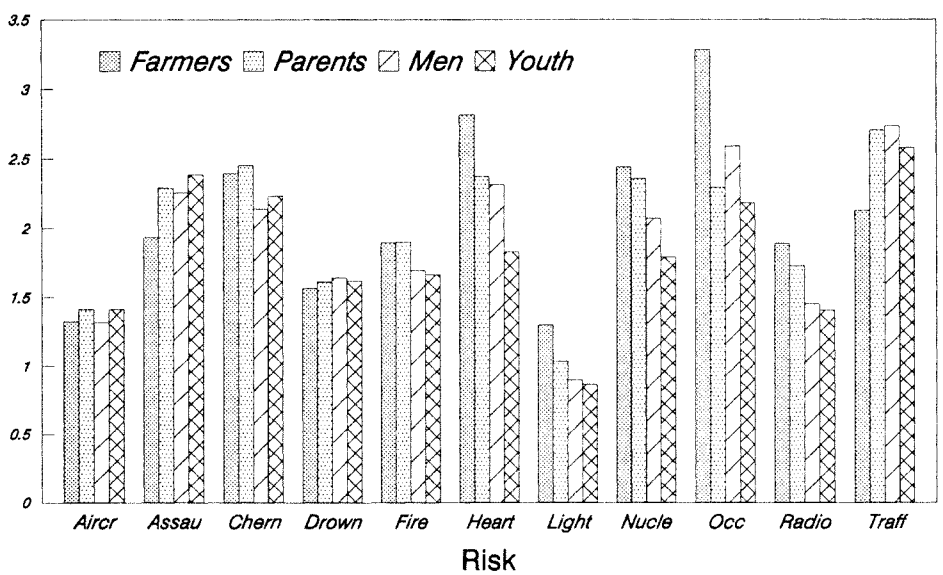

FIGURE 4. Average risk ratings of four groups of persons and eleven risks.

* This finding is of course not inconsistent with the fact that the stock of iodine pills available in pharmacies was very quickly sold out. Even if only 1% of the adult population buys the pills this is still some 65,000 customers.

Discussion

The most important result of the survey study was the discovery of considerable differences between men and women, different parts of the country and our four groups with regard to attitude to nuclear power and risk perceptions, especially the perception of radiation risks. Since the differences were in accordance with what could be expected if the accident had been their cause, it is reasonable to conclude that the accident in fact had caused them. This conclusion is strengthened by the fact that the differences could not be accounted for by differences in general level of risk perception. Therefore, the data demonstrate that the accident strongly increased worry about the risks of nuclear power and also that it made the groups most directly involved considerably more negative to nuclear power. It was particularly interesting to see that 15 times as many persons were totally negative as were totally positive. We suggest that the more salient political consequences of the accident in our country may come because some people hold very strong opinions about the dangers of nuclear power and strongly negative attitudes, especially after the accident*.

We were surprised by the finding that adolescents turned out to be the least risk aversive group. Note that the group we investigated were of the ages 18-20. A Swedish TV show reported, in December 1986, that school children aged 13-16 were quite negative to nuclear power. (About 70% wanted to abolish nuclear power before 2010; only 11% wanted to keep it after that date.) Other surveys have shown a high level of concern about nuclear arms in young people. Further study of the development of risk attitudes is clearly called for.

It was possible to explain the variation in attitude to nuclear power rather well with reference to risk perceptions. We note, in particular, that the risks connected with the accident and with the Swedish nuclear program were rated as quite large, much larger than most experts hold them to be. Other variables, besides risk perception and sex, were not strongly related to nuclear attitudes. However, parents of newborn children were more concerned than others, with the exception of farmers, a group that seems not to have been investigated before in the context of nuclear attitudes and risk perception. It was found in studies of reactions of the local population to the Harrisburg accident that parents of young children reacted especially strongly[9]. Sex differences could not be accounted for entirely by variation in risk perception, as claimed by Brody[14] for American data, but still to a large extent.

A rather interesting finding was the fact that a direct question about 'anxiety' or 'worry' (in Swedish 'oro') was less sensitive to variability among groups and areas than attitude and value questions. We also found that different questions intended to measure different aspects of anxiety were only weakly correlated, something not at all true of value and attitude questions, e.g. concerned with nuclear power risks.

Later polls, by e.g. SIFO[15], have shown that people tend to become less anxious and also that the attitude to nuclear power becomes more positive or less

* Even if the most decidedly negative group is rather small, it could be enough to upset the rather delicate balance in the Swedish parliament in the elections scheduled for 1988.

negative. This is quite in line with the availability concept of Kahneman and Tversky[16], postulating that a risk is judged as more aversive if it is more salient. The most important question is, however, how those people react who were most decided in their opinions.

THE PANEL STUDY

The purpose of the panel study was to provide some information about the stability of the attitude to nuclear power at the level of individuals. It is of course possible that all individuals change their opinion about an issue and that the population mean still stays roughly the same at two different points in time. Therefore, the question can be answered only if panel data are available.

Because of the short time of planning and the necessity to submit a final report by the middle of October 1986, we could only allow a short time, about a month, to elapse between the two attitude reports requested from the panel participants. A longer time interval would have been of interest to further document the stability of the attitudes.

It is possible that some people may have remembered some of the ratings they made in the first questionnaire when they answered the second, due to the relatively short time interval. Since the first questionnaire was rather extensive we do not, however, believe that the memory factor is a major obstacle to validity of the findings.

Method

We sampled 300 persons each from the counties of Bohus (except Göteborg and suburbs), Kopparberg and Gävleborg, on the basis of the published tax-payers' directories for these counties. The questionnaire was mailed to them at the end of August 1986; 148 replied. The second questionnaire was mailed 3 weeks after receipt of the first questionnaire; 105 persons had replied by 7 October, after three reminders. It is possible that the rather low response rate is dependent on the circumstance that the respondents were informed from the beginning, for ethical reasons, that there would be a second questionnaire as a follow-up to the first one. However, the main interest of the panel study was not so much to be able to generalize to population location data but to gather some notion as to the individual stability of attitudes. We have a data set of 105 individuals to answer that question.

Questionnaire

The first questionnaire was quite similar to the one used in the survey study, with the major exception that ratings of general risk levels were not asked for. In the second questionnaire there was a repetition of some questions from the first one, and also some questions about mass media influence on opinions. The second questionnaire was much shorter than the first one.

Results and discussion

The major interest was focused on changes in attitude to nuclear power. There was only one significant mean change between the two occasions; the respondents had become more pessimistic about the risks of being injured by radioactivity in Sweden.

On the other hand, the correlations between the two occasions varied considerably (see Table 5). The stability of the global attitude to nuclear power was as high as 0.88, while, to take an example from the other extreme, the rating of the importance of the issue only had a stability of 0.35.

There were no significant correlations between size of attitude change and other variables, including the time elapsing between the two measurements.

When it came to background variables we found once more that sex correlated with nuclear attitudes, women being more negative than men.

TABLE 5

Correlations between responses to various attitude items and scales, with an interval of about 1 month

Attitude item	*Correlation*
Attitude to nuclear power	*0.88*
The importance of the issue of nuclear power	*0.35*
Change of attitude following the Chernobyl accident	*0.63*
Difference between Swedish and foreign nuclear power	*0.73*
Change of one's personal life after the accident	*0.60*
Can a similar accident happen again?	*0.70*
The risk of people in general to be injured by radioactivity	*0.68*
Own risk of being injured by radioactivity	*0.74*
Judgement of the probability of having been injured	*0.77*
The risks of Swedish nuclear power	*0.83*
The risks of nuclear power in general	*0.74*
Standard of living effects of abolishing nuclear power	*0.66*
The possibility of having an influence on energy policy	*0.59*

GENERAL DISCUSSION

Our studies, and those published by Hultåker[13] and Höijer[17], as well as regular opinion polls by IMU and SIFO, show that the population was strongly affected by the Chernobyl accident, especially those living in the most strongly affected areas and women and farmers. Adolescents emerged in our studies as the least affected group. It was hard to find persons who were strongly and univocally in favor of nuclear power. Most people expected new accidents to happen, especially abroad. The economic disadvantages of deploying Swedish nuclear power were not considered to be very great. As noted in the account of the interview study, people frequently perceived a conflict between economics and safety, so a more direct question on that issue may have been more revealing than the present formulation.

People judged the risks of injury due to the Swedish nuclear power program and the Chernobyl accident to be quite substantial, much larger than the official risk assessments.

The attitude to nuclear power was stable during the time studied, which was short, but it was also a period of continued mass media controversy about the issues.

In November 1986, after the conclusion of our studies, the National Institute for Radiation Protection issued a leaflet to all households in Sweden stating some basic facts about the radiation and the Chernobyl accident, and with the general message that the impact on the population in Sweden was negligible. Stütz[10] investigated the information effects of the leaflet and found that some 50% had at least looked over it quickly (about 25% said that they had read all of it). Any effects of the information contained in the leaflet were probably very small but it is very hard to know what to conclude from such a study because those who read the information do not constitute a random sample of the population. Other designs are called for. However, Stütz did ask about anxiety and worry (with a formulation slightly different from ours) and found that those who said they were 'very' or 'rather' anxious were about 50%, considerably less than reported in previous studies.

Still later polls[15,18] have, as mentioned above, suggested that anxiety is tapering off and attitudes to nuclear power are becoming more positive. The difficulties involved when it comes to comparing samples with different response rates, at times obscurely reported, as well as different ways of defining the population are not trivial, however. To this we must add that the formulations of questions at times demonstrate factual errors and manipulative attempts, see Sjöberg and Drottz[19] for a further discussion.

The present data on basic value dimensions and nuclear power attitudes introduce a somewhat new perspective on the issues. Moral aspects of risks have been found to contribute rather strongly to the determination of whether risks are acceptable[20] and the moral dimension seems to be responsible for the strong affective flavor of some debates on issues of risk[1].

A final point on risk perception concerns credible expertise. Stütz reported that women more often than men mistrusted the information that was given by the

National Institute for Radiation Protection[10]. It would be interesting to find out whether this is a general trend or if it is confined to the issue of radiation risks.

Sjöberg[1] reviewed cases in which statements by credible experts, in this case medical doctors, gave rise to considerable public controversy over risks. In Sweden, the general trend seems to be to trust both government officials, often perceived as having technical expertise as well, and experts associated with the academic world. Indeed, one may speculate that even the present Minister of Energy (Dahl) has succeeded in creating such an image of expertise since there was so little criticism directed against her in the media in May of 1986 (in spite of considerable criticism of the lack of preparedness and what was conceived as inconsistency in the statements issued by the National Institute for Radiation Protection).

If it is true that credible experts often have a strong influence on public opinion, and physicians are surely one eminently credible group in the eyes of most people, why do not people more willingly follow the advice from their doctors in avoiding certain risks to their health, such as the risks associated with smoking or eating too much? The reasons may partly be that they rationally decide to enjoy themselves in the short run and consciously decide to ignore the long run, but more often it is probably the case that they ignore risks either by postponing a definite solution, taking a decision 'in principle' to quiet guilt feelings[21], or by various kinds of twisted reasoning that tend to lead quickly to relapses from attempts at a more healthy way of living[22]. It has, indeed, been argued that health risks in contemporary society are psychological in the sense that people could avoid them if they could behave in a different manner[23]. This is less true, of course, of the risks associated with large scale social programs such as nuclear power. Here the individual is rather helpless and it is perhaps the feeling of lack of control over a significant part of the environment which, in the long run, makes such risks so unacceptable to many people. The aversive properties of perceived lack of control over one's own actions have been demonstrated by Sjöberg and Magneberg[24].

In order to promote health, it is often attempted to inform the population, by means of mass media, about the risks they run and how they can be avoided. The problem with most risky individual actions, such as smoking, is, however, that individuals find it hard to control their own behavior, not so much that they lack adequate information about the risks. Stress seems to play an important role here, and the search for pleasure[25]. A large amount of research has shown that mass media campaigns most often have only a slight effect. Attitudes are hard to change, behavior even more so[26].

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ADOLESCENTS' ATTITUDES TO NUCLEAR POWER AND RADIOACTIVE WASTES

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ADOLESCENTS' ATTITUDES TO NUCLEAR POWER AND RADIOACTIVE WASTES*

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ABSTRACT

High school students (N=380) rated their attitude to nuclear power and to various risks; nuclear and non-nuclear, personal and societal. They also rated risks related to the handling and disposal of radioactive waste. It was found that ordinary personal risks obtained lower risk ratings than risks to society, and accident risks related to the handling and disposal of radioactive waste. However, the risk of personal injury due to exposure to radioactive wastes was rated as the highest of a set of 11 risks. In general, items which made reference to radiation were rated higher than items which did not mention this aspect. Compared to a national sample dominated by adults, the adolescents held more positive attitudes to nuclear power and rated risks of the technology lower than adults. Students specializing in economics or technology were the least concerned about nuclear power risks and had the most positive attitudes to nuclear power. Female students most often rated risk higher than did male students. Persons worried about nuclear power emphasized risks of accidents, waste disposal problems and radiation exposure whereas those who did not worry saw nuclear power as quite safe and emphasized its basis on advanced technological knowledge and skill. The results of the study are discussed in relation to the differences in risk perception of experts and the public. The results suggest that future experts will be recruited from groups which have, already in adolescence, established beliefs about nuclear technology risks which are lower than those of other groups.

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INTRODUCTION

Nuclear power plays a prominent role in discussions of risk in modern society. On the basis of environmental concern arguments have been presented both for and against the use and development of nuclear power facilities. Arguments in favor of nuclear power often stress its efficiency and its clean production of energy during periods of normal operation. Antagonists of nuclear power instead often emphasize the risk of radioactive contamination due to accidents or in the process of handling waste products. The risks associated with accidents in power plants and with radiation are highly salient to many people (van der Pligt, Eiser & Spears, 1986; Hohenemser & Renn, 1989). A recent example is the Chernobyl accident in 1986, which caused a strong increase in worry over nuclear power risks in many parts of the world (e.g. Sjöberg & Drottz, 1987; Drottz-Sjöberg & Sjöberg, 1990; Renn, 1990; Eiser, Hannover, Mann, Morin, van der Pligt & Webley, 1990).

Contemporary with the debate about nuclear power plant accidents, and their possible consequences, the storage of nuclear waste products has gradually emerged as a highly salient concern demanding rational solution. The industry and concerned governmental agencies are currently involved in developing plans and measures for the safe handling and disposal of radioactive wastes (Gelin, 1985; Carleson, 1985; Moberg, 1990). They are also involved in confrontations with public interest groups, including legal disputes, when it comes to the testing and implementation of such plans (Krauskopf, 1990). According to Rankin and Nealey (1978) and Nealey, Melber and Rankin (1983) there has been an increase of public concern in the USA about nuclear waste disposal issues since the mid 1970's. Kasperson et al. (1980) also emphasized the public concern over problems of radioactive wastes, and Bord (1987) further documented the fear and distrust of the general public as to radioactive waste disposal (cp. Lindell, Earle, Herbert & Perry, 1978; Rankin & Nealey, 1981; Payne, 1984; Morell & Magorian, 1982).

Thus, two related issues are involved in the nuclear power energy debate. Firstly there is the question of the merits and the risks of producing energy by utilizing nuclear energy. The expressed views range from a further extension to a total abandoning of the nuclear program. Secondly there is the issue of the proper handling and storage of radioactive wastes already produced. The latter issue will stay on the agenda regardless of future decisions concerning the operation of nuclear power plants, since the 'abolishing' of accumulated waste is exactly the challenge to be addressed. Until this challenge has been met satisfactorily, attempts to keep the two issues apart will probably prove futile.

A great number of studies have examined public opinions and their development over time regarding attitudes and opinions to nuclear power. Some of these studies have included aspects related to radioactive waste, but there has generally been less research focusing on attitudes and perceptions of waste risks than on other aspects of nuclear power.

We have previously reported results of a survey of public opinion in the population at large on nuclear waste related issues (Sjöberg & Drottz, 1988). In the

present study we focus on adolescents. There are several reasons why this is a particularly important group to study, some of which will be presented below.

In a developmental study covering the age range 10 - 16 years of age it was found that children became more risk tolerant (with respect to both individual and societal risks) as they grew older (Sjöberg & Torell, 1990). In our study of attitudes to nuclear power after the Chernobyl accident (Sjöberg & Drottz, 1987) we included a group of young people (aged 18-20). We found that they, especially the young men, were the least negative to nuclear power of all groups. This finding is in accordance with reports of risk seeking behavior being common among young men (Wilson & Daly, 1985), and with young male drivers' perceptions of risk in traffic situations (Tränkle, Gelau & Metker, 1990). To our knowledge, there have been no studies of attitudes to nuclear waste focusing on this age group so far. We therefore considered it to be of interest to investigate the attitudes and risk perceptions of a group of adolescents at the age of maximum risk tolerance and to compare the results with those of our national survey mentioned above (Sjöberg & Drottz, 1987). Thus we wanted to investigate whether or not the adolescent group would rate risks of nuclear power and nuclear waste lower than the adult group. The prediction was that they would.

Another reason for studying adolescents is related to the socialization of values and beliefs regarding nuclear power issues, and the difference between experts and public opinion in this respect. Expert and lay opinions often differ drastically (Kasperson et al., 1980; Fischhoff, Slovic and Lichtenstein, 1982). It is sometimes argued, especially by experts, that experts differ in risk estimation from lay people because of their superior knowledge. It is also possible, however, that the difference could be traced to value systems differing between groups, including certain values established early in the socialization processes and present already in adolescence. Some values established in adolescence have been found to be rather stable (Jennings & Niemi, 1981). The importance of values for risk assessment was stressed by Whitmore (1983) and Lynn (1986).

In the present study we therefore compared the perceptions of risk of adolescents belonging to different educational groups, some of whom are traditional recruitment bases for future energy experts. We assumed that they had formed opinions about issues related to nuclear power and predicted that those opinions would be in accordance with the general interest orientation of the chosen study program. If attitudes of future experts already in adolescence are similar to those of adult experts, i.e. in the direction of lower perceived risks, it would seem that the hypothesis of a conclusive knowledge basis of risk estimates by experts is weakened.

An investigation of high school students of social science, humanities and natural science and their study interest (Drottz-Sjöberg, 1990), showed that all groups of students emphasized the importance and value of the study program they had chosen. Furthermore, students of natural science were more positive to new technology than others. In working with somewhat older students at the college level we have found that there are quite extensive attitude and belief differences between students of technology and students of psychology (Jansson, Drottz-

Sjöberg & Sjöberg, 1989). The high school students who participated in the present study covered an even broader range of interests.

We predicted that students specializing in technology and economics would judge the risks of nuclear power and wastes to be lower than would other groups. Similar response patterns were expected regarding students of natural science. The latter group seemed more unpredictable, however, since research on study interest (Lybeck & Sjöberg, 1984) often shows a marked sex difference in terms of a female preference for life oriented subject matters, e.g. biology, and a male preference for non-living nature subject matters, e.g. physics.

The goal of pursuing a successful career as an engineer or an economist involves internalizing positive values connected with technology and industry. Technology and industry will be cherished as "belongings" (cf. Abelson, 1986) and negative aspects such as technology risks will be denied or less pronounced. Similar denial phenomena have been pointed out in the perception of somatic illnesses, where symptoms are frequently denied (Weinstein, 1984, 1987) and with respect to risks to one's home from radon gas (Sjöberg, 1989).

Students of social science and humanities, on the other hand, were expected to express attitudes and a social orientation focusing on human social functioning and moral values in contrast to valuing technological and economical progress and efficiency, and to be more skeptical to nuclear power technology as well as more prone to emphasize technological risks (Jansson, Drottz-Sjöberg & Sjöberg, 1989; Drottz-Sjöberg, 1990).

To summarize, the plan of the present study was (a) to investigate attitudes to nuclear power and risk perception of nuclear waste in groups of adolescents as compared to an adult population, and (b) to compare risk judgments of adolescent groups differing in their orientation of interests. The study was aimed at investigating whether the youth group considered nuclear waste risks as lower than adults did and whether groups of youths who differed in study orientations also differed in risk perception and risk related beliefs and attitudes.

METHOD

Subjects

The subjects were enrolled at three different high schools in the Stockholm county. The schools were those in the Stockholm district which offered education in the five major areas of natural science, social science, technology, economics and humanities. All recruitment areas of the three participating schools included students of varied socio-economic backgrounds. The data collection took place during ordinary class hours in late 1986. This was a period when the strong initial reactions to the Chernobyl accident had largely tapered off (Sjöberg & Drottz, 1987). Participation in the study was of course voluntary, but no student was absent or left class due to the data collection.

The total number of subjects was 380, 223 women and 157 men. Their mean age was 18.2 years. They were all students of the last year of 3 or 4 year high

school programs (grades 12-13) and were enrolled in the following study programs (number of students participating in the present study given within parentheses): natural science (48), technology (75), social science (86), humanities (76) and economics (95). There were few men in the humanities group, and relatively few women in the technology study program.

Population data of a survey of the Swedish population (N=591) (Sjöberg & Drottz, 1988) will be used in the present paper for comparisons between adolescents and adults. The survey covered to a large extent the same questions as those put to the adolescents. Only questions with the same wording were used in the comparisons. Population data included respondents in the age range of 18-65 years (about 6% was between 18-20), the mean age was 41.0 (SD=13.5 years). The proportion of men was 0.53. The total adult sample was used in the comparisons since the young age group, which could have been deleted, was small and their influence on mean values only marginal.

Questionnaire

Two open-ended questions about advantages and disadvantages of domestic nuclear power were included in the questionnaire prior to questions regarding nuclear waste. The students listed the three most important advantages and disadvantages in their own words. The responses were coded in two steps; firstly, a main categorization organizing the often very short replies in accordance with what they expressed, e.g. risk, economy, energy supply, etc. Secondly a somewhat more detailed categorization was made within the larger categories, e.g. "cheep energy" and "cheeper than ..." responses were identified within the 'economy' category. Only the resulting main categories are presented here (for a more detailed presentation, see Drottz and Sjöberg, 1988).

The importance of the current nuclear power and nuclear waste issues was measured on 7-point bipolar scales (-3 to +3) with anchoring categories given as very important and very unimportant. The midpoint of the respective scales was labeled "neither important nor unimportant".

Nuclear power attitude was measured on a bipolar 7-point scale (-3= "Absolutely negative", through 0="Neither, nor", to +3="Absolutely positive"). The adolescents' attitude was compared to the attitude of a sample of the population. This adult sample responded to the same question by using the same scale.

The questionnaire also covered questions about potential threats to society, including the threats from pollution and nuclear power, as well as the AIDS disease, violent crime and drug abuse. The threats were measured on 6-point scales ranging from (0)="No threat at all" to (5)="Very large threat". The adolescents' ratings of some of these items were compared to the corresponding ratings of the adult sample. Six of the "threat" items, i.e. excluding nuclear power, were used for the construction of the THREAT index (Cronbach's alpha=0.68).

One question concerned whether the students worried about something in relation to nuclear power. They were asked to respond either "Yes" or "No", and

to give a motivation of their reply in their own words. The qualitative replies were coded into main response categories.

Risks with nuclear power, the operation of nuclear power plants and with respect to handling of nuclear waste were all measured on 5-point scales (1="Very large risks" to 5="No risks at all"). These three items were subsequently pooled into a nuclear power risk index (Cronbach's alpha=0.91). The subjects were also asked for an assessment of the current risk to people in general of being exposed to harmful radiation on a similar 5-point scale. The latter question was introduced because of the increased worry reported after the Chernobyl accident some eight months prior to the study (see also Sjöberg & Drottz, 1988; Drottz-Sjöberg & Sjöberg, 1990).

The students were asked to what degree they felt confidence in experts with respect to handling and disposal of radioactive waste. The six response categories ranged from (1)="To a very high degree" to (6)="Not at all". This item was combined with a question, rated on the same scale, of their perceptions of the parental generations concern of their personal future, regarding use of nuclear power, to an index of TRUST (Cronbach's alpha=0.58).

Eleven items were rated with respect to personal risk. The list included seven ordinary adverse events, e.g. to have a serious traffic accident, to be assaulted, to drown, etc., and three items which included some reference to radiation, e.g. to be injured by natural background radiation, by radiation from a leaking deposit and by radiation from an accident in the handling of radioactive waste. All items were measured on 6-point scales ranging from (0)="Non-existent" to (5)="Very large" risk. The seven items of ordinary adverse events were subsequently used in the PRISK index (Cronbach's alpha=0.75) as a measure of general risk sensitivity. The adolescents' ratings of eight of the items included in the list could be compared to adults' ratings of the same risks.

Another eleven ratings focused on radioactive waste and concerned the risk of serious accidents in relation to its handling and disposal. For example, the students rated the risks during transportation of waste on land and water, due to debilitation of container material, changes in bedrock, sabotage and theft. All 11 items used the same 6-point rating scales as presented above for the personal risk ratings. All items were included in the ACC index (Cronbach's alpha=0.90). Exactly the same task had been presented the respondents of the adult sample, and the risk ratings of the two samples were compared. The adolescents furthermore used an 11-point scale to indicate the risk to humans they perceived associated with disposal of spent fuel rods in the bedrock. The scale ranged from (0)="No risk at all" to (10)="Very large risk". They were also asked if they considered the issues related to disposal of radioactive waste satisfactorily solved at the present time. They responded on a 7-point scale (-3 to +3) with the anchoring categories of "No, absolutely not" and "Yes, absolutely".

There were furthermore questions asking the students to assess, for low, medium and high level waste, the length of time during which the different kinds of waste would be dangerous to human beings, and at which level of depth in rock they should be deposited. They could give any number or answer in open ended

response formats. Low level waste was exemplified as maintenance material, medium level waste as for example demolished material, and high level waste as used fuel rods.

The open-ended responses varied extensively, both with respect to type of answer (quantitative and qualitative), and with respect to content. A detailed account of the responses is given elsewhere (Drottz & Sjöberg, 1988). The presentation below schematically exemplifies the responses, and compares adolescents and adults also in this respect.

One question asked the students to reveal their current level of knowledge of the domestic handling and disposal of nuclear waste. Five response categories were available, ranging from (1)="I know very much about these issues" to (5)="I know nothing about these issues". Similar response alternatives had been given the adult sample, and the assessments of personal knowledge were compared.

The questionnaire also covered the five basic values of physical health, economic standard, freedom, hope for the future and possibility to influence one's own life. These "life values" were rated with respect to how positively or negatively they were influenced by nuclear power. A 6-point scale ranging from -3 to +3 was used. The students could also respond that the life value in question lacked importance in the context. These latter responses were in the regression analyses coded as zero, i.e. introduced in the middle of the scale, primarily for the reason of avoiding the deletion of subjects from the analyses.

Finally, the questionnaire listed seven positively or negatively framed statements related to risk, moral, nuclear waste and its disposal. The students responded by indicating their agreement or disagreement on bipolar 7-point scales (-3="Do not agree at all", through 0="Uncertain", to +3="Agree completely"). One item stated, for example, that the benefit of nuclear power is much larger than the risks of its radioactive waste. Another that it is not right to leave unsolved problems to future generations. Four items framed in a positive manner relative to nuclear power were combined into the POSATT index (Cronbach's alpha=0.73), and the three negatively framed items were used for the NEGATT index (Cronbach's alpha=0.60).

Another list of 13 items asked the subjects to estimate the likelihood that certain events would happen within 200 years. The response scale ranged from (0)="Non-existent" to (5)="Very large". An example is the statement that radioactive waste will be retrieved by mistake, another that the ground-water will be contaminated. Ten of these items explicitly mentioned an adverse event including radiation. These items were collapsed into the RAD index (Cronbach's alpha=0.94).

Design and procedure

The SYSTAT statistical package (Wilkinson, 1989) was used for all statistical analyses. Due to the unbalanced design of the study with respect to sex and educational program, all reported values of analyses of variance regarding the adolescent sample are based on two-way ANOVAs (2*5 design). Indices were

tested for reliability by Cronbach's alpha. Details are given under the questionnaire heading above and in the text. Comparisons between the adolescent sample and a sample of the Swedish population used *t*-statistics after appending cases and relevant variables into one data file. Multiple regression analyses were performed for prediction of nuclear power attitude on the basis of ratings indicating nuclear power influence on life values, as well as to predict perception of nuclear waste. Qualitative responses from open-ended response formats were coded manually and classified into rough categories.

The students had prior to the study been informed by their teachers that they were about to be asked to respond to a questionnaire concerning Swedish nuclear power. This information was repeated before data collection. They were not told, however, that the focus of the study concerned radioactive wastes. Furthermore, students were asked not to look ahead in the questionnaire or go back to make changes, but to answer the questions in the order they appeared. Background data were asked for first, followed by questions about threats to society, general attitude to nuclear power and the open ended questions about its advantages and disadvantages. By this procedure we aimed at collecting spontaneous open-ended responses before the topic of nuclear waste was introduced. The response time to the questionnaire varied from 20 to 45 minutes.

RESULTS

Advantages and disadvantages of nuclear power

Two open-ended questions about advantages and disadvantages of domestic use of nuclear power were inserted in the first part of the questionnaire. The students listed the three most important aspects in response to each question.

Advantages of nuclear power were coded into eleven main categories, e.g. economical aspects, efficiency, and environmental concern, etc. The listed *disadvantages* were also classified into eleven categories, e.g. risk aspects, and concern over waste, etc. Of the total of 380 students about 88%, 67% and 35% listed a first, a second and a third advantage of nuclear power. With respect to disadvantages the corresponding figures were 95%, 74% and 45%. The main results of the categorization are presented in Table 1 below.

Table 1 shows that environmental concern, economic benefit and energy supply issues were among the most frequently given kinds of replies to the question of advantages of nuclear power. Nobody mentioned risks or waste products among the advantages. The responses categorized under the 'economic' heading included, from the advantage perspective, the view that nuclear power is a relatively cheap source of energy. The category of 'energy supply' mainly contained responses pointing to a large or lasting source of energy, as well as some responses which stressed the country's self-reliance with respect to energy production. The largest category among the advantages, i.e. the 'environmental' aspects, expressed to a large extent that nuclear power is a clean source of energy, often in comparison

to coal or oil produced energy. Some respondents qualified such an answer by adding "if no accident occurs" or when "disregarding waste" products. Other respondents saw the advantage of nuclear power in the thereby lessened need to regulate rivers (a quite controversial issue in Swedish politics).

TABLE 1

Frequencies of responses regarding perceptions of three advantages and three disadvantages, respectively, with the use of nuclear power (numbers refer to order of mentioning), percentage responses of total number of responses to the respective questions, number of respondents and number of coded responses

Categorized aspect	Advantages					Disadvantages				
	1	2	3	Total	%	1	2	3	Total	%
Environmental	91	90	39	220	30	15	20	11	46	6
Economical	127	49	11	187	26	4	5	6	15	2
Energy supply	59	37	16	112	15	-	-	-	-	-
Risk	-	-	-	-	-	216	154	92	462	56
Waste products	-	-	-	-	-	118	78	19	215	26
Efficiency	21	23	9	53	7	-	-	-	-	-
Good alternative	15	21	10	46	6	-	-	-	-	-
Controlled plants	9	20	17	46	6	-	-	-	-	-
Controlled society	-	-	-	-	-	0	0	2	2	>1
Dependence	-	-	-	-	-	2	3	6	11	~1
Information	-	-	-	-	-	3	3	6	12	~1
Employment	0	4	6	10	~1	-	-	-	-	-
Research (know-how)	1	3	2	6	>1	-	-	-	-	-
Geography	-	-	-	-	-	0	4	1	5	>1
Health	1	0	0	1	>1	0	3	0	3	>1
Responsibility	-	-	-	-	-	0	2	1	3	>1
Living standard	0	0	2	2	>1	-	-	-	-	-
No advantages	7	2	2	11	~1	-	-	-	-	-
No disadvantages	-	-	-	-	-	3	2	2	7	>1
Other response	2	7	8	17	2	6	10	22	38	5
Don't know	6	4	12	22	3	1	1	5	7	>1
No. of coded responses[1]	360	260	134	733	-	368	285	173	826	-
No. of respondents	336	255	132	-	-	362	282	172	-	-

[1] *Note: Each respondent was asked to list three advantages and three disadvantages of the use of nuclear power. A few respondents listed additional responses, however. All responses were included in the classification since the effect of these extra ones did not seriously influence the results.*

The largest resulting category of *disadvantages* of the nuclear power was 'risk'; 56% of all disadvantage responses were classified into this category. More than half of these responses (60%) referred to the risk or the fear of accidents, that "something might happen", or that nuclear power is dangerous or unsafe. About a fourth of the responses of the 'risk' category referred explicitly to radioactivity or the risk of radioactive leakage. The remaining responses categorized under the 'risk' heading concerned, for example, the vulnerability of nuclear power plants (e.g. in war or due to sabotage), the risk of production of material for nuclear weapons, and the risk of personal or genetic injury.

About a quarter of the total number of "disadvantages" responses were categorized under the heading of 'waste products'. Approximately half of these responses (49%) were unspecific references to "waste", "the waste problem", or the quantity of waste. The remaining responses referred to perceived uncertainty or problems regarding disposal of waste, e.g. "What will happen to the waste?" or "There is still no solution regarding waste disposal".

The results of the two open-ended questions thus showed that five major categories could be extracted from the responses: environmental, economic and energy supply issues accounted for about 70% of all listed advantages of nuclear power, and the combined 'risk' and 'waste' categories accounted for more than 80% of the disadvantages responses. Interestingly, replies of economic and environmental aspects were given both among advantages and disadvantages. From the perspective of disadvantages, the economy of building and maintaining nuclear power plants was seen as unsound, and the mere existence of nuclear power plants was seen as a threat to the environment. It was also noteworthy that there were about 3% explicit "don't know" responses in the whole material regarding advantages, but only 0.8% of such responses with respect to disadvantages.

The qualitative classification seemed to highlight two features in the data: Firstly, that most subjects volunteered at least one advantage and one disadvantage with respect to domestic use of nuclear power. Secondly, that the 'risk' and 'waste' categories clearly dominated among the disadvantages. The results thus lend some support to the more general conclusions that the students were aware of both advantages and disadvantages of nuclear power, and that they treated risks and waste issues as problematic aspects of nuclear power, i.e. did *not* treat nuclear power and its waste as separate issues.

The perception of nuclear power as having both advantages and disadvantages also gained some support from ratings of the respective importance of the issues of current nuclear power and of disposal of radioactive waste. Based on the same 7-point rating scale (-3 to +3), the results showed that the latter issue was perceived as much more important ($M=2.60$, $SD=0.82$) than the former ($M=1.78$, $SD=1.11$). There were no group differences with respect to the importance of the nuclear power issue, but a difference between the study programs regarding the importance of the waste issue, $F(4,369)=2.41, p<0.05$. The technologists gave the lowest ratings of importance ($M=2.45$, $SD=1.06$) and students of social science the highest ($M=2.80, SD=0.43$). The Pearson correlation

coefficient of the two importance questions was 0.32 ($p<0.01$). The results will be discussed below.

One attitude statement used in the questionnaire suggested that "benefits of nuclear power are much larger than risks of the radioactive waste". The students marked their response on a 7-point scale (-3 to +3) ranging from total disagreement to total agreement. The results illustrate the perceived relationship between benefits and risks regarding nuclear power and its waste. See Figure 1.

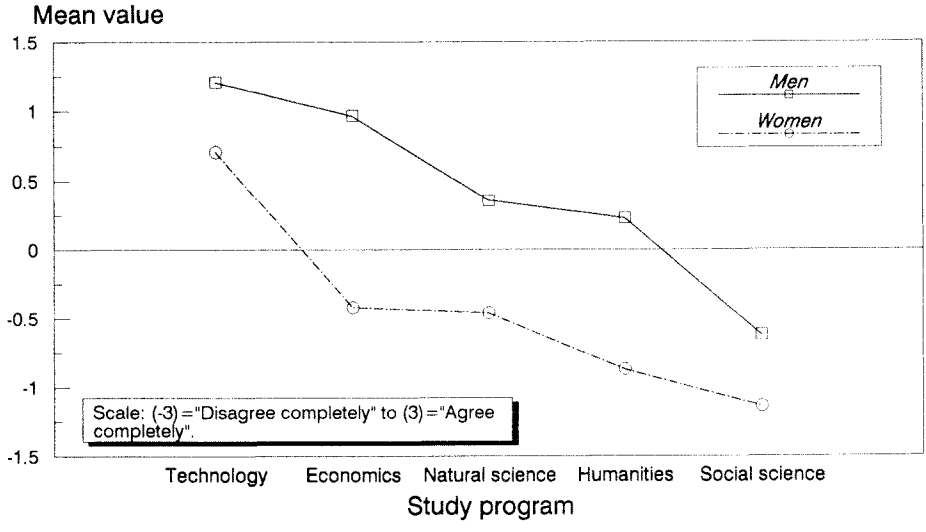

FIGURE 1. Mean values of the statement that benefits of nuclear power are much larger than risks of nuclear waste; high school students of five study programs, men and women.

The overall mean value of the ratings was -0.11 ($SD=1.96$). As can be seen in Figure 1 there were large group differences: for men and women, $F(1,352)=16.22, p<0.0005$, and for the study programs, $F(4,352)=8.65, p<0.0005$. All male students, except those of social science, agreed that benefits are larger than risks, whereas only female technologists accepted that proposition.

Attitudes and perceived nuclear power threat

Nuclear power attitude was rated on a 7-point bipolar scale. The scale ranged from "Totally negative" (-3), through "Neither positive nor negative" (0), to "Totally positive" (3). The mean value of the total group of students was -0.02 ($SD=1.74$).

The results showed a significant sex difference $\{F(1,368)=25.16, p<0.001\}$. Men ($M=0.76$) were clearly more positive to nuclear power than were women ($M=-0.58$). There was also a significant difference among the study programs $\{F(4,368)=11.00, p<0.001\}$. The results are illustrated in Figure 2. Students specializing in technology or economics were most positive to nuclear power, social science students the least positive. Students of natural science were found in between. See Figure 2.

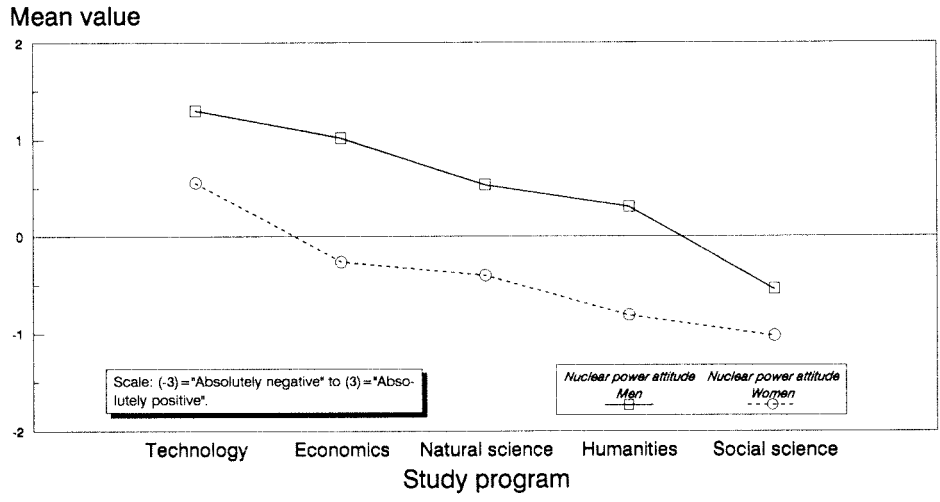

FIGURE 2. Mean values of ratings of attitude to domestic nuclear power; high school students of five study programs, men and women.

In accordance with Figure 1 above, this figure illustrates that four male groups had an overall positive attitude to nuclear power compared to only one positive female group, *viz.* the female technologists.

The attitude to nuclear power observed for the adolescents was compared to the value in the general population. The population was overall significantly less positive to nuclear power $\{t(894)=2.39, p<0.02\}$. This was true for both men and women. The t values, with 370 and 494 df's, were found to be 2.83 ($p< 0.005$) and 2.31 ($p< 0.05$), respectively. The results are shown in Figure 3.

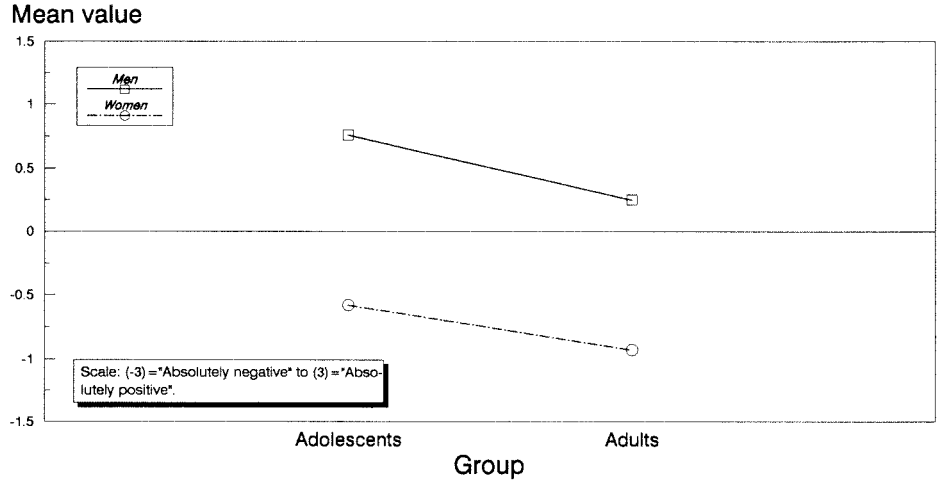

FIGURE 3. Mean values of ratings of attitude to nuclear power; high school students (adolescents) and a population sample (adults), men and women.

The results presented in Figure 3 support the hypothesis that adolescents perceive less risk of nuclear power than the average population.

The students also rated the severity of seven threats to society. The ratings provided comparison data of the students' perceptions of nuclear power as a threat to society related to the perceived societal threats of, for example, violent crime, military conflict, environmental pollution and the AIDS disease. The seven threats were throughout rated as more severe by women than by men (at least at the 0.001 level of significance), with the exception of environmental pollution, where ratings did not differ between sexes. Environmental pollution was perceived as the most serious threat among both men and women, and among students of all educational programs ($M=4.00$, $SD=0.96$ for the total sample, on a 6-point scale with the range 0-5). Educational groups differed somewhat, however, in their perception of the societal threat of pollution, $F(4,368)=2.59, p<0.05$. Students of technology and economics gave slightly lower threat ratings than other students ($M=3.80$ and $M=3.82$ respectively vs. $M=4.12$, $M=4.18$ and $M=4.19$).

The ratings of perceived threat of nuclear power resulted in a large sex difference with an F-ratio of 45.60 ($p<0.0005$). In this comparison the sex difference was second only to military conflict $\{F(1,367)=49.20, p<0.0005\}$. The threat of nuclear power was ranked third by women (after pollution and the AIDS disease) and sixth by men (followed only by abuse of alcohol and narcotics). The nuclear power threat to society, as compared to the other listed threats, resulted in the largest difference between educational groups, $F(4,367)=6.19, p<.0005$. As can be seen in Figure 4 below, men and students of technology and economics gave the lowest ratings. Figure 4 also shows the mean values of threat to society of pollution. (See Figure 4).

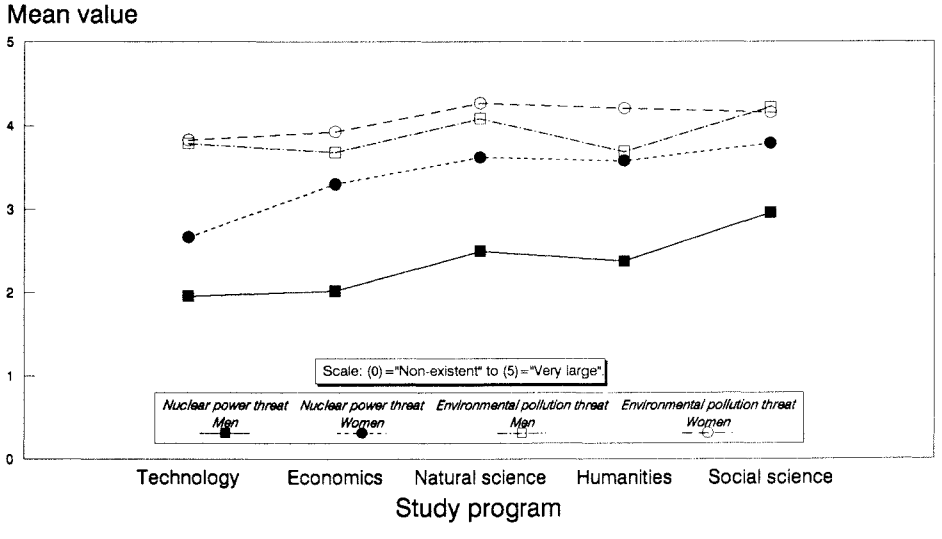

FIGURE 4. Mean values of ratings of perceived threat to society from environmental pollution and nuclear power; high school students of five study programs, men and women.

The results of a more positive nuclear power attitude and consistently lower risk ratings among especially students of technology and economics in contrast to, for example, students of social science, lend support to our hypothesis of socialized values. Environmental pollution was seen as a serious threat among all students, equally serious by men and women, but slightly less serious by technologists and economists. The loose label of environmental pollution can certainly be attached to a variety of events and phenomena, which in turn may be judged very differently regarding their perceived roles as environmental polluters. Above we mentioned, for example, that environmental aspects were mentioned as both advantages and disadvantages of nuclear power. The generality of the item might thus have increased response concordance. The more specific label of nuclear power increased the polarization between groups considerably, although the same trend prevailed in the data, indicating less perceived risks among students in the study programs of technology and economics.

The rating of nuclear power as a threat to society given by the adolescents was compared to that obtained in the national sample. The adolescents rated the threat lower ($M=2.98$, $SD=1.45$) than did the adult group ($M=3.18$, $SD=1.48$), $t(819)=2.03$, $p<0.05$, and especially young male students gave low threat ratings ($M=2.24$, $SD=1.39$ vs. $M=3.50$, $SD=1.24$ for young females). The male groups of the two samples differed significantly, $t(330)=3.68$, $p<0.0005$, but there was no difference between the female groups.

The results again supported the hypothesis that young people, especially young men, give lower risk ratings than the general population.

Worry and perceived risks of nuclear power

One question asked whether there was something the student worried about in relation to the domestic use of nuclear power. Only "Yes" and "No" response categories were available, and the students were asked to motivate their answer regardless of response. Eleven percent of the students refrained from answering the question, 65% gave an affirmative reply and 24% answered "No", ($M=1.27$, $SD=0.44$). Among those indicating worry, 31% worried about accidents of some kind, 26% about waste and its handling, 12% explicitly mentioned radiation, and 12% worried with reference to risks of nuclear power.

More than 60% of those who did not worry instead mentioned that they trusted security procedures. Other responses, about 12%, pointed to the small or non-existent risks involved. The mean values indicated that especially students of social science and female economists were worried in contrast to students of technology and male students of economics. Female technologists were the least worried of all. See Figure 5.

The very brief motivations given by the students of their feelings were not specific enough to enable more than a rough categorization of the responses. On the basis of such a categorization the results indicated that on the one hand there were students who expressed trust in security measures and nuclear technology, whereas on the other hand there were students who distrusted such aspects and

personally worried about accidents and risks. These worries might well have had the fear of radioactive contamination as a common denominator even though few responses were explicit in this respect.

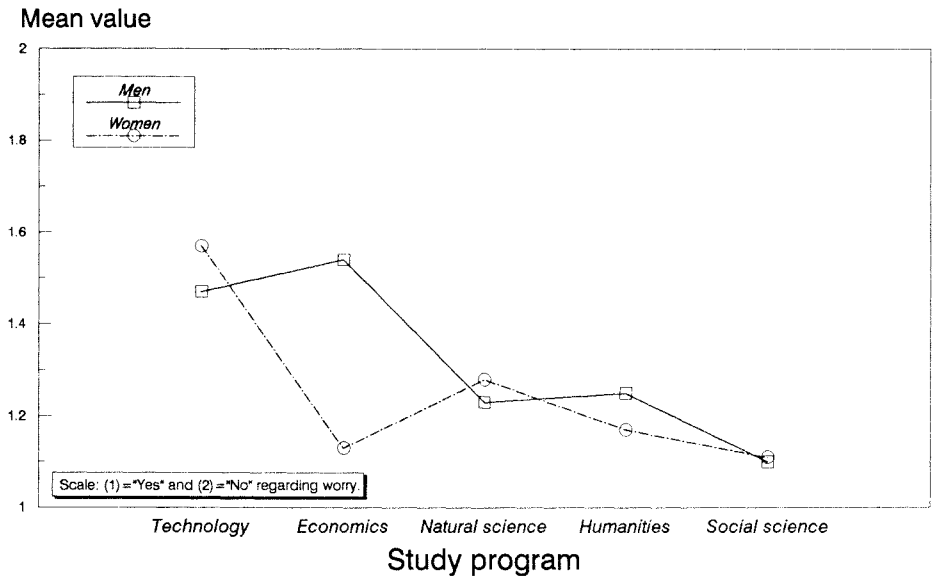

FIGURE 5. Mean values of responses to the question if there is something one worries about in relation to the domestic use of nuclear power; high school students of five study programs, men and women.

The current risk of injury due to radiation was measured separately in the study. The risk for people in general was measured on a 5-point scale, where 5 denoted a very small risk. The mean overall risk of injury was 3.34 ($SD=1.21$). The resulting ratings were similar to the ones obtained for nuclear attitude, *viz.* men rated the risk of radiation injury as smaller than women did $\{F(1,324)=16.11, p<0.001\}$, and the study programs differed significantly $\{F(4,324)=3.89, p<0.01\}$. Men, technologists and economists again rated risks lower than did women, and e.g. students of social science. Especially male and female economists differed in their risk ratings. See Figure 6.

Ratings of personal risk involved 11 items, seven of which were ordinary adverse events and three of which included a reference to radiation. The scale ranged from "Non-existent" risk (0) to "Very large" risk (5). The risk ratings of ordinary adverse events varied from the small perceived risk of being struck by lightning ($M=0.71$, $SD=0.77$) to traffic accidents ($M=2.41$, $SD=1.12$). The two top ranking risks in the list, however, were to be injured by radiation due to leakage from a radioactive waste repository ($M=2.44$, $SD=1.47$) and to be injured by radiation due to an accident in the handling of radioactive waste ($M=2.75$, $SD=1.54$). There were again large sex differences in the data, and women produced the higher risk ratings. Figure 7 shows mean values of the ratings of personal risk with respect to the eight items which were also used in the adult sample. See Figure 7.

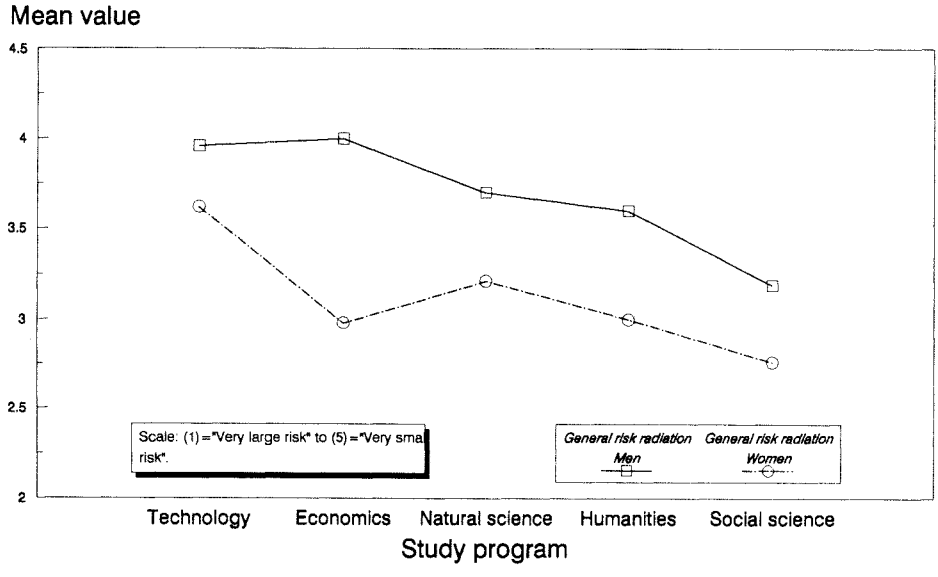

FIGURE 6. Mean values of ratings of current risk of radiation injury among people generally; high school students of five study programs, men and women.

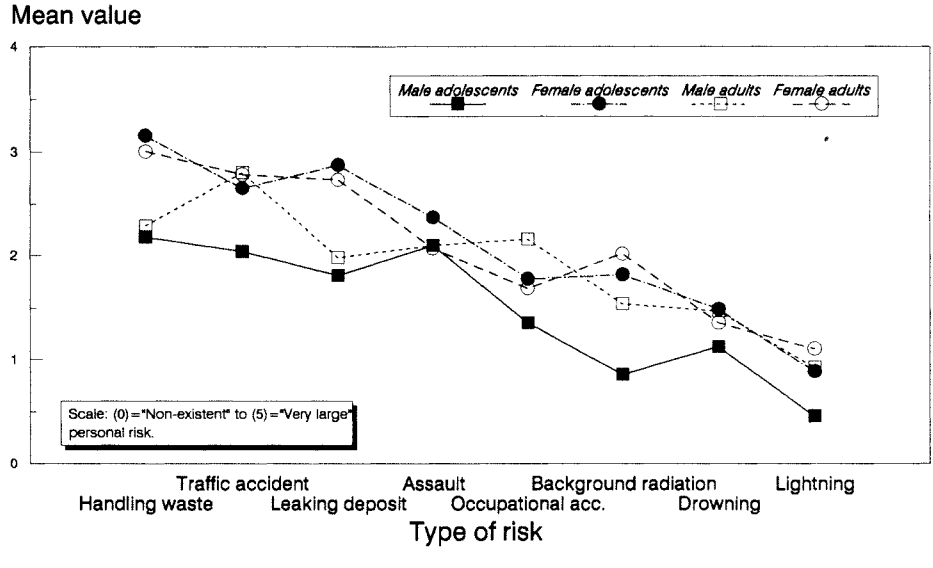

FIGURE 7. Mean values of ratings of personal risk with respect to eight types of risks; male and female high school students (adolescents), and men and women of the population sample (adults).

The figure shows that all groups rated the "Handling waste" and "Leaking deposit" items high, and that women emphasized these items more than men did. Even the "Background radiation" item got high ratings, especially by women.

The results point to a very aversive perception of radiation. An alternative interpretation is, however, that subjects rated the risks *given* release or leakage of radioactivity. The interpretations are further discussed below.

Three questions concerning risks of nuclear power in general, risks connected to operation of power plants and risks associated with waste disposal correlated highly and were combined to an index of nuclear power risk. The index showed the same trend as previously presented; men, technologists and economists giving the lower risk ratings and women and social science students the higher. {The sex difference, $F(1,364)=19.62, p<0.0005$, and the difference between study programs $F(4,364)=8.36, p<0.0005$}. The Pearson correlation coefficient between nuclear power attitude and the nuclear risk index was 0.72 overall, and 0.78 for men and 0.62 for women.

General risk sensitivity was considered a possible source of influence on the risk ratings and was therefore separately measured by means of the items concerning the ordinary possible adverse events mentioned above, excluding all items with an association to radiation. Using PRISK as a covariate, especially the sex difference was reduced, but the significant main effects of both sex and study program remained. General risk sensitivity could thus not explain the trend mentioned in the data to any large extent when entered as a covariate in an ANCOVA.

The results thus showed that nuclear power attitude, risk perception and personal worry were closely connected. Furthermore, general risk sensitivity could not account for the differences obtained. The open-ended question on worry showed that the absence of worry was explained in terms of trust, whereas feelings of worry were rooted in fear of accidents and radiation.

Radioactive waste disposal and knowledge

The students were asked to assess the time period they believed that three types of radioactive waste would be harmful to humans, and to suggest the depth in bedrock where it should be placed. The results showed, firstly, that high level waste was preferred deeper in the bedrock than low level waste. The suggested depth in meters, by those who gave quantitative answers, ranged for low level waste from 1 meter to 2 million meters (one person suggested 100 million meters). For high level waste the numerical responses ranged from 6 meters to 10,000 million meters, i.e. 10 million kilometers (!). The very extreme responses were few, however. Some qualitative responses just stated a preference of disposing of the waste "as deep as possible".

Secondly, the time period radioactive waste from nuclear power plants was perceived as harmful to humans ranged from 0 to 5,000 years with respect to low level waste, and from 0 to "millions of years" regarding high level waste. Some qualitative answers suggested the "eternity". Table 2 presents percentages of

responses within very broad intervals of preferred depth in bedrock, and of the time period during which (a) low, (b) medium and (c) high level waste was perceived to pose a risk.

The table shows that the subjects used either quantitative or qualitative responses. The use of the very wide intervals in the table provides only an idea of the response patterns. The location of a Swedish high level waste repository has been suggested at about 500 meters in bedrock. Approximately a third of the respondents in each sample gave a response under or equal to this figure. About a sixth of them suggested the deposit of high level waste to be disposed even deeper, up to 1000 meters. Among the "other responses" were those who suggested figures which exceeded this depth considerably, and respondents who choose to respond in their own words, e.g. "very deep", "as deep as possible". A small proportion of the respondents did not wish to deposit radioactive waste in bedrock at all. The table also shows that there were somewhat more "don't know" responses from the adult subjects than from the adolescents.

TABLE 2

Percentages of open-ended responses within broad categories of depth and time regarding how deep (a) low, (b) medium, and (c) high level radioactive waste should be deposited, and for how long time it can cause harm to human beings, an adolescent and an adult sample

	Adolescents; %			*Adults; %*		
	(a)	*(b)*	*(c)*	*(a)*	*(b)*	*(c)*
			Depth in meters			
1-500	*58*	*48*	*37*	*58*	*49*	*32*
501-1000	*9*	*13*	*13*	*11*	*13*	*19*
"Other response	*22*	*28*	*40*	*16*	*22*	*34*
"Don't know"	*11*	*11*	*10*	*16*	*15*	*14*
No. coded response	*313*	*310*	*319*	*457*	*455*	*468*
			Time in years			
0-100	*80*	*64*	*36*	*70*	*51*	*23*
101-1000	*8*	*21*	*30*	*10*	*26*	*39*
>1000	*1*	*6*	*24*	*2*	*5*	*16*
"Other response"	*3*	*3*	*4*	*6*	*6*	*10*
"Don't know"	*7*	*6*	*5*	*12*	*12*	*12*
No. coded responses	*349*	*350*	*352*	*512*	*510*	*519*

With respect to time period, the largest proportion of the adult sample estimated that the high level waste would be harmful to humans between 100 and 1000 years. The corresponding largest proportion among the adolescents was instead 0-100 years. However, more adolescents than adults believed that high level waste could be harmful for more than a thousand years. Adults were again more prone to answer "don't know".

The students, as well as the adult sample, were asked about their current knowledge of the domestic handling and disposal of nuclear waste. The wording of the questions used in the two studies were exactly the same, but the response formats differed. The adolescents responded on a 5-point scale, ranging from (1) "I believe I know very much" to (5) "I know nothing". The 6-point response scale of the adult sample had added as the first category (1) "I believe I know almost everything", followed by the five response categories also used in the adolescent study.

The mean knowledge value for the adolescents was 3.31 ($SD=0.87$), pointing to a rather humble estimation of personal knowledge of waste handling and disposal issues. There was no difference between the five study programs. However, there was a substantial sex difference, $F(1,366)=17.70$, $p<0.0005$. Male students ($M=3.03$, $SD=0.82$) believed they had more knowledge of these questions than did the female students ($M=3.51$, $SD=0.84$). The sex difference in the adult sample was also significant, $F(1,585)=34.08$, $p<0.0001$. The mean value of the adult sample was 4.22 ($SD=1.16$) on the 6-point scale. Table 3 below shows response percentages within the respective response categories available to the two samples, and of men and women separately. Missing data were excluded prior to the computations of percentages.

TABLE 3

Response percentages within the respective response categories of two samples, adolescents and adults, regarding personal knowledge of domestic handling and disposal of nuclear waste

Response alternative	*Adolescents*			*Adults*		
	All	*Men*	*Women*	*All*	*Men*	*Women*
Almost everything	-	-	-	0.2	0.7	0.4
Very much	0.0	0.0	0.0	1.6	2.7	0.4
Rather much	18.6	27.7	12.2	18.3	25.0	11.0
Rather little	39.9	45.8	35.7	39.6	43.0	35.9
Very little	33.2	21.9	41.2	31.1	23.0	39.9
Nothing at all	8.2	4.5	10.8	8.9	5.7	12.4
N excl. missing	376	155	221	573	300	273

The results of the open ended response format of time and depth estimates firstly showed a surprisingly great response variation, and secondly illustrated a tendency to push away, in depth and time, the nuclear waste. The respondents did not feel knowledgeable in the field of handling and disposal of radioactive waste, and their estimates were supposedly based more on feelings than on facts. The magnitude of many of their estimates again points to radioactive waste as highly aversive.

Accidents involving radioactive waste

The risk of serious nuclear waste accidents was rated in connection to 11 events or activities associated with handling and disposal of radioactive wastes. The items concerned such accidents during transportation, when disposed in bedrock, due to criminal or unforseen human activity, etc. All items got high risk ratings on the 6-point scale (0-5), with the lowest overall mean value of 2.75 regarding theft. The most serious risks were rated as those associated with war, "the human factor", unanticipated events and deterioration of repository material. Women gave significantly higher risk ratings throughout this section. The results are illustrated in Figure 8.

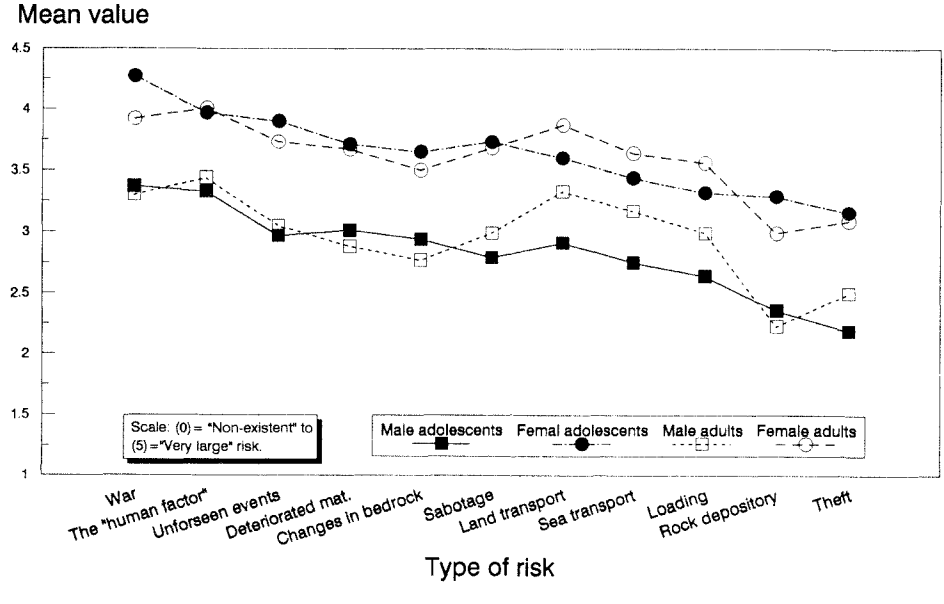

FIGURE 8. Mean values of ratings of risk of serious accidents in the handling and disposal of radioactive waste due to specific events, and during handling and disposal of waste; male and female high school students (adolescents) and men and women of a population sample (adults).

Figure 8 shows the mean values of students' ratings, by sex, as well as the corresponding ratings made by the adult sample. The most striking result of this comparison was the gender difference. The accident risk ratings by women compared to those by men were higher irrespective of age group. There were only minor variations with respect to adolescents and adults. Perhaps the only interesting differences worth attention were those related to transportation and loading of waste, where the lower perceived risk ratings by young men are in accordance with reports of their risk perception of traffic situations.

There were differences, significant at least at the 0.05 level, between the educational groups with respect to five items: transport on water, disposal in bedrock, changes in bedrock, theft and unforseen events. The technology students gave in all instances the lowest ratings and humanists or social science students the highest.

The risk ratings of serious accidents involving radioactive waste did not generally support the hypothesis of adolescents giving lower risk ratings than adults. Instead was the different risk perception of men and women highlighted. The ratings were generally high, however, and the interpretation is that accidents or events involving the possible release of radioactivity is commonly feared, and because of this fear scenarios which include such accidents render high risk ratings.

Effects of nuclear power on life values

We also had reports about the extent to which each of five basic values was supported or threatened by nuclear power. The students gave their ratings with respect to the perceived influence on themselves and their families. The life values used were "Economic standard", "Physical health", "Freedom", "Hope for the future" and the "Possibility to influence one's own life".

The most negatively influenced life values were perceived to be physical health and the possibility to influence one's own life, but all life values except economic standard were found on the negative side of the rating scale (-3 to +3), considering the total group of students.

There were significant sex differences with respect to the physical health and hope for the future values. Females rated the influence of nuclear power in these respects more than one scale unit below the male ratings. Apart from the economic standard item, the average male rating of freedom was also positive. Only the economic standard item obtained a positive rating by the women.

For predicting nuclear attitude, separate multiple regression analyses were carried out for men and women and for a combined group of economists and technologists on the one hand, and the remaining study programs on the other (social science, humanities, natural science). The results can be seen in Table 4. Hope for the future was the most important value dimension in the latter group among both men and women, whereas results from especially male technologists and economists gave beta values more evenly spread over dimensions. The multiple correlations (squared and adjusted) were higher for men than for women. See Table 4.

TABLE 4

Multiple correlations (adjusted, squared) and beta-weights for the prediction of attitude to nuclear power on the basis of ratings of importance of selected life values, high school students separated into groups of technologists and economists versus students of social science, humanities and natural science.

	Technologists, economists		*Soc. sci., nat. sci., humanists*	
	Men	*Women*	*Men*	*Women*
Multiple correlation	*0.427*	*0.313*	*0.505*	*0.311*
Beta-weights				
The physical health	*0.640***	*0.174*	*-0.076*	*0.020*
Economic standard	*0.404***	*0.207*	*0.323*	*0.129*
Freedom	*0.047*	*0.379***	*0.269*	*0.024*
To be able to influence one's own life	*0.089*	*0.260*	*0.353*	*0.221*
Hope for the future	*0.395***	*0.272*	*0.850****	*0.670****

** $p<0.01$, *** $p<0.001$

The table shows that life values had a rather strong relation to nuclear power attitude, particularly among male students. The most striking result, however, was the salience of the "hope for the future" life value among students of humanities, social science and natural science in contrast to values of especially male students of economy and technology, which indicated important contributions of also other life values. One conclusion is that future oriented considerations play an important role for many people with respect to their view of nuclear power, but that such a view may involve considerations which vary both in their content and in number of aspects otherwise involved.

Predictions of nuclear waste perception

In an attempt to produce an overview of the results of the study, five measures related to nuclear power waste were constructed and used as dependent variables in separate regression models. The variables were: (1) The ACC index; the eleven ratings regarding the risk of a serious accident in the handling and disposal of waste, (2) the RAD index; ten statements describing negative events within 200 years which included mentioning of radiation, (3) the general question of risks regarding domestic nuclear power with respect to handling of waste (here called RISK), (4) the question about whether the issue of radioactive waste currently was solved satisfactorily (here called SATIS), and (5) the item regarding risks to humans of disposal of spent nuclear fuel rods in bedrock (here called ROCK).

Eight predictors were used: (1) general nuclear power attitude and perceived societal threat from nuclear power were pooled after correction of the response scale directions and standardization (the ATT predictor), (2) the THREAT index, including six threats to society, and excluding the threat of nuclear power, (3) the PRISK index; seven ordinary personal risks, excluding items mentioning radioactivity, (4) the TRUST index measuring confidence in experts regarding nuclear waste issues, and trust in the parental generation's handling of nuclear power issues with respect to the future generation, and (5) the POSATT index; four statements formulated in a positive frame vis à vis the use of nuclear power and (6) the NEGATT index; three negatively formulated statements of nuclear power use, (7) the KNOW item; one question of personal knowledge of handling and disposal of domestic nuclear waste and finally, (8) the WORRY item; degree of worry about something related to nuclear power.

Five separate regression analysis were computed (listwise deletions). Adjusted squared multiple correlations and beta-weights are presented in Table 5.

Table 5 shows that the overall perception of risks related to nuclear waste (RISK) could fairly well be accounted for by the predictors used. The adjusted squared R^2 was 0.49. The predictors of nuclear attitude (ATT), TRUST and POSATT, as well as the THREAT index, excluding nuclear power threat, contributed significantly.

TABLE 5

Multiple correlations (adjusted, squared) and beta-weights for predictions of perception of nuclear waste related issues among adolescents

	ACC	*RAD*	*RISK*[1]	*ROCK*	*SATIS*[1]
Adjusted, squared R^2	*0.611*	*0.691*	*0.487*	*0.490*	*0.302*
Beta-weights					
ATT[1]	*-0.24****	*-0.36****	*0.33****	*-0.21***	*-0.01*
THREAT	*0.26****	*0.14****	*-0.11**	*0.19****	*-0.10*
PRISK	*0.15****	*0.07**	*0.00*	*0.03*	*0.07*
TRUST	*0.15****	*0.13****	*-0.14***	*0.12**	*-0.21****
POSATT[1]	*-0.06*	*-0.21****	*0.18***	*-0.20***	*0.28****
NEGATT	*0.12***	*0.07*	*-0.05*	*0.09*	*-0.02*
KNOW	*0.07**	*0.09***	*0.01*	*0.03*	*0.02*
WORRY[1]	*-0.09**	*-0.08**	*0.09*	*-0.10*	*0.16***

[1] *Note: Variables marked with the* [1] *are measured on scales where high values indicate a positive evaluation of nuclear power, low risk, high satisfaction or little worry. The direction of the scales of the unmarked variables is the reversed, i.e. high values indicate a negative evaluation of nuclear power, or high risk, etc.*

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

The used predictors were also good at predicting accident risk related to radioactive waste (ACC), the rated likelihood of negative events including radiation (RAD), and risks associated with disposal of nuclear waste in bedrock (ROCK). The least influential predictors among those used were NEGATT and KNOW. WORRY contributed significantly to the prediction of satisfaction with the current handling of nuclear waste, together with the indices of positive attitudes and trust. However, the R^2 value of SATIS (0.30) was the lowest obtained.

It was noteworthy that the personal risk ratings (PRISK) contributed significantly only to the prediction of ACC and RAD; the only dependent variables which included explicit mentioning of radiation.

The regression analyses suggest that measures of general nuclear power attitude, general threat perception and trust, and to some extent, measures of worry and knowledge should be included in attempts to predict perceptions of radioactive waste issues. The results showed that such prediction is quite feasible. Regarding items mentioning radiation is seems wise to include a predictor of personal risk. The results of the presented analysis regarding the prediction of satisfaction with the current efforts to handle the waste issue, however, show that further predictors should be considered.

DISCUSSION

The purpose of the present study was to investigate adolescents' perceptions of nuclear waste issues and to compare their attitudes and perceptions to a population sample. The hypothesis was that younger people would rate risks lower than the adults. A second objective of the study was to challenge the often suggested interpretation of experts' low risk estimates in comparison to those of lay people as based on purely a better knowledge. We suggested that the existence of early socialized values in accordance with general interest orientations, may provide yet another angle to the interpretation.

The results of the study generally supported our notions. The adolescents reported a more positive attitude to nuclear power than adults. And this was also the case in both male and female subgroups. Adolescents rated the societal threat of nuclear power lower than adults, and young males differed significantly from adult men in the population sample. Personal risk ratings revealed the female tendency to give high risk estimates. In comparison to the adult sample, however, especially young men differed from others in reporting considerably lower personal risks.

Risk ratings of serious accidents involving radiation did not support the hypothesis that young people rate risks lower than adults. The obvious difference was instead between sexes, even though all risk estimates were rather high. However, the results are mainly in accordance with our hypothesis, and also with findings in our previous work on psychological reactions after the Chernobyl accident (Drottz-Sjöberg & Sjöberg, 1990). Young people, and especially young

men, reported less worry about the Chernobyl accident, perceived the risks as lower and reported less influence from the accident on their daily lives.

Gender differences in the present study agree with results in this well documented research area, where women often report more worry generally (Maccoby & Jacklin, 1974; Brody, 1984), and are more worried about nuclear power than men are. With respect to risk ratings in the present study, the sex difference was usually larger than the difference between educational programs.

Studies of both actual risk levels and development of risk perception over a wide age span are of considerable interest to consider in relation to our results. Vågerö and Östberg (1989) presented results of mortality rates by socioeconomic group for children and adolescents of the ages of 1-19 years. They found that children of manual workers and self employed persons had significantly higher mortality rates than children of non-manual workers. And, furthermore, that boys had a higher mortality risk than girls. Sjöberg and Torell (1990) found an increase in risk tolerance over the years of 10-16, and increased sex differences over tome regarding risk perception. Cross-cultural studies of Sivak and colleagues (Sivak, Soler, Tränkle & Spanhol, 1989; Sivak, Soler & Tränkle, 1989) have shown that younger drivers, especially young men, report lower risk in traffic situations. Vogel et al. (1988) presented data which showed huge differences in risk perception between men and women of adult and elderly groups with respect to perceived crime risks.

Regarding socialization of values, we found throughout the study that students specializing in economics and in technology rated risks lower than others did. This difference was not due to differences in knowledge about radiation risks and nuclear physics since these students were not yet very knowledgeable in the field. Furthermore, students of the different study programs reported an equally low level of knowledge.

Students of some of these educational programs are likely to occupy, in the future, leading roles in administration and in technological development. If it can be assumed that beliefs and values associated with technology risks are relatively stable, we find it interesting to inquire whether the positive attitude of many experts and administrators to nuclear power is caused by their expert knowledge or whether it preceded that knowledge. The results of the present study lend support to the notion that the early developed general attitude might be of some importance. A related research topic would be to investigate to what extent early developed values and attitudes hinder adolescents to pursue an education or career within technology or the natural sciences. University administrators and researchers have expressed concern over the low interest level of higher education in these fields.

The adolescents of the present study could list both advantages and disadvantages of nuclear power. The three most frequent replies to the question of advantages were that nuclear power was cleaner or less destructive to the environment than fossil fuels, economically advantageous and that it provided needed energy. The two most important disadvantages concerned risks in general and waste disposal problems. The prominence of waste disposal questions was also

evident from the fact that the rated importance of waste questions was judged to be larger than the importance of the issue of nuclear power itself! This result could indicate a mental weighing of perceived advantages and disadvantages before the ratings and that there were more positive aspects associated with nuclear power than with radioactive waste, hence the higher rating in the latter case.

The replies to the statement that benefits of nuclear power are larger than risks of nuclear waste were very similar indeed to the replies to the question measuring nuclear power attitude. A positive evaluation of nuclear power in these respects was made by all male students except those of social science, and of female technologists. More than half of the students worried about something related to the domestic use of nuclear power. The responses among students of the different study programs again showed a trend similar to that of the nuclear power attitude.

Risk and waste disposal issues were thus influential when it came to judging nuclear power. The reported lack of knowledge regarding the domestic handling of nuclear waste furthermore suggests that risk ratings were made primarily on the basis of attitudes and feelings.

A few "life values" were used in the study for prediction of the nuclear power attitude, and showed some relevance in this respect. When students were divided into two groups, the results showed that students of humanities, social science and natural science particularly emphasized the "hope for the future" aspect. With respect to female economists and technologists the value of "freedom" was instead prominent, whereas their male counterparts differed by including several of the given life values in their attitude. The results might be of interest in the context of understanding how nuclear power attitudes are composed, and could in this regard be of interest when it comes to risk communication. The different emphasis on certain values perhaps reveals more information than the overall attitude. Van der Pligt and his colleagues have, for example, studied attitudinal differences in relation to nuclear power (van der Pligt, van der Linden & Ester, 1982; van der Pligt, Eiser & Spears, 1986), and shown this to be a feasible way to understand different points of view.

The predictions of the students' perceptions of nuclear waste showed that the combined predictor of attitude and perceived societal threat of nuclear power was influential in explaining risk ratings of serious accidents involving radioactivity, the perceived risk of nuclear waste, raings of likelihood of adverse events within 200 years and risk perception of disposal of waste in bedrock. The predictor including ratings of personal risk regarding ordinary negative events contributed only to the predictions which involved radioactivity. Trust in experts and the parental generation was the only predictor which contributed significantly in all equations, thus suggesting the importance and generality of this aspect.

The high ratings of items which involved radioactivity demand a comment. Both with respect to such items related to personal risk ratings and with respect to the risk estimations of serious accidents in the handling and disposal of waste it is possible that they were judged from the point of view that accidents were given and the risks judged from that situation. Such ratings might reflect a conjunction

fallacy (Tversky & Kahneman, 1983). If this was not the case, it is very hard to suggest an interpretation of these high risk ratings. In future work it is desirable to change instructions so as to avoid the possibility of conditional probability interpretations.

The possible release of radiation, however, seems to be a good candidate for understanding the negative attitudes toward nuclear power. The high ratings of risk related to nuclear power would probably not occur were there no radioactivity involved. Although many people know that high doses are harmful and can indeed be fatal, much concern is future oriented. Risks incurred for future generations by nuclear waste produced by our generation appear morally unjustifiable to some people. And it is indeed worth some second thoughts that we, who currently populate this planet, are able to influence the lives of many generations yet to come.

One thousand years ago there was no technology which heavily polluted the atmosphere or produced toxic or radioactive wastes that would be dangerous to people living now. If there had been such a technology, possibly the Norse poet's warning would have been heard:

> Cattle die,
> and kinsmen die,
> and so one dies one's self;
> one thing I know
> that never dies,
> the fame of a dead man's deeds.

(Snorri Sturluson's Edda, Havamal).

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KNOWLEDGE AND RISK PERCEPTION AMONG NUCLEAR POWER PLANT EMPLOYEES

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ABSTRACT

This is a study of knowledge, risk perception and attitudes among nuclear power plant employees. A total of 236 persons participated, belonging to 10 different professional groups and working at 2 Swedish power plants. Job related radiation risks were judged about average as compared to a number of other risks. On the whole, the participants in the study were satisfied with the measures of safety at work, but there were some exceptions to this rule, especially among those hired for temporary jobs through external contractors. The experience of job related radiation risks was related to the level of knowledge about radiation and its risks: those who knew less experienced larger risks. General level of anxiety did not correlate with risk perception. The latter was accounted for mainly by perceived radiation risks. Job satisfaction was more strongly related to perceived conventional job risks than to nuclear risks. Risk ratings were related to how subjects defined the concept of risk. Those who stressed consequences as part of their risk definition gave higher risk ratings.

Key words: *nuclear power, subjective risks, personnel, radiation knowledge, personality*

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INTRODUCTION

Research on risk perception has often been concerned with reactions of the public to modern technology, in particular nuclear power (1). Studies of knowledge of radiation and related risks have shown that such knowledge is scanty and that many misconceptions exist. According to an NSF sponsored poll various misconceptions of science are widely spread among the American public. According to the survey "it appears that 93 percent to 95 percent of those sampled lacked fundamental knowledge of scientific vocabulary, methodology and an understanding of science's impact on the world" (New York Times, October 25, 1988). Though these findings did not specifically address knowledge of radiation there is no reason to believe that the general level of knowledge is better in that area.

It also appears that it is very hard to inform the public about scientific concepts and facts. In Sweden, in the fall of 1986 and in the midst of intense media coverage of the Chernobyl accident and its effects (2,3), it was still quite difficult to inform effectively about radiation (4).

Most work on risk perception has employed either convenient or population samples. There has been little published research on risk perception in special groups, such as employees of nuclear power plants. Power plant employees constitute an important target group for research on risk perception since they are in a situation where their own actions are likely to have consequences for the actual risk that they are exposed to. Under- or over-estimation of risk can lead to undesirable effects.

The purpose of the present study was to investigate risk assessments and risk attitudes in various groups of power plant personnel and to relate these variables to knowledge about radiation and related risks. Knowledge about this relationship is important because if power plant personnel have erroneous conceptions of radiation and related risks it is imperative to improve their knowledge.

More specifically, we wished to investigate:

(1) the level of risk experienced by the workers, and to compare it with an expert estimate of the risk;

(2) the level of knowledge about radiation and its relationship to perceived risk;

(3) other potentially important factors in risk perception, such as personality, background data, and job tasks;

(4) the importance of risk perception for job satisfaction.

Standardized procedures for studying risk perception in the work environment did not exist. Risk perception can of course be studied in many ways - by interview questions and by various types of rating tasks. To get a broad picture of the views of the subjects and to avoid obtaining data dependent on the properties of one particular procedure we used several interview questions and rating scales for measuring risk perception. In addition, we noted that in previous work on risk perception subjects have not been asked to specify what *they* mean by the concept of risk. Hence, group differences could reflect distinctions among risk definitions rather than risk perceptions. We therefore included questions about risk definitions and related such answers to risk ratings.

Our study thus had two methodological purposes in addition to the over-all purpose of studying the relation between knowledge and risk perception, *viz.* to investigate

(5) relationships among different procedures for eliciting risk judgments;
(6) the risk definitions used by the subjects and the relationship between the definitions of risk and risk ratings.

METHOD

Subjects

A total of 236 persons participated in the study, 83 percent men and 17 percent women. They varied in age from 19 to 62 years. The interviews were almost all carried out at the two plants, only a few had to be performed at other places of work.

The subjects reported that they had been on the same job between less than 1 year and up to 20 years. The proportion of married[1] persons was 0.7. There were 9 percent immigrants in the group, all of whom were judged to have a sufficient knowledge of Swedish to participate in the study.

The subjects were chosen so as to represent different jobs of interest in the present context. Quite a few of our subjects were hired through external contractors and were required to work at the plants only during refueling periods. Some externally recruited groups were permanently assigned to a plant (custodians), while others were there for a shorter time. The jobs varied with respect to radiation exposure, educational level and gender distribution. Brief descriptions of the groups and their professional responsibilities are as follows:

Radiation protection personnel were hired by the plants on a permanent basis; 28 participated, all male. They were responsible for personnel radiation safety at the plant. They monitored safety measures and informed other groups about them.

Control rod insertion workers were hired by external contractors; 14 participated, all male. They were specialized workers who performed service on control rod insertion systems.

SA-personnel were also externally hired, and employees of a central government agency located in Stockholm; 22 participated, 19 of whom were male. They visited all nuclear power plants in the country. They performed their own tests and checked tests made by other companies, mainly on pipes and tanks classified as pressure vessels.

Custodians were externally hired; 12 participated, 8 of whom were male. They usually worked full time at the plant, on a permanent basis.

Chemists were employees of the plants; 15 participated, 11 of whom were male. Their responsibilities included collecting samples of water from various parts of the process, and for testing those water samples.

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[1] Married or living together with a partner on a more or less permanent basis.

Service and repair workers were mostly externally hired; 55 participated, 53 of whom were male. They worked with mechanical repair work, and as electricians or tele communications technicians.

Thermal insulation workers were externally hired; 10 participated, all male. It was their task to fit and remove thermal insulation for systems of pipes, pumps and other components.

Steam generator workers were predominantly (80-90 percent) externally hired; 21 participated, all male. Their tasks were to check and repair steam generator tubes.

Decontamination workers were predominantly (80-90 percent) externally hired; 27 participated, 18 of whom were male. It was their task to clean the plant by means of ordinary cleaning methods and special cleaning techniques (e.g. high pressure spray cleaning). They also decontaminated radioactive components before repair work was to be carried out by other personnel groups.

The plants contained areas in which protective measures, such as protective clothing, were called for. These areas are called "controlled" sections. Different groups of personnel spent varying amounts of their working time in such controlled sections of the plants.

We assumed that the amount of time spent in controlled sections was an important factor in accounting for risk experience. It was therefore considered to be desirable to include a group of persons who were not exposed to any radiation risk, in order to get a *control group*. The group of *other employees* was used for this purpose. The group members were administrative staff personnel who had regular office work; 32 participated, 15 of whom were male. This group seldom worked in a controlled area.

There were more women in the control group than in the other groups, disregarding decontamination workers. It is well known that women are more risk averse than men, so this aspect of the design gives it a conservative bias, i.e. any differences in risk perception between the control group and other groups would tend to be attenuated.

About 1/3 of the participants had only elementary school, possibly with some brief vocational training in addition to that, some 40 percent had completed upper secondary school[2], most often with a specialized technological orientation and the rest had a great variation of, mostly, secondary level education. There were a few graduate engineers (3.8 percent) in the group but otherwise very few had a college level education or graduate school.

Plant personnel were willing to participate, encouraged by management and unions. Very few declined. It was somewhat more difficult to recruit personnel

[2] Upper secondary school extends through grades 10 to 11, 12 or 13 and its graduates are formally qualified for post-secondary education. Graduation is normally at the age of 19 for those who have completed grade 12. For admission to engineering schools, 12 or 13 grades are required, but graduates of upper secondary schools grade 13 with a technological orientation also have the title of "engineer" and constitute an important recruitment base for the plants. Graduate engineers are rather few and have supervisory positions.

from independent contractors, and management of one of those contractors refused absolutely to take part in the study.

Design and procedure of the study

The study was initiated in the beginning of 1984, with a meeting of representatives of the National Radiation Protection Institute (SSI)[3], the two plants, the unions and the research group. Discussions were carried out during January and February of that year, resulting in a definitive plan, which was presented to all concerned personnel, using first their personnel newsletters and later at meetings at the plants, in March of 1984. The interviews were then carried out during April to September, 1984.

The design of the data collection was as follows. Each person was interviewed[4] individually. The interviews were tape recorded. The following themes were covered in the interview:
- Background data
- Opinions about nuclear power in general
- Risks in the work environment
- Satisfaction with work conditions and salary.

The interview was semi-structured, i e the interviewer followed an established scheme with already formulated questions but he or she was free to formulate follow-up questions if necessary. The answers were coded by the interviewer in a number of categories.

After the interview, which took about 1 hour, the subject was asked to fill out three[5] questionnaires, namely:
- Judgments of general risks and specific radiation risks, including risk definition questions
- General radiation knowledge questions (for everybody)
- Specialized radiation knowledge questions[6] (only for radiation protection personnel)
- The KSP questionnaire[7] (a measure of generalized anxiety and worries).

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[3] A central government agency located in Stockholm. Its responsibilities include, but are not limited to, nuclear power. It works in close contact with the Nuclear Power Inspectorate (SKI), also a central government agency, which is responsible for nuclear power security inspection.

[4] Interview data are not reported here but a detailed account of them can be obtained from the authors.

[5] Four questionnaires in the case of radiation protection personnel.

[6] Both types of questionnaires measuring knowledge about radiation and its risks were constructed by SSI experts.

[7] The KSP questionnaire has been constructed by Professor Daisy Schalling of the University of Stockholm.

Risk judgments were carried out in three formats: (a) absolute category ratings, (b) comparative category ratings and (c) number ratings. In (a) subjects rated 16 personal risks on 6-point scales, from 0 (non-existent) to 5 (very large). In (b), they rated the same risks compared to the risk they perceived from their work environment, on 5-point scales, from 1 (much smaller) to 5 (much larger). The neutral category of no difference was denoted 3. (A zero used in the comparative scale would have been the middle category, of course, and it would have necessitated the use of negative numbers). In (c), finally, the subjects were asked to consider a group of people similar to themselves, choosing the size of the group as 1000 or 100,000. They were then asked to state, for each of the same 16 risks, how many persons in the group they believed would be killed or seriously injured due to each of the risks.

The inclusion of a possibility for the subject to choose his or her own base for making the frequency ratings was motivated by our goal to make the task optimally suitable for each subject. If all subjects are forced to use the same base some might find that they have to estimate fractions of people and that seemed undesirable.

The KSP questionnaire had been used in an earlier study of home-owner's reaction to radon risks in their homes (5). It was scored in three factors, on the basis of a factor analysis. Factor 1 was a measure of self confidence, Factor 2 measured somatic anxiety and Factor 3 muscle tension. The other questionnaires were constructed especially for the present study. There was a certain amount of missing data since all subjects did not wish to respond to all questionnaires. The prevalence of missing data was about 5 percent.

In order to get a comprehensive view of the data we analyzed, by means of component analysis, a large sample of the interview questions and the category risk judgments. Five components could be discerned: (a) general accident risk, (b) job satisfaction, (c) job risks in general, (d) nuclear risks and (e) risk judgment strategy. The job related risk variable was measured by the interview judgment of general job risk, the two questionnaire judgments of job risk (absolute category and number per 100,000, the latter in logarithmic form), and mean comparative risk judgment in the questionnaire. These four variables all had rather high intercorrelations, around 0.35. They were pooled after standardization to a common mean and variance.

To measure perceived nuclear risk we pooled, in a similar manner, 10 interview variables which measured various aspects of such risks, including how dangerous the subject believed their present exposure levels of radiation to be and the risk of a nuclear accident. Their intercorrelations were around 0.2.

Risks other than nuclear risks were also measured by interview questions and ratings and pooled into an index, called Other job risks.

A final risk index was constructed by pooling absolute category judgments of "traditional" accident risks, such as the risk of drowning, being struck by lightning, etc. This index excluded all radiation risks.

RESULTS

Relations between risk scales

As mentioned above, risk perceptions were measured by means of three different rating scales (absolute category ratings, comparative category ratings and number ratings). Before discussing the results in terms of reported risk levels it is of interest to analyze the scale properties of these ratings. This task was especially important since there was some concern especially about the validity of the number ratings which many subjects felt were hard to perform. We therefore investigated some properties of mean risk judgments, means being computed across the whole sample (about 230 observations behind each mean). The mean raw judgments were first plotted, see Figures 1 and 2.

As can be seen from Figure 1, there is a very strong linear relationship between absolute and comparative category scales. The number ratings produced a curvilinear (exponential) trend when plotted against category ratings, as seen in Figure 2. (The arithmetic means correlated lower than the geometric means with category ratings, but gave a similar exponential plot).

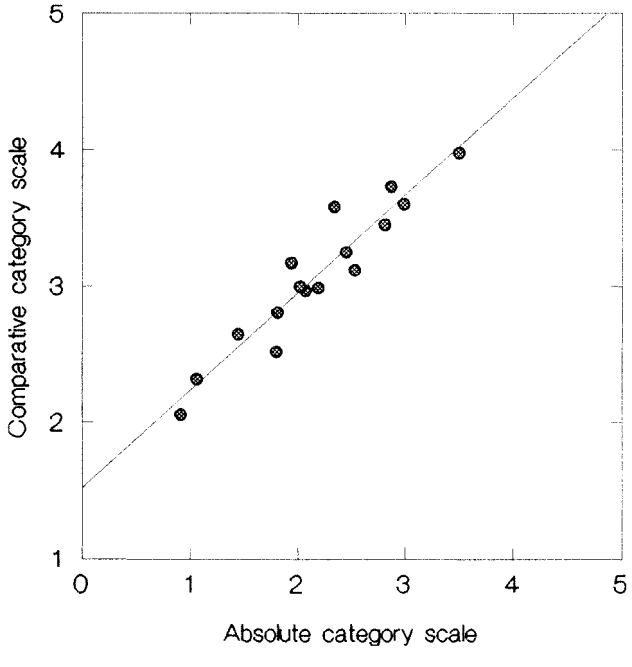

FIGURE 1. Comparative risk rating plotted against absolute risk rating for 16 different risks, with a linear regression function.

We conclude that the problem with the number judgments first of all was the numerical scale rather than the rank order - all three types of judgments tended to give the same rank order and in that sense the same information - and the non-linear tendency in plots like these have been found in many previous studies.

To further analyze the scale properties, risk ratings were correlated across individuals, giving some rather low values for correlations between category judgments (absolute and comparative) and number judgments, see Table 1. Table 1 also shows that log number judgments correlated much stronger with the absolute category judgments, partly because outliers were less extreme in this case, partly because the regression plots of raw data actually called for a curvilinear regression.

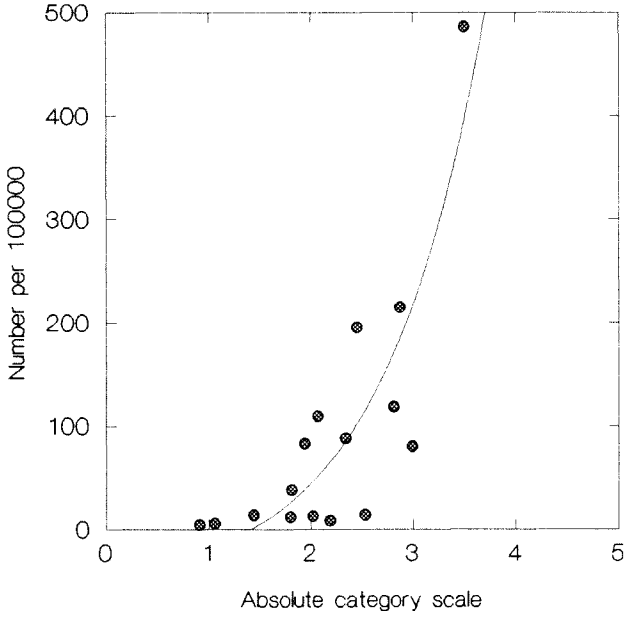

FIGURE 2. Number risk rating (number of accidents per 100,000 persons) plotted against absolute risk rating for 16 different risks, with an exponential regression function.

The comparative category judgments correlated rather weakly with absolute category and number judgments (see columns A, E, and F in Table 1), especially the latter even after log transformation. It should be realized, however, that the comparative judgments called for comparisons of the job environment risk with other risks. The absolute category and the log number judgments were therefore adjusted by forming differences between each risk and the corresponding judgment of the rating of job environment risk made by each individual. We then found consistently much higher correlations with comparative judgments, as expected, see columns C and G. The level we arrived at is in the neighborhood of 0.2-0.3, a common level of intercorrelation between individual items in judgment scales, cf. (6). This finding is comforting in view of the fact that many subjects felt that it was difficult to make some of the risk ratings.

TABLE 1
Correlations between judgement scales

Type of risk situation or event	*A*[1]	*B*	*C*	*D*	*E*	*F*	*G*
Lung cancer from smoking	0.281	0.122	0.323	0.248	0.003	-0.018	0.137
Live in a radon house	0.415	0.090	0.510	0.338	0.020	0.215	0.401
Falling from a height	0.313	0.137	0.436	0.345	0.033	0.094	0.217
Drowning	0.204	0.008	0.403	0.134	0.054	0.005	0.198
Struck by lightning	0.231	0.310	0.443	0.140	0.095	0.148	0.315
Fire	0.158	0.103	0.418	0.211	0.026	0.139	0.260
Aircraft accident	0.139	0.061	0.410	0.101	0.024	0.064	0.247
Mycardial infarct	0.395	0.097	0.515	0.194	0.047	0.100	0.237
Physical abuse	0.198	0.118	0.394	0.150	0.013	0.027	0.252
Traffic accident	0.310	0.190	0.394	0.294	0.025	0.047	0.229
Regular office work	0.112	0.026	0.359	0.133	0.019	0.035	0.265
Construction work	0.304	0.036	0.398	0.165	0.019	0.012	0.148
Hospital X-ray work	0.474	0.089	0.572	0.273	0.142	0.207	0.397
Down hill skiing	0.550	0.058	0.550	0.198	0.014	0.065	0.256
My kind of work environment	. -	. -	.12	. -	.32	. -	. -
In a job similar to mine, with no radiation risk	0.178	0.114	0.193	0.260	0.002	0.029	0.251

[1] *Correlations refer to the following scale pairs: A:absolute/comparative, B:absolute/raw number, C:absolute adjusted/comparative, D:absolute/log number, E:comparative/raw number, F:comparative/log number, G:comparative/adjusted log number.*

Next, we wished to pursue the question of *how* people made these judgments, expecting the risk judgments to be differentially affected by judgement strategy. We therefore analyze, in the next section, the relations between the risk definition variables and risk ratings.

Risk definitions

We report the over-all means for the four judgments that were included in the risk questionnaire in order to investigate judgment strategies, see Table 2.

It can be seen from the table that risk was considered, most of all, to be a function of the probability of an event, second as a combination of consequences and probabilities.

TABLE 2
Mean judgments of scales corresponding to questions about the definition of risk and what strategy the subject employed in judging risks.

Definition	*Mean*[1]
Risk is mainly a question of how probable an event is	*1.79*
Risk is mainly a question of how large the consequences of an event are likely to be	*2.79*
Risk is a combination of probability and consequence	*2.36*
The meaning of the concept of risk depends entirely on the nature of the event	*2.90*

[1] *The scale had five categories, from 1, denoting complete acceptance of the statement to 5, complete rejection. A low value in the table therefore implies a high degree of acceptance.*

There was a tendency for female subjects to agree more often than men that risk is a matter of size of consequences and that the meaning of risk depends entirely on the kind of event. Ratings of the four judgment strategies also varied somewhat as functions of educational level. Probability definitions of risk were most popular with subjects with an intermediate level of education, while those with the highest and the lowest levels tended to favor consequence definitions. Contextual definitions were especially often rejected by those with a high education who were also more in favor of risk defined as a combination of consequence and probability. The 10 occupational groups did not differ in terms of risk definitions.

There were several response patterns in the four risk definitions questions. We have chosen to analyze further four groups which gave patterns that are logically clearcut. (Disregarding missing data and subjects answering Don't know to all four items there were in all 10 clusters of subjects but only 4 will be reported here). The groups were:

A. *Pure probability definition*. In this group, subjects accepted only the definition stating that risk is mainly defined in terms of probability. $N=39$.

B. *Probability and combination definition*. In this group, subjects accepted both the statement that risk is defined mainly as probability and the notion that risk is a combination of probability and consequence. $N=47$.

C. *Pure combination definition*. The subjects of this group accepted only the statement that risk is a combination of probability and consequence. $N=9$.

D. *Consequence and combination definition*. The subjects of this group accepted that risk is mainly a question of consequences and that risk is defined by a combination of consequences and probability. $N=18$.

There were no subjects who accepted only the consequence definition and only two subjects who accepted only the definition that the concept of risk is unique to each situation. The risk definition groups were not systematically related to the occupational groups.

Means were computed in each of the four subgroups A-D for each of the 16 risks, for absolute category risks, number ratings and comparative risks separately. The groups were rank ordered for each risk and rating method. A summary of the results are given in Table 3.

TABLE 3
A summary of rank orders of the four groups

Group	*Frequency of rank position* 1	2	3	4
	Absolute category ratings			
A	0	9	6	1
B	4	3	6	3
C	1	2	3	10
D	11	2	1	2
	Log number judgments			
A	0	5	9	2
B	0	10	6	0
C	0	1	1	14
D	16	0	0	0
	Comparative judgments			
A	0	3	5	7
B	1	3	8	3
C	11	4	0	0
D	3	5	2	5

Table 3 states, e.g., that for absolute category ratings group C had the highest mean on 1 of the 16 scales while group D had the lowest mean on 2 of the 16 scales.

The data were analyzed for each scale separately by means of Friedman's non-parametric two-way analysis of variance. The test statistic was 14.700, 20.280 and 39.225 for absolute category ratings, comparative ratings and log number ratings, respectively. These values are all significant well beyond $p<0.01$. The concordance coefficients were, for the scales in the same order, 0.306, 0.451 and 0.817. It can hence be seen that the log number ratings were most sensitive to the variation in risk definition.

Disregarding the C group for a moment, a glance at Table 3 is sufficient to see that the D group, which accepted the notion of risk as consequences, gave the highest risk ratings. The statement is true also if the C group is included, except for the comparative ratings. In that case, group C gave the highest risk ratings.

The comparative ratings were made with reference to the work environment risk. That risk was rated as 4.7 per 100,000 in group C (geometric mean) while it was rated much higher in the other three groups (21.1, 22.1 and 102.2 for groups A, B and D, respectively). It is hence natural that group C comparative ratings should be high, since these were ratings made with reference to a low perceived work environment risk.

Summing up, the analysis shows that:
- the type of risk definition accepted by the subjects correlated with the level of risk ratings;
- numerical risk ratings seemed most sensitive to risk definition, absolute category risk ratings least;
- subjects who accepted a consequence definition of risk gave the highest risk ratings (with one exception);
- comparative risk ratings were especially high for subjects who accepted only the definition of risk as a combination of probability and consequence. These subjects tended to rate their own job risk as especially low.

Risk judgments: over-all level

The mean risk judgments across all subjects and rating tasks are given in Table 4. It can be noted that several risks were judged as larger than that in the work environment of the respondent, but that work similar to one's own but without radiation danger was judged as less risky, naturally enough. The elevated level of the arithmetic means of the number judgments suggests that many risks were considerably exaggerated, partly due to deviant outliers. The geometric means were at least an order of magnitude smaller[8].

The geometric means still appear to be exaggerated, however. For example, there are about 1000 traffic deaths in Sweden per year, a figure about 1/16 of that implied by the geometric mean in Table 4 for the risk of a traffic accident. Naturally, subjects could have considered also non fatal[9] accidents, but the figure for aircraft crashes corroborates the interpretation that there is risk exaggeration[10].

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[8] Medians were not very informative due to clustering of responses at "even" values.

[9] Instructions called for an estimate of the number of fatal or very serious accidents.

[10] The question of choice of the size of a basis and its effects is obviously of interest for future work. The literal interpretation of these judgment results is of course risky since subjects may have failed to realize the national implications of estimating a certain number of fatalities per 100,000 or 1000 individuals.

TABLE 4
Mean risk judgments

Judgment type	*Absolute category*		*Comparative*	*Number*
Range of scale	*0 - 5*		*1 - 5*	*per 100,000*
	AM[1]	*GM*[2]		
Type of risk situation or event				
Lung cancer from smoking	*3.50**[3]	*3.98**	*5882**	*485.9**
Live in a radon house	*2.53**	*3.12**	*1276**	*14.3**
Falling from a height	*2.34**	*3.58**	*2346**	*88.2**
Drowning	*1.94*	*3.17**	*2069**	*83.0**
Struck by lightning	*1.06*	*2.32*	*115*	*5.7*
Fire	*1.81*	*2.81*	*872**	*38.0**
Aircraft accident	*1.44*	*2.65*	*1197**	*13.7**
Myocardial infarct	*2.45**	*3.25**	*3044**	*195.8**
Physical abuse	*2.07**	*2.97*	*2815**	*109.3**
Traffic accident	*2.87**	*3.73**	*3396**	*215.1**
Regular office work	*0.91*	*2.06*	*68*	*4.6*
Construction work	*2.81**	*3.45**	*1139**	*118.4**
Hospital X-ray work	*2.19**	*2.99*	*339**	*8.5*
Down hill skiing	*2.99**	*3.60**	*1263**	*80.4**
My kind of work env.	*2.02*	*3.00*[4]	*250*	*12.9*
In a job similar to mine, with no radiation risk	*1.80*	*2.52*	*261**	*11.8*

*[1] Arithmetic mean. [2] Geometric mean. [3] We use * to mark that a type of risk has been judged, on the average, as larger than the risk in the work environment, for that type of judgment. [4] Note that this level was defined as 3.0, not rated, in the comparative judgments.*

It can be inferred from Table 4 and the difference between the last two rows, geometric means, that subjects perceived their job risk enhancement due to radiation to be about 10^{-5} per year. According to official risk estimates, the correct figure for the two power plants we investigated was of that magnitude (7).

Modelling judgments of job risks

It can be seen in Table 5 that risk judgments (questionnaire data) were to some extent related to background data, radiation knowledge and personality, across individuals.

There were quite a few significant correlations, although the over-all level was rather low, with some notable exceptions.

TABLE 5
Correlations between the pooled job risk index and selected variables

	Category judgment of job risk
Sex	*-0.142**
Age	*-0.161**
Educational level	*-0.175***
How often work in a controlled area	*0.220****
Nuclear power attitude	*-0.042*
Job satisfaction	*-0.181***
Radiation knowledge, general	*-0.165**
Radiation knowledge, specialized	*-0.171*
Nuclear risk	*0.580****
Other job risks	*-0.137**
General accident risks	*0.235****
Evaluation of radiation protection measures	*-0.252****
Amount[1] of radiation instruction	*-0.170**
Credibility of radiation instruction	*-0.241****
Weak self confidence	*0.133**
Somatic anxiety	*0.150**
Muscle tension	*0.138*

[1] *Measured as the number of days of instruction.*

To analyze the issue further we performed several stepwise regression analyses of the job risk index (see introduction for explanation of indices used). A few variables emerged with consistent beta weights, namely:
- Perceived nuclear risk ($\beta=0.523, p<0.001$)
- Frequency of work in controlled sections ($\beta=0.157, p=0.001$)
- General accident risk ($\beta=0.119, p=0.026$)
- Amount of radiation instruction ($\beta=-0.218, p<0.001$)

The multiple correlation for predicting perceived job risk from these predictors was 0.633 in the sample, and the adjusted squared multiple correlation was 0.390, thus yielding a high level of predictability of perceived job risks.

The index of other job risks which correlated significantly with the pooled index of perceived job risks (see Table 5, "other job risks") but this variable did not contribute to the prediction of perceived job risks.

Hence, the nuclear risk was by far the most important predictor of general job risk, followed by how often the subject worked in a controlled section. Nuclear risk itself accounted for almost 34 percent of the variance of perceived job risk. The rather large weight given to general accident risk testifies to the importance of that aspect for the experience of job risks.

Finally, education seems to have had some effect in making the subject perceive smaller risks. The achievement test did not contribute to the prediction

of job risks when entered simultaneously with the measure of the amount of training. It correlated rather strongly with the latter variable (r=0.477).

Knowledge about radiation and risk perception

We used two separate achievement tests. Each answer was coded as correct or incorrect. We found a negatively skewed distribution of scores on the general knowledge questions. They seemed to be rather easy for the present subjects. For radiation protection personnel we employed a more difficult set of questions and obtained somewhat less encouraging results. The correlation between the two knowledge questionnaires was 0.41 for this group. The items of the general knowledge questionnaire correlated rather evenly and positively and so did the items in the specialized questionnaire given to the radiation protection personnel, except in the case of two items.

The 10 professional groups differed widely in their scores on the achievement test, $F(9,224)=4.386$, $p<0.001$. Holding general level of education and amount and credibility of received radiation instruction constant, we still obtained a very clear variation among groups in test scores, $F(9,208)=4.487$, $p<0.001$. The variation among groups is illustrated in Figure 3 which shows that, in spite of group differences, all groups scored rather high on the test.

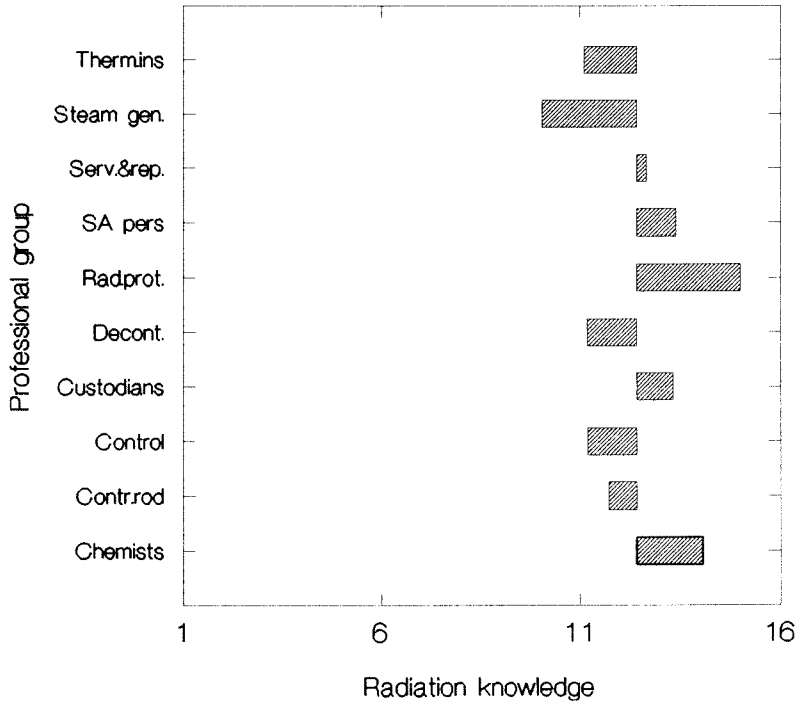

FIGURE 3. Average score on the radiation knowledge test in the 10 professional groups, plotted as deviations from the over-all mean.

There was a quite strong relationship between radiation knowledge and perceived job risks across group means, see Figure 4. Note the deviating value of the control group.

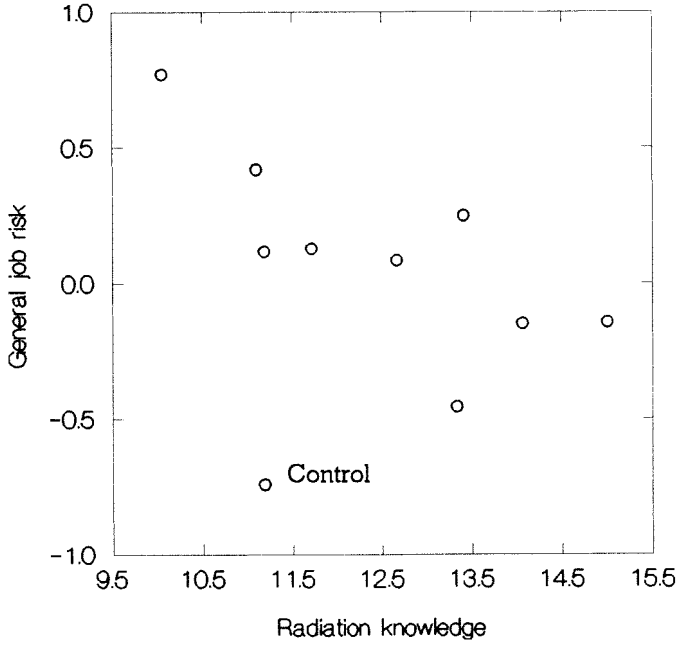

FIGURE 4. General job risk plotted against radiation knowledge score. Note the deviating value of the control group.

There is a strong linear trend in this plot, when the control group is disregarded. The question is if the trend is a reflection of varying degrees of knowledge or if it reflects a third factor, such as differences in job conditions and real risk variation. When controlling for the time spent in a controlled area, the trends did not disappear but rather they appeared to be somewhat stronger. If time in a controlled area is accepted as a proxy for actual exposure to radiation it thus appears that variation in actual risk cannot explain the relationship exhibited in Figure 4.

Group differences in exposure to radiation risks

As a preliminary step to studying variations among groups in risk perception, we investigated how often[11] persons in different groups worked in a controlled

[11] The measure is admittedly rather crude since it does not directly take the total time spent in controlled sections into account, nor its distribution over a year. Still, it probably gives a reasonable indication of exposure to controlled sections.

section. In Figure 5 we illustrate group differences with respect to how many stated that they worked daily in a controlled section.

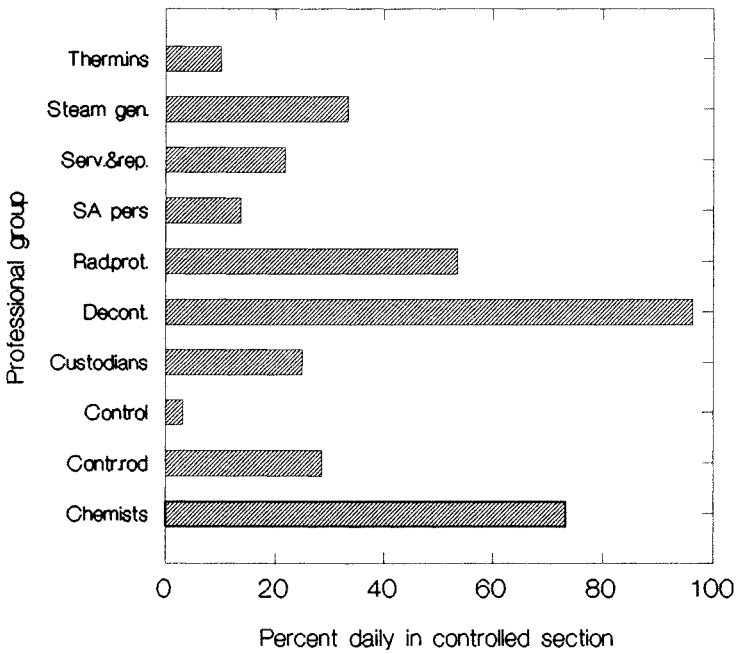

FIGURE 5. Per cent of respondents in the 10 professional groups who stated they worked daily in a controlled section.

It is clear from the figure that there were considerable differences among the groups regarding how often they worked in a controlled area. As expected, the control group least frequently worked in such areas. We calculated chi^2 for the null hypothesis of no group differences. Its value was 281.87, $df=36$, $p<0.001$. We conclude that the groups differed in this respect. The amount of time spent in controlled sections was correlated with questions about how risky they considered their job to be in general, and how large they regarded the risk of exposure to radiation to be. These two variables correlated 0.251 and 0.385 with time in controlled sections, both highly significant, supporting the validity of the risk perception measures.

It can be noted that even in the control group there was sometimes work in controlled areas. It was not possible to define a group which was completely homogenous in this respect. Decontamination workers constituted an extreme group in the sense that they differed rather strongly from other groups with respect to how often they worked in controlled areas, a fact consistent with their professional tasks. They worked almost daily in a controlled section.

Risk judgments: group differences

The differences in level of perceived job risks between the 10 professional groups were subjected to a one-way ANOVA. The between-group variance was highly significant, $F(9,226)=11.163$, $p<0.001$.

ANOVAs were used to study the differences among the professional groups in each of the 16 risks. There were no significant over-all differences except when it came to perceived job risks, when the absolute category judgments were studied. The comparative risks all differentiated the groups, which was natural since they concerned comparisons between job risks and other risks.

The steam generator workers judged own work environment risks as quite high and, logically enough, other risks in comparisons as lower compared to other groups. They also judged other risks rather low in absolute category judgments. They seemed quite concerned about job risks, perhaps due to a then recent accident in a shipyard where some of them had been employed.

The steam generator workers thus gave a low rating of general accident risks, combined with a high rating of job risks, see Figure 6.

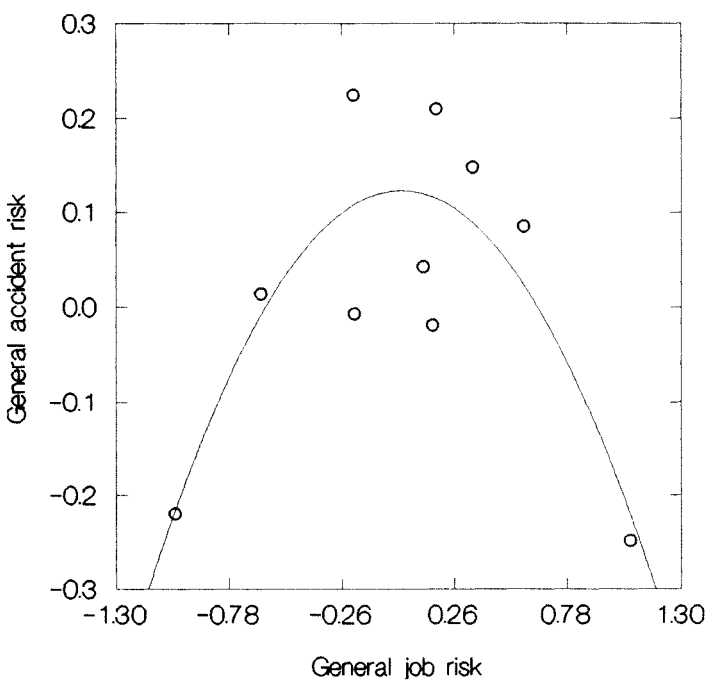

FIGURE 6. General accident risk plotted against general job risk, with a quadratic regression function.

There is a rather good fit to a reversed U shaped relationship across groups of the relation between general accident risks and job risks. It appears that if the perceived job risk gets very high, other risks will be judged as lower by contrast. On the other hand, if there is no threat present and the job risk is perceived as

quite low, other risks will also be judged as low possibly because the individual is not alerted to danger signals.

Personality and risk perception

We have already noted that personality variables did not contribute to the prediction of perceived job risk. However, we found that two of the personality variables correlated significantly with perceived job risk, suggesting that people with weak self confidence and high anxiety tended to judge job risks as larger than others (see Table 5). A closer analysis revealed that perceived *nuclear* job risk was more strongly correlated with personality than conventional job risks. There was a borderline significant tendency for an inverse U shaped relationship between anxiety and nuclear risk, $t(233)=1.893$, $p=0.06$, implying that high anxious and low anxious people tended to judge lower risks, based on a test of regression coefficients in fitted quadratic regressions.

Job satisfaction

We finally considered the job satisfaction variable. In a stepwise regression analysis with job satisfaction as the dependent variable, only three predictors emerged: tension ($\beta=-0.323$, $p<0.01$), satisfaction with salary ($\beta=0.199$, $p<0.001$) and perceived conventional job risk ($\beta=-0.131, p<0.01$). Multiple R was 0.392, adjusted squared value 0.143.

Interestingly enough, neither over-all job risk nor nuclear risk emerged as efficient predictors beyond the three mentioned variables.

DISCUSSION

The job risks perceived by personnel of the two nuclear power plants were rated about average, roughly matching the expert estimate. Since small subjective probabilities are very hard to measure it may be of interest to consider the present technique in future work.

The finding might be interpreted in the light of the fact that most other risks were grossly exaggerated. The risk of one's own job environment is probably a risk which is so closely related to one's own person that risk denial dynamics is aroused in the rating task. Risk denial is well known to exist in other fields, such as perceived radon risks (8).

Bastide and Moreau (9) reported results from a questionnaire study of risk perception among the personnel of a French nuclear establishment (Saclay). Their subjects rated risks somewhat differently from ours, in terms of dangerousness, on a scale from 0 to 5 (same number of categories as we used). They found that the job environment risk ("Travailler dans une centrale nucléaire") was rated as number 23 out of 27 risks in the questionnaire, on the surface quite different from our findings. However, a closer scrutiny shows that they listed many activities that

seem dangerous and few of a more ordinary kind, such as ours "Ordinary office work". In addition, they reported a mean rating of job environment risk of 2.19, very close to our 2.02. Bastide and Moreau also found differences among professional groups that appear similar to ours, groups with higher education judging the risks to be smaller. On the job training did not correlate with perceived risk but they measured it only with a yes-no type of question. They included no test of actual knowledge of radiation.

We found that knowledge tended to correlate negatively with level of perceived job risk and nuclear risk. Perceived risk was negatively correlated with radiation knowledge, even within the group of radiation protection personnel which was given a specialized test calling for considerably more advanced knowledge. The lack of knowledge noted in some cases, among them radiation protection personnel, called for improved on the job training. The amount of instruction correlated stronger with perceived risk than knowledge, which suggests that instruction may have had other effects than mere informational ones, e.g. attitudinal.

Why did perceived risk correlate negatively with knowledge about risk related matters? One possibility is, of course, that those who rated risks as large were misinformed. Another possibility is that those persons in fact had the most risky jobs, at the same time as they had received the least amount of education. The latter possibility was not supported by the present data, since the relationship between perceived job risk and knowledge persisted even when exposure to controlled areas was held statistically constant.

We found evidence for a rather undifferentiated risk concept of nuclear risk. The subjects tended to judge various, logically unrelated, risk events as aspects of a common underlying nuclear risk. Other studies have shown similar tendencies (10). The perception of job risk emerged as a function of perceived nuclear risk (by far the most important predictor), generalized risk aversion, exposure to controlled sections in the plants and amount of radiation instruction. Background and process variables beyond these did not contribute to explaining variance in perceived job risk. About 40 percent of the variance of perceived job risk could be explained by the predictors, a high level.

The three methods for eliciting risk judgments tended to give results that agreed rather well at the aggregated level. However, our analysis of the relation between reported judgment strategies and levels of risk judgments showed that their dynamics may be different and that they may appeal to different sub-groups in the sense that they tended to elicit higher risk judgments in different groups. Subjects who define risk in terms of consequences can be expected to give higher risk ratings than those who define risk in terms of probability.

When various groups are compared in terms of risk ratings it is therefore important to find out if differences in mean ratings reflect different definitions of the concept of risk or if they reflect variation in risk perception.

The finding that some background characteristics (gender, education) correlated with the choice of risk definition, further points to the importance of

mapping how people conceive of the concept of risk if different groups are to be compared by means of risk ratings.

The relationship between general accident risk and job risk was clearly curvilinear (an inverse U shape). These findings suggest that (a) people who feel little threatened (in this case the control group subjects) tend to rate general risks as low, and (b) people who are strongly threatened (steam generator workers in the present study gave indications of perceiving a pronounced job risk threat) also rate general risks as low, due to a contrast effect. In addition, intermediate levels of threat produce heightened general risk judgments, possibly due to a vigilant response to intermediate threat levels.

Job satisfaction was more related to concrete and everyday events and concerns, including perceived conventional job risks and stress level, than to perceived nuclear risks. It is interesting that general job risk was still much more closely related to nuclear risks than to conventional job risks. These findings suggest that questions about general risk levels may be related more to salient than efficient risk, under the assumption that nuclear risks were most salient to the subjects. The assumption seems reasonable since the study was so much concerned with nuclear risks and since these are a major concern of any nuclear power plant.

The groups investigated here included only a few persons with college training and no managers. In future work it would be interesting to investigate such groups too, and to relate their risk perceptions to those of other employees. Effects on risk perception and job satisfaction due to recent nuclear accidents would also be important to investigate.

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RISK PERCEPTION AND DEFINITIONS OF RISK

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ABSTRACT

The paper focuses on definitions of risk. Six studies were analyzed with respect to how non-expert subjects defined the concept of risk. In five of the studies subjects also rated risks of various adverse events with respect to personal risk, risk for people generally, and threat to society. Data from an additional study allowed a comparison between responses to a unidimensional scale measuring subjects' risk definitions and four suggested risk definitions.

The results showed, firstly, that subjects rated risk significantly different when utilizing different perspectives. Thus personal risk was rated lower than risk to people in general, which in turn was rated lower than risk regarding the threat to society. Secondly, on the basis of two subsequent categorizations of the responses to the suggested risk definitions, the results showed that naive subjects did not usually employ a logically coherent definition of risk which exclusively involved the probability and consequence elements. Thirdly, subjects who could be accommodated within logical risk definition categories differed in their ratings on the basis of definition preference. Subjects who focused on a probability definition of risk gave lower risk ratings than those who used a risk definition which focused on consequences of an event. Fourthly, the comparison of a unidimensional rating scale and four separate definitions of risk indicated that the use of a unidimensional scale for measuring subjects' risk definitions may conceal a great variation of responses, especially with respect to the middle response alternative.

The results are related to some diverging examples of how researchers define risk, and discussed in a framework where the different ratings emanating from the use of different perspectives are related to concern and behavior. It is suggested that differences between novices' and experts' risk assessments may, in part, be related to clarity, as well as type, of personal risk definition. Risk perception research concerned with low probability/high consequences events is finally related to research which also involves high probability/low consequences events, e.g. in marketing, and it is suggested that future risk perception research might benefit from considerations of both approaches.

INTRODUCTION

In risk perception research it is often taken for granted that the likelihood and the severity components of an adverse event are both employed in the assessment of risk. This paper challenges the validity of such an assumption. There is no reason to believe that all naive subjects who volunteer risk judgements conceive of risk in such a way. Neither is there reasons to believe they conceive of risk in the same or even similar manners (Vlek & Stallen, 1981). The same is true of experts. When researchers define the risk concept explicitly they too vary with respect to the emphasis they put on different components.

Risk estimates derived from different perspectives also vary, i.e. risk related to one's person, to others, and to societal phenomena. It is common knowledge that subjects rate many personal risks as lower than risks affecting others (Tyler & Cook, 1984; Weinstein, 1987), and that they often rate personal prospects or abilities as more favorable than those of others. These findings have been interpreted in terms of perceived personal control over one's actions and life circumstances, and in terms of information sources being differentially effective in relation to the different perspectives (Tyler, 1980). This paper also considers risk ratings regarding people generally versus threats to society, i.e. yet another level of generality.

The paper presents data concerning naive subjects' personal conceptions of the risk concept. A reanalysis of several survey studies with respect to risk definitions was motivated by the need to test to what extent subjects defined risk in terms of probability of an event, consequences of an event, or in terms of the combination of these components. Another aspect of the same issue concerned to what extent subjects' used these kinds of conceptualizations at all. A third aspect concerned whether subjects who defined risk differently also rated the risk of the same event differently.

The basis for these considerations was the definition of risk derived from expected value principles, which involve the multiplying of probabilities and consequences of an adverse event (Svenson & Karlsson, 1983; Hansson, 1987). It was thus assumed that subjects who used a risk definition based on the probability of an event would come up with a lower risk estimate than subjects who also, or exclusively, considered the consequences of an event in their conception of risk.

The first results to be presented in this paper are based on risk ratings derived from instructions to estimate different kinds of risks from three perspectives: to one's person, to people generally, and to society. The main reason for this comparison was to establish if different risk levels were obtained with respect to perceived risk when different perspectives were utilized in the ratings. Ratings related to the three perspectives were subsequently analyzed in connection with subjects' personal definitions of the risk concept. It was hypothesized that both the definition of risk and the perspective in which an adverse event is rated are important for the resulting risk estimate.

Finally, in an additional study, responses to the suggested risk definitions were compared with responses to a unidimensional scale measuring definition of risk, all from the subjects' points of view. The comparison was motivated by the assumption that a single rating scale may mask a diversity of naive risk definitions.

In the area of risk research often concerned with low probability and high consequences risks, there exist two major approaches to the definition of the risk concept. Firstly, there are probability estimates of risk (or safety) on the basis of accumulated empirical data. Studies of this kind usually include explicit reference to how the risk concept was conceived and the risks estimated. They may concern estimates of fatalities, injury, short or long term health effects, etc. In this vein Sowby (1965) compared everyday activities regarding risk of death, expressed as the "death-rates per hour in a population of 10^9" (p. 880), and pointed to problematic aspects of such comparisons. Fischhoff, Watson and Hope (1984), and Hansson (1987), have discussed the implications of different kinds of risk definitions on risk acceptability. They have also considered the value systems underlying the definition of risk, and (Hansson, 1987) discussed the rationality of different risk assessment methodologies. Probabilistic safety analyses (PSA analyses) also belong to this area, in which probabilities of technical component damage and series of events resulting in an accident are estimated (SKI Rapport, 1990). Although this area of research does not belong to risk perception studies, the results are sometimes used in the latter kind of studies for reference to objective risk levels or for comparisons to naive subjects' risk estimates.

Secondly, there is an area of studies which use risk judgements from lay subjects, or samples of the public, as the data base. Researchers in this area more seldom explicitly define the used, or assumed, concept of risk with respect to its components. Although there may be explicit mentioning or ratings of e.g. severity of events, likelihood of harm, seriousness of harm, etc., the explications usually concern what subjects are supposed to rate, not how they conceive of the risk concept. Vlek and Stallen (1981), however, reported a study of cognitive dimensions underlying subjects' conceptions of "riskiness", "acceptability" and "beneficiality". Within this research field a more coherent overall structure of findings might result from investigations of how subjects actually conceive of the risk concept itself in connection with giving the risk estimates. The current risk perception literature presents results based on profoundly different assumptions and procedures with respect to the definition of the risk concept, making comparisons of results from different studies difficult at the very best.

The different assumptions concerning the risk concept seem to vary in at least two dimensions: Firstly, they vary regarding *the basis* for the estimation of the probability of an event. For example, Fischhoff and Svenson (1988) wrote: "For some, the natural unit of risk is an increase in probability of death; for others, it is a reduced life expectancy; and for still others, it is the probability of death per unit of exposure (where "exposure" itself may be variously defined)" (p. 458). Secondly, there exist different views of to *what extent* the probability and the magnitude components should be addressed in risk estimations. For example, Svenson and Karlsson (1983) reported that the risk concept has been defined in

different ways by different scientists for different reasons, but that: "Two components are always, however, included in risk definitions. Firstly there must be a *probability* (likelihood or possibility) at hand for an event which secondly has *negative consequences*" (p. 4)[1]. They stated their own definition of risk as: "The risk is the probability or an assessment of it for an event with negative consequences to occur" (p. 4)[2]. They pointed to the advantage of separating the components for theoretical reasons, and on the basis that the public does not make systematic use of the risk components in risk judgements.

Lowrance (1989) instead put it as follows: "'Risk' is a compound estimate of the *likelihood* and *severity* of adverse health effect. Notice the two elements: likelihood (or probability) and severity (or magnitude). A particular risk description may be either relative or absolute. (...) In all cases it must incorporate both the consequences and their likelihood" (p. 9). (See also Bento, 1989). Hansson (1987) distinguished between the probability and uncertainty meanings of the term risk. He asserted that: "The technical term "risk" is conventionally defined as something that can be given a numerical value. The procedure is "to multiply the probability of a risk with its severity, to call that the expectation value, and to use this expectation value to compare risks". (Bondi 1985, p. 9)[3]. Sometimes the expectation value is *called* "the risk", sometimes it is only taken as the sole measure of the severity of the risk. In both cases, the concept of a risk is reduced to a unidimensional concept, that can be expressed numerically" (p. 4). Negative consequences were in turn described by Hansson in terms of their multidimensionality and included, for example, the character, magnitude and distribution in the population, etc., and the uncertainty surrounding the occurrence of such consequences, e.g. lack of knowledge, probability of negative consequences, and chances to avoid them.

Urquhart (1988) differentiated between "talking definitions" and "pricing definitions" of risk. The former definition states that "risk is the combined probability and severity of an adverse happening" (p. 13-14). It is only a "qualitative tool", however, leaving open the question of how probability and severity should be merged into one. The latter definition of risk, the "pricing definition", states that "risk is the probability of a defined adverse happening" (p. 14). This definition of risk projects the frequency of future events on the basis of available data and measurements, and "leaves the evaluation of severity to the individual", in

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[1] My translation from Swedish. The italics in the text corresponds to underlining in the original text. In Swedish: "Två komponenter ingår emellertid alltid i riskdefinitioner. För det första skall en sannolikhet (trolighet eller möjlighet) föreligga för en händelse som för det andra har negativa konsekvenser."

[2] My translation from Swedish. The complete sentence was underlined in the original text. In Swedish: "Risken är sannolikheten eller en skattning av denna för att en händelse med negativa konsekvenser skall inträffa."

[3] Cited by Hansson (1987).

Urquhart's terminology (p. 14). The author asserted that the latter definition bears on 300 years of practical experience with respect to pricing insurance of all kinds, and that "in keeping with that practice, it is simplest to define risk simply as the probability of something bad happening within a stated period of time" (p. 14). Furthermore, the author asserted that: "Technological opinion seems to have shifted from the 'talking' to the 'pricing' definition also in the past several years" (p. 14). If Urquhart is indeed right, it is hard to understand why private insurance companies or consortia in the U.S. refuse to take over the liability of nuclear accidents (Newbery, 1988).

A further complication of the state of the art concerns risk estimation of well-documented and well-known risk situations relative to new risk scenarios. (See for example Fischhoff, Slovic, Lichtenstein, Read & Combs, 1978). Letzel (1989) stated, in a context of "low-risk" perception and management that: "To some extent the perception of risk depends on whether a manifestation of the risk has already taken place or not. Thalidomide and Chernobyl have clearly shown this. They also show that *low* risk refers only to the likelihood, not the severity, of an adverse advent. The term seems to mask the fact that risk may be low but is nevertheless present, and the consequences may range from small to immeasurable. "Low risk" gives rise to the illusion that nothing deleterious will in fact happen" (p. 70).

The nuclear power authorities in Sweden distinctly separate safety analyses, e.g. PSA analyses, from the assessments of possible consequences of a nuclear incident or accident. The components are only merged together in a later stage to give an overall "risk picture"[4]. Consequences of an accident in a nuclear power installation concerns radiation doses to the population. The assessment of consequences are based on population density, weather conditions and type of landscape. They can be assessed in various categories of possible severity (SKI Rapport, 1990).

The divergent views of researchers and scientists, and the different presentations of what is included in an assessment of "risk" ought to be reflected in the minds of the public. The main part of the present paper investigates naive subjects' personal conceptions of the risk concept. Four statements defining the concept of risk were presented, and the subjects indicated their degree of agreement to each of them on the basis of the meaning they "normally" ascribed to the risk concept. Risk definition responses of subjects of five different studies were analyzed. All five studies used mail questionnaires, the same risk statements, and the same rating scales. The studies are presented in more detail below. The investigation of the risk statements was motivated by the hypotheses that (1) people differ with respect to what they include in the concept of risk, and that (2) people who include or focus their conception of risk on consequences of an event rather than on the probability of an event also rate the risk associated with the event as higher.

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[4] My translation. In Swedish riskbild.

METHOD

General outline

Several sets of data (see below) were available for reanalysis. To investigate the hypotheses presented above two main categorizations were made on the basis of the given risk statements. Subjects' ratings of perceived risk were collapsed into indices of personal risk, risk for people in general, threats to society, and risks related to radiation. The indices were then compared for subjects in different risk definition categories and of different sex. In addition, and due to the reduced sample sizes after categorizations, subjects of five different studies were collapsed into a single sample relative to each index after standardization of the dependent variable. The procedure allowed for more powerful analyses, and facilitated comparisons of the categorizations. Towards the end of the paper background variables, especially sex and educational level, are addressed with respect to their relation to risk ratings. A comparison was also made between ratings of the definition of risk using the multi-item procedure presented in this paper and the use of a unidimensional rating scale with respect to the content of the risk concept.

Presentation of the data base

In a number of studies on attitudes and risk perception we have repeatedly used the same items and the same rating scales, as well as four suggested definitions of risk. Those data will be reanalyzed here. Results of another two studies are also analyzed. One of those studies concerned interests in higher education and reasons for educational choice, in which risk ratings of threat to the society were included, as well as the risk definition statements. This study, called the D-study below, has not yet been published. The other study, also unpublished, mainly concerned interests, reasons for educational choice, and self characterizations in a group of high achievers. The study also contained attitude statements regarding risk taking behavior and attitudes to use of computers. A unidimensional scale was included in the questionnaire of this study together with four risk statements defining risk for the purpose of comparison of responses to the respective procedures to measure how subjects defined risk. The latter risk statements were included in the list of attitude statements, and will be described in more detail in a later section. This study was only used for the comparison of measurement procedures. A short presentation of the other five studies (A-E) follows below.

Study A. A representative sample of the Swedish population (ages 18-65) was studied in the spring of 1987 (N=591). There were 53% men among the respondents. The mean age was 41 years. The study concerned disposal of radioactive waste. The questionnaire asked for attitudes and risk ratings regarding various aspects of nuclear power, personal knowledge of the issues, attitudes regarding future consequences of disposal of radioactive waste, and ratings of confidence in certain expert groups. There were also lists of items which were rated with respect to personal risk (of which some were related to radioactivity), risks for

serious accidents regarding handling and disposal of radioactive waste, as well as threats to society with respect to a number of possible events. Only the risk ratings were used in the present study. The results of this study have been presented in Sjöberg & Drottz (1988a).

Study B. A study of attitudes, knowledge and risks regarding the AIDS disease was carried out in 1990, using a representative sample of the Swedish population aged 30-45 (N=465). The items relevant to the present study concerned ratings of risk to the own person and to people generally with respect to lists of possible adverse events. The respondents also rated possible threats to the society. The mean age of the sample (46% men) was 38 years. Results of this study was presented by Sjöberg (1990).

Study C. This study was conducted in 1986 and designed to be a pilot study to the A-study above (N=380). It concerned the use of nuclear power in Sweden, and aimed to investigate attitudes, knowledge and risk perception among adolescents with respect to radioactive waste. The sample was drawn from high schools in the Stockholm area, and included students of the last year of five major study programs: natural science, technology, social science, economics and the humanities. The study included 41% men due to the unproportional sex distribution of the various educational lines. The mean age of the students was 18 years. Results of this study were presented in Drottz & Sjöberg (1988), and at the 1987 Annual Meeting of the Society for Risk Analysis, in Houston, Texas (Drottz & Sjöberg, 1987).

Study D. The study was conducted in 1989 and represented the last data collection in a longitudinal project of students of engineering and psychology (N=243). The project concerned interest in higher education and the students answered a variety of questions summing up the former study period. Included in the questionnaire was a list of possible threats to society, the responses to which were used in the present study. There were 63% male engineers in the study, and 21% male psychologists.

Study E. A study of nuclear power plant personnel, conducted in 1984 (N=236). It investigated attitudes to nuclear power, and risks related to the work environment in general as well as with respect to radiation. The respondents answered interview questions and responded to risk rating lists. The data used in the present study emanate from the ratings of personal risk regarding adverse events, excluding radiation aspects. The sample contained 83% men, and the mean age of the respondents was 36.5 years. Results of the study were also presented at the Annual meeting of the Society for Risk Analysis, Washington, DC., (Sjöberg & Drottz, 1988b), and will be reported in a forthcoming paper (Sjöberg & Drottz-Sjöberg, in press).

As can be seen in the presentation above, the data base of this study included studies of two kinds: representative samples (the A and B studies), and samples of selected groups of respondents (the C-E studies). There is at least one advantage and one disadvantage with this fact. The advantage concerns the possibility to compare responses of the various samples with respect to the hypotheses, as well as the possibility to compare results of selected groups to

responses of representative samples. In the present case it was also possible to compare responses of two representative samples with different age ranges.

The disadvantage concerns influence on ratings with respect to the general context of a study and other items included in a questionnaire. A related aspect is the possible influence on subjects' mood state of the topic investigated.

The influence of perceived "typicality" and "atypicality" in ratings were investigated by Schwarz, Münkel and Hippler (1990). They addressed the issue of what is included in a "perspective" in judgements in a framework of contrast effects. The authors showed that target items (i.e. coffee, milk and wine) were rated as less typical (in Germany) if preceded by a "typical" item (i.e. bier) in the same list, compared to if they were preceded by a "low typicality" item (i.e. vodka). They furthermore showed that the extreme stimuli "must have been thought about with regard to the dimension of judgement to affect judges' perspective" (p. 361). Johnson and Tversky (1983) induced affect by giving subjects newspaper material of tragic or happy events. They reported that the newspaper material had a global impact on judged frequency of risks and undesirable events, e.g. readers of tragic events estimated the frequency of risks higher irrespective of the degree of similarity between the event described in an article and the risk judged. Furthermore, the subjects were unaware of the impact on their risk estimations of the manipulation of mood.

The examples point to possible influences on subjects' responses of the varying contexts of the studies used in the present paper. The A, C and E studies all concerned some aspect of nuclear power, handling of radioactive waste, work conditions and radiation risks. The B-study, on the other hand, focused on the AIDS disease, and the D-study included risk ratings in a context of attitudes to technological development, and risks and benefits regarding higher education. No explicit comparisons regarding contrast or mood effects are made in this presentation with respect to the different samples. The above aspects are mentioned here merely to make the reader aware of them, and as a background to the following presentation.

Items and indices

The questionnaires of four studies asked for ratings of threats against the society, including environmental pollution, the AIDS disease, foreign submarines, abuse of alcohol and drugs, violent crime, and nuclear power. These six items have here been collapsed into the respective THREAT indices[5]. Subjects also rated risks with respect to the own person. The items included the risk to drown, to be hit by lightning, to be assaulted, to have a serious traffic accident on the way to work, and to be injured at work (or at school). These five items are found in the respective

[5] Seven items were originally included among those threat variables in each study. However, in some studies the item "military conflict" was included, whereas in others the item "nuclear war" was included. These items have been excluded from the indices to obtain comparability.

PRISK indices in this presentation. Subjects of four studies responded to the items. The subjects of two studies furthermore rated the personal risk related to injury caused by radioactivity, including the items of the risk of being injured by the natural background radiation, by radiation due to leakage from a radioactive waste disposal, and by radiation due to an accident in the handling of radioactive waste. The RADI indices contain these items. Two studies also included a list of items which was rated with respect to the risk of serious accidents related to the handling and disposal of radioactive waste. The list included risk ratings which concerned loading and unloading of such waste, transport on water, transport on land, disposal in bedrock, debilitation of container material, "the human factor", sabotage, theft, war, and unforseen events. These eleven items are here included in the ACC indices. Table 1 presents the respective studies in which the items were included, and the reliability of the respective indices as measured by Cronbach's alpha.

TABLE 1
Cronbach's alpha of reliability of four indices, in five samples

Study		*THREAT*	*PRISK*	*RADI*	*ACC*
A	*(N=591)*	*.742*	*.730*	*.841*	*.944*
B	*(N=465)*	*.719*	*.749*	-	-
C	*(N=380)*	*.695*	*.682*	*.841*	*.900*
D	*(N=243)*	*.682*	-	-	-
E	*(N=236)*	-	*.711**	-	-

* *The item "to be injured at the work place" had the wording "to be injured in my kind of work environment".*

The B-study also included data allowing for comparisons between perceived personal risk and risk for people generally. Two identical lists of 12 items, all concerned with risks regarding health and life, asked for ratings of risk with respect to the own person, as well as regarding people generally. The 12 ratings of personal risk were collected in the PERPRISK index (Cronbach's alpha=0.839), and the 12 risk ratings related to people generally were collapsed into the GENRISK index (Cronbach's alpha=0.885). The included items concerned the risk of getting lung cancer from smoking, to get lung cancer from living in a radon house, to fall from a height, to drown, to be hit by lightning, to be burnt to death in a house, to have an air accident, to have a heart infarction, to be assaulted, to have a serious traffic accident on the way to work (or school), to be injured at the work place, and to fall ill with AIDS. Choosing only the items corresponding to the ratings of personal risk (PRISK) in other studies, one index was constructed for risk ratings related to people in general. This index was called ALLRISK (Cronbach's alpha=0.797).

Due to the heavy loss of subjects after the first categorization described below, the indices were retested relative the subjects who were included in the sub-samples, and the error variance was estimated on the basis of the formula ($S_E = S_X \sqrt{1-r_{ii}}$). The results are presented in table 2.

TABLE 2

Reliability values of Cronbach's alpha with respect to indices based on the total samples, and indices based on the sub-samples after categorization into risk definition groups, and estimates of corresponding error variances

		Total sample			*Sub-sample*		
Sample	*Index*	*Alpha*	S_E	*N*	*Alpha*	S_E	*N*
A-study	*THREAT*	.7423	.4381	591	.7626	.4395	141
	PRISK	.7301	.3720	591	.6935	.3842	141
	ACC	.9443	.2603	591	.9427	.2734	141
	RADI	.8411	.4907	591	.8333	.5148	141
B-study	*THREAT*	.7188	.3786	465	.6762	.3858	143
	PRISK	.7486	.3966	465	.7657	.3896	143
C-study	*THREAT*	.6951	.4285	380	.6557	.4600	69
	PRISK	.6824	.3674	380	.7300	.3689	69
	ACC	.8997	.2860	380	.9000	.3039	69
	RADI	.8412	.4989	380	.8524	.4994	69
D-study	*THREAT*	.6822	.4155	243	.6550	.4487	90
E-study	*PRISK*	.7111	.3741	236	.7092	.3910	142

Table 2 shows that seven of the twelve described indices decreased in reliability in the sub-sample, whereas some indices (specifically in the C-study) increased. The differences between reliability levels were small, however, and did not threaten the acceptability of the indices. The error variance increased somewhat in the sub-sample indices, with one exception, in comparison to the error variance of the indices based on the total sample. The differences are negligible.

One-way analyses of variance with the total samples grouped into "included" and "excluded" subjects relative the risk definition categories presented below showed significant group differences in some samples (the B- and C-studies) in the direction that the "excluded" group of subjects rated risks higher than the "included" one. These differences generally disappeared, however, in two-way ANOVAs when also sex was included as an independent variable. Overall the results of these analyses indicated that "included" and "excluded" subjects, with respect to categorization into risk definition categories, did not differ systematically, and that the indices were reliable and could be used also in the smaller sub-samples which resulted from the first categorization.

RESULTS

In one study (the B-study) subjects reported the risk they perceived in relation to items concerning (a) personal risk, (b) risk for people in general, and (c) threat to society. The 'personal' and 'general' risk estimates were made on two lists of 12 identical items, whereas the threats to the society were measured on a third list with seven items. Figure 1 shows the differences between ratings of personal risk and risk for people in general.

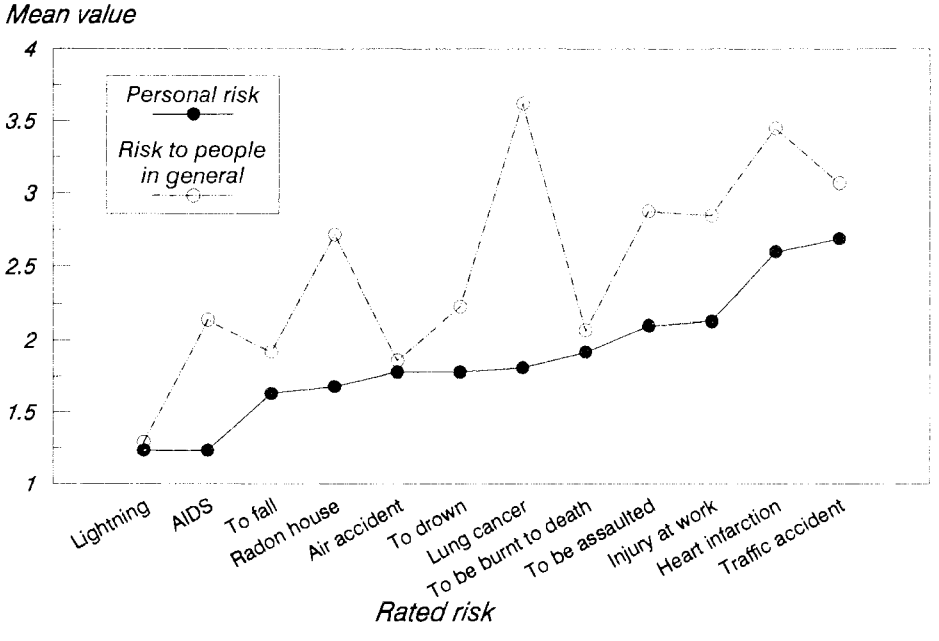

FIGURE 1. Ratings of personal risk and risk to people in general, 12 different risks.

Another expected finding concerned sex differences. The results showed significant sex differences only with respect to six items regarding *personal risk* (lung cancer from smoking ($p<0.04$), and by living in a radon house ($p<0.02$), to be hit by lightning ($p<0.0005$), to be burnt to death in a house ($p<0.001$), to have an air accident ($p<0.05$), and to fall ill with AIDS ($p<0.0005$). However, all sex differences with respect to perceptions of risk concerning *people in general* were significant at least at the 0.001 level of significance. Statistics of the risk ratings of personal and general risks, by sex, are given in Table 3 below.

The table shows that the largest perceived personal risk, on the average, involved having a serious traffic accident on one's way to work, followed by heart infarction and an accident at work. The smallest perceived personal risk involved falling ill with AIDS, being hit by lightning, and to fall from a height. The largest perceived risk for people generally involved getting lung cancer from smoking, to have a heart infarction, and a serious traffic accident. The smallest risk with respect to people in general involved being hit by lightning, to have an air accident and to

fall from a height. As can be seen in the table, the rank order of items differed somewhat between perceived personal risks and risks involving people generally. The main differences between the two kinds of ratings, however, concerned the mean values, and the table shows that risks to people in general were consistently perceived as higher than risks to one's person. As noted above, this difference was expected.

TABLE 3

Mean values and standard deviations (in parenthesis) of risk ratings regarding personal risk and risk for people in general; men and women

	Personal risk		*Risk for people in general*	
Rated item	*Men*	*Women*	*Men*	*Women*
To have a serious traffic accident going to work	2.66 (0.99)	2.72 (1.05)	2.89 (0.99)	3.22 (0.90)
To have a heart infarct	2.64 (1.04)	2.58 (1.05)	3.18 (0.96)	3.68 (0.84)
To be assaulted	2.18 (1.06)	2.03 (1.24)	2.67 (1.00)	3.07 (1.02)
To be injured at the work place	2.17 (1.25)	2.10 (1.13)	2.70 (0.94)	2.99 (0.91)
To be burnt to death in a house	1.75 (0.97)	2.06 (1.09)	1.79 (0.91)	2.31 (0.99)
To get lung cancer from smoking	1.63 (1.64)	1.97 (1.77)	3.40 (0.92)	3.81 (0.88)
To drown	1.78 (1.01)	1.78 (1.13)	2.00 (0.92)	2.43 (0.98)
To be involved in an air accident	1.67 (1.05)	1.88 (1.17)	1.65 (0.91)	2.05 (1.00)
To get lung cancer by living in a "radon house"	1.50 (1.34)	1.84 (1.48)	2.44 (1.02)	2.96 (1.08)
To fall from a height	1.69 (1.20)	1.58 (1.19)	1.75 (0.98)	2.06 (0.94)
To fall ill with AIDS	1.06 (0.85)	1.38 (1.07)	1.87 (0.83)	2.38 (1.02)
To be hit by lightening	0.92 (0.98)	1.50 (1.21)	0.99 (0.95)	1.55 (0.97)
INDEX	1.80 (0.66)	1.95 (0.76)	2.28 (0.61)	2.71 (0.62)
N=	(212-214)	(246-248)	(212-214)	(242-244)

Tests of the differences between the personal and the general risk ratings regarding all twelve items were conducted using repeated measurement analysis with sex as the category variable. Between group comparisons showed significant sex differences in nine cases of twelve, that is, with respect to all items except to fall from a height, to have an air accident, and to be assaulted. The within subjects differences were highly significant in ten cases. The exceptions were being hit by lightning, and to have an air accident. The largest effect concerned getting lung cancer from smoking, $F(1,452)=438.67$, $p<0.0005$, and the smallest significant effect concerned being burnt to death in a house, $F(1,142)=7.47$, $p<0.007$.

Another issue related to group differences concerns education. Kind of education can vary greatly and be more or less relevant to the risk ratings. In general, however, the expectation is a negative relationship between perceived risk and educational level. In the data presented here, the Pearson correlation coefficient for educational level[6] and the index of personal risk (the PERRISK index) was -0.17, and for the index of general risk (the GENRISK index) -0.20. Both correlations were statistically significant ($p<0.0005$), although weak.

Seven threats to society were measured on the same scale (0-5) as used for the 'personal' and 'general' risk ratings presented above. The wording of the overall question given was: How do you perceive the possible threat to society from the aspects listed below? The items were given under the heading "The threat is" followed by the alternatives: (0)= "No risk at all, (1)="Very small", (2)="Rather small", (3)="Neither large nor small", (4)="Rather large", and (5)="Very large". The results including the total sample, as well as for men and women separately, are shown in Table 4.

TABLE 4

Means and standard deviations for ratings of threats to society, the total sample and for men and women separately

	Total		*Men*		*Women*	
Rated item	*M*	*SD*	*M*	*SD*	*M*	*SD*
Environmental pollution	*4.29*	*0.81*	*4.11*	*0.93*	*4.44*	*0.65*
Abuse of alcohol and narcotics	*3.42*	*1.04*	*3.25*	*1.01*	*3.57*	*1.05*
Violent crime	*3.40*	*1.03*	*3.15*	*1.03*	*3.62*	*0.99*
The AIDS disease	*2.92*	*1.22*	*2.74*	*1.24*	*3.07*	*1.18*
The nuclear power	*2.85*	*1.27*	*2.36*	*1.22*	*3.28*	*1.15*
Nuclear war	*2.51*	*1.22*	*2.17*	*1.09*	*2.80*	*1.26*
Foreign submarines	*2.30*	*1.21*	*2.04*	*1.11*	*2.53*	*1.24*
N=	*(458-460)*		*(214-215)*		*(244-246)*	

The possible threat to the society from environmental pollution obtained the highest rating as can be seen in Table 4. The second and third largest perceived threats emanated from the use of alcohol and narcotics, and from violent crime. The lowest ratings concerned foreign submarines and nuclear war. Again women gave significantly higher risk ratings than did men. The sex difference was generally significant at least at the 0.003-level of significance. An index of the collapsed seven ratings of threats to the society (here called THRSOC, Cronbach's alpha=0.761) was tested with respect to the sex difference. The mean value for men was 2.83

[6] Measured in four categories: (1) Elementary school, (2) Swedish 2 year high school, (3) Swedish 3 or 4 year high school, and (4) University education.

(SD=0.66), and for women 3.33 (SD=0.69), $F(1,459)=62.46$, a difference statistically significant at the 0.0005 level.

Two items rated with respect to 'personal' and 'general' risk were also included in the list of threats to the society, although somewhat differently framed. Thus the subjects rated the risk related to their own person and to people generally regarding "to be assaulted" and "to fall ill with the AIDS disease", and the threat to society from "violent crime", and from "the AIDS disease". Although the impact on the ratings of the somewhat different framing of the contexts can be discussed, comparisons between the three kinds of ratings showed a marked increase in risk estimates when the larger perspectives were used. That is, personal risks were perceived considerably smaller than risks for people generally, and the latter ratings were in turn considerably smaller than perceptions of risks threatening the society at large. Figure 2 is based on the mean values of all subjects' ratings of personal, general and societal risks associated with violent crime and the AIDS disease.

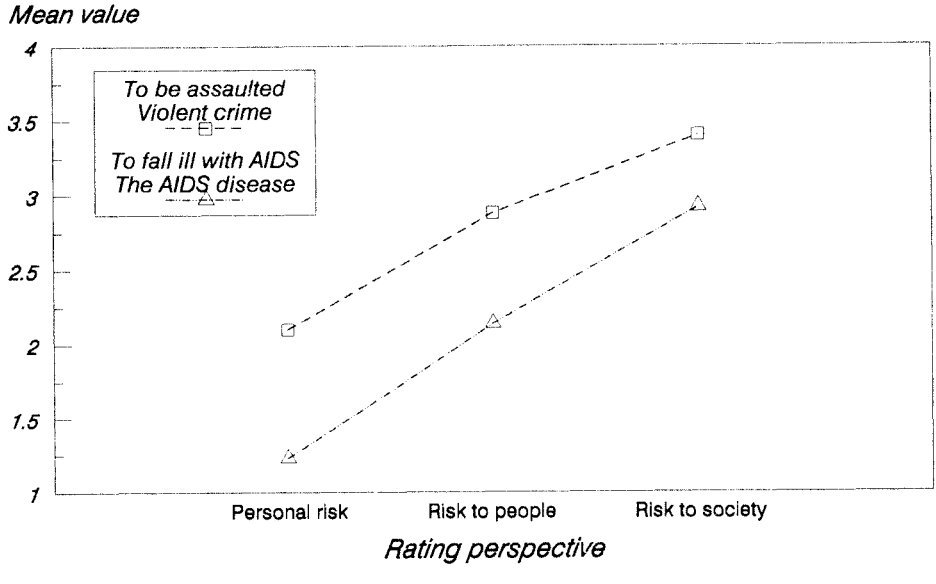

FIGURE 2. Ratings of personal risk, risk to people in general and threat to society regarding the AIDS disease and violent crime.

Analyses using repeated measures with sex as the grouping factor for estimating the differences between the three kinds of ratings again resulted in substantial F-ratios. The results concerning the AIDS disease showed the largest within subjects difference, $F(2,892)=421.24$, $p<0.0005$. Ratings of violence as a threat to society and the risk of being assaulted gave the F-value of 221.42 (2,896), indicating differences significant at the 0.0005 level. The between group differences regarding sex, in the respective analyses, were also significant: $F(1,446)=29.05$,

$p<0.0005$, and $F(1,448)=11.49, p<0.001$, showing that women made the higher risk ratings.

The ratings of risk in three different frameworks in study B, i.e. with respect to one's person, to people generally, and to society, hence presented two major results. Firstly, that risk ratings increased, on the average, in relation to the framework in which they were considered, and secondly, that sex differences can be expected, and specifically so when the risk ratings are related to a larger framework beyond one's own person.

Risk ratings and risk definitions

The introduction discussed the possibility that risk ratings might be influenced by the content of, or the meaning associated with, the risk concept, especially if the term 'risk' is used without precise instructions of its expected meaning. Risk ratings can be assumed to be based on estimates of the *probability* of a certain event to occur, or the estimates might instead be focused on the expected *consequences* (and their magnitude) if an event should occur, and the estimates might be based on a combination of *probability and consequences* of an event. A fourth possibility is to argue that the 'risk' concept should be defined on the basis of the *nature* of the event involved.

In the present study four definitions of the risk concept were suggested, and the subjects were asked to indicate their *normal* use of the risk term by marking their level of agreement to each of the given statements. They responded on 5-point scales, where 1="Yes, absolutely", 2="Yes, maybe", 3="Uncertain", 4="No, maybe not, and 5="No, absolutely not". The wording of the definitions given were as follows:

A. "Risk is mainly a question of the probability of an event".

B. "Risk is mainly a question of the extent of the consequences of an event".

C. "Risk is a combination of probability and consequences".

D. "The meaning of the concept of risk is entirely based on the nature of the event".

The inclusion of the word "mainly" in definition A and B above aimed to make these alternatives mutually exclusive. The forth (D) definition was included to collect responses of the subjects who did not normally think in terms of either probabilities or consequences with respect to risks or who used very diffuse or varying definitions of risk. The fourth statement should not be regarded as a definition of risk in a strict sense, although 'definition' is used interchangeably in the paper for convenience reasons, with the expression "risk statement".

The results indicated firstly that subjects' were more inclined to agree ("Yes, absolutely" and "Yes, maybe") with the different definitions of risk than to disagree with them, and secondly, that a majority of the subjects normally used the risk concept on the basis of the probability of an event. This majority was not overwhelming, however, and Table 5 shows that subjects who agreed to one of the definition of risk also could agree with one or more of the other risk definition statements, i.e. there were 465 subjects in the study and there were more than 500

agreement responses of the respective alternatives of "Yes, absolutely" and "Yes, maybe" over the four definitions. Table 5 reports response frequencies and percentages, by response alternatives. Percentages are based on the number of respondents to the respective statements.

TABLE 5
Frequencies and percentages (in parenthesis) by response alternatives regarding indications of normal use of the concept of risk

Risk definition	*Yes, absolutely*	*Yes, maybe*	*Un-certain*	*No, maybe*	*No, abso-lutely not*
Risk is mainly a question of the probability of an event	*202 (45.8)*	*127 (28.8)*	*60 (13.6)*	*17 (3.8)*	*35 (7.9)*
Risk is mainly a question of the extent of the consequences of an event	*96 (21.8)*	*126 (28.6)*	*88 (20.0)*	*44 (10.0)*	*86 (19.6)*
Risk is a combination of probability and consequence	*95 (21.5)*	*155 (35.1)*	*100 (22.6)*	*34 (7.7)*	*58 (13.1)*
The meaning of the concept of risk is entirely based on the nature of the event	*117 (26.4)*	*98 (22.1)*	*92 (20.8)*	*47 10.6)*	*89 (20.1)*

Table 6 below presents a grouping of respondents in the B-study in terms of those who *agreed* ("Yes, absolutely" and "Yes, maybe", and who *disagreed* ("No, maybe" and "No, absolutely not"), respectively, with the three suggested risk definitions based on probability (Prob), consequences (Cons), and their combination (Comb) in relation to risk ratings of personal, general and societal risks, i.e. possible threats to society. Subjects indicating an "Uncertain" response were excluded here together with strictly missing data. The fourth definition of risk was also excluded, since it focused on the "meaning" of the risk concept rather than explicitly on its definition[7]. Table 6 shows mean values of those who agreed, and disagreed, respectively, to each of the three risk definitions related to ratings of personal risks, risks for people generally, and threats to society.

[7] "Meaning" could perhaps denote "definition" in certain contexts, but it might also denote signification or implication, which guides associations towards consequences. It is also profoundly unclear what "the nature of an event" denotes and how it is understood if it does not concern probabilities and consequences. Furthermore, the fourth definition was included in the questionnaire in the first place only to collect odd answers. Even though this proved to be a mistaken assumption, as Table 5 shows, it will not be considered in the present context, but it is discussed in later sections of the paper.

TABLE 6

Mean values of ratings of personal risks, risks to people in general, and threats to society by respondents in the B study agreeing and disagreeing to definitions of risk in terms of probability, consequences and the combination of probability and consequences

	AGREE			*DISAGREE*		
Rated item	*Prob*	*Comb*	*Cons*	*Prob*	*Comb*	*Cons*
		Personal risks				
To have a serious traffic accident going to work	2.68	2.75	2.81	2.76	2.54	2.54
To have a heart infarction	2.57	2.72	2.74	2.80	2.36	2.47
To be assaulted	2.15	2.14	2.24	2.18	2.02	1.94
To be injured at the work place	2.09	2.27	2.32	2.28	1.77	1.84
To be burnt to death in a house	1.90	1.99	2.13	2.06	1.71	1.58
To get lung cancer from smoking	1.79	1.91	2.07	1.56	1.44	1.59
To be involved in an air accident	1.79	1.85	1.98	1.90	1.63	1.56
To drown	1.78	1.84	1.99	1.90	1.66	1.56
To get lung cancer by living in a "radon house"	1.64	1.84	1.93	1.94	1.29	1.48
To fall from a height	1.61	1.72	1.84	1.82	1.40	1.36
To be hit by lightening	1.24	1.32	1.49	1.26	0.99	0.90
To fall ill with AIDS	1.23	1.32	1.38	1.40	1.09	1.03
Index: PERRISK	1.87	1.97	2.07	1.99	1.66	1.66
		Risks to people in general				
To have a serious traffic accident going to work	3.05	3.13	3.20	3.19	2.88	2.89
To have a heart infarction	3.41	3.44	3.54	3.50	3.36	3.29
To be assaulted	2.83	2.92	3.09	3.08	2.75	2.63
To be injured at the work place	2.85	2.89	2.94	3.06	2.74	2.79
To be burnt to death in a house	2.03	2.09	2.28	2.23	1.92	1.80
To get lung cancer from smoking	3.61	3.60	3.66	3.65	3.64	3.60
To be involved in an air accident	1.82	1.91	2.11	1.96	1.77	1.53
To drown	2.19	2.24	2.41	2.25	2.04	1.95
To get lung cancer by living in a "radon house"	2.68	2.75	2.85	2.86	2.56	2.52
To fall from a height	1.90	1.94	2.12	1.92	1.77	1.61
To be hit by lightening	1.26	1.23	1.48	1.38	1.24	1.01
To fall ill with AIDS	2.13	2.20	2.33	2.10	1.82	1.85
Index: GENRISK	2.48	2.53	2.67	2.60	2.38	2.29
		Threats to society				
Environmental pollution	4.24	4.26	4.32	4.49	4.32	4.33
Abuse of alcohol and narcotics	3.36	3.44	3.50	3.58	3.34	3.30
Violent crime	3.36	3.36	3.54	3.60	3.41	3.33
The AIDS disease	2.85	2.92	3.11	3.02	2.63	2.68
The nuclear power	2.82	2.86	2.94	2.92	2.79	2.78
Nuclear war	2.45	2.52	2.63	2.71	2.42	2.29
Foreign submarines	2.30	2.33	2.44	2.06	2.01	1.96
Index: THRSOC	3.06	3.10	3.21	3.20	2.99	2.96

Table 6 shows that subjects who reported that they used a definition of risk based on probability, consistently rated risks lower than subjects who accepted a definition of risk based on consequences of an event. The mean values of those who reported that they defined risk as a combination of probability and consequences were in eleven cases of twelve found in the range between the means of the other two groups. With respect to disagreement with the suggested definitions of risk, a reverse pattern could be found in eleven cases of twelve regarding personal risks. That is, the subjects who disagreed with a probability definition of risk gave higher risk ratings than subjects who disagreed with the consequence based definition of risk. In eight cases of twelve the mean values of those who disagreed with the combined probability and consequence definition could be found in between the mean values of the other groups. The same general patterns, with higher mean levels of rated risk, could be found in ratings regarding people in general and threat to society.

A natural reflection at this point of the presentation concerns the possible confounding of data, i.e. the possibility of underlying dependencies causing the regular patterns presented. It was noted above that subjects were asked to indicate their normal use of the risk concept by responding to each of the suggested definitions of risk. These definitions were formulated to be mutually exclusive given a "Yes, absolutely" agreement to any one of them. The results, however, pointed to subjects' agreeing with more than one definition, and generally being more positive than negative to the suggested definitions. The results presented below are therefore based on a categorization of responses to three of the suggested risk definitions into independent groups of respondents. In this manner each subject was represented in one category only. The fourth risk definition, i.e. that the meaning of risk is entirely based on the nature of an event, was again excluded from the categorization and the analyses, but will be discussed later. The categorization procedure described below resulted in a heavy loss of subjects, but that seemed to be the price to pay for logically consistent and independent groups. The "residual", or the "rest" of subjects, will be discussed in a later section of the paper.

A first categorization of risk definitions

The categorization of responses to three suggested definitions of risk into independent response groups was conducted in two steps. Subjects were first grouped into five independent response categories: (A) those who agreed only with the definition of risk as mainly a question of probability of an event and disagreed with the other two definitions, (B) those who agreed with the definition of risk as mainly probability, as well as with the definition of risk as a combination of probability and consequences of an event, and who disagreed with risk as mainly a question of consequences, (C) those who agreed only with the combination of probability and consequences as their definition of risk and also disagreed with the other two risk definitions, (D) those who agreed with the risk definition based on

mainly consequences of an event and also agreed with the definition combining consequences and probability of an event, and disagreed with the probability based definition, and (E) those who agreed only with the definition of risk as mainly the consequences of an event and disagreed with the other two definitions. (See Table 7 below).

Subjects who responded to only one or two of the three risk definitions were included in the categories if their responses otherwise corresponded with the conditions. They were excluded if they agreed to all three definitions, which would be a logically incoherent response pattern. They were also excluded if they disagreed with all three suggested definitions, and thus had some other definition in mind which was not represented among the alternatives. Subjects using the third response alternative of the original 5-point scale, i.e. "Uncertain", were excluded from the categorization. The inclusion of "uncertain" responses in any one of the response categories would have resulted in a less strict logical structure with respect to the content of the five respective groups. This strict procedure implied that persons who gave an "uncertain" response to any one of the three risk definitions discussed here were excluded from the analyses.

The "agree" condition included the responses of "Yes, absolutely" and "Yes, maybe", and the "disagree" condition similarly included the response alternatives of "No, maybe" and "No, absolutely not". These fusions were motivated on the basis that relatively few subjects gave extreme responses, especially with respect to the E-group described above.

TABLE 7

A theoretical categorization in two steps of responses to three definitions of risk into independent groups of respondents

Step 1 Group	*Risk as probability*	*Risk as combination*	*Risk as consequence*	*Step 2 Risk definition category*
A	*Agree*	*Disagree*	*Disagree*	*1*
B	*Agree*	*Agree*	*Disagree*	*1*
C	*Disagree*	*Agree*	*Disagree*	*2*
D	*Disagree*	*Agree*	*Agree*	*3*
E	*Disagree*	*Disagree*	*Agree*	*3*

The second step in the categorization was necessary due to the small number of subjects in some categories, and specifically so considering the intention of further subdividing the groups also with respect to sex. The second step of the categorization, which can be seen in Table 7 under "Step 2", grouped subjects who focused on a definition of risk in terms of "mainly probability" together in one category. The grouping is consistent with the wording of the suggested first definition, which used the term "mainly". The second category included those who

agreed only to the definition which combined probability and consequences of an event, and the third category included subjects who defined risk in terms of "mainly consequences" of an event. This categorization model will be used below with respect to the five available samples of subjects.

Risk perception on the basis of a personal definition of the risk concept

In the following presentation, data from five different samples have been analyzed using the categorization of the three risk definitions outlined above (see Table 7). Each of these samples and the relevant items and indices were presented in the Method section above. The main hypothesis predicted higher risk ratings given a definition of risk based on a focusing on consequences of an event, compared to ratings based on a risk definition focusing on the probability of an event. The categorization also considered a third group of respondents, however, i.e. these who combined probability and consequences, and the mean values of these subjects were expected to be found in between those of the other two groups.

Two-way analyses of variance were used throughout for testing of group differences regarding sex and risk definition category. Although the latter was of primary interest, the unequal representation of men and women in the samples, as well as a male dominance in the "mainly probability" category, indicated that two-way ANOVAs were appropriate for separating the group effects. Table 8 gives an overview of the results of the categorization with respect to original sample sizes, and total number of subjects accounted for in the categorization, including a "rest" category which will be discussed later. The table gives the number of men and women in the three risk definition categories: "mainly probability" (Prob.), the combination of probability and consequences (Comb.), and the "mainly consequences" of an event (Cons.).

In relation to the subjects accounted for in the categorization, the table shows that between 15 and 32 percent of the men, in the five studies, were found in the "mainly probability" category, corresponding to 7 to 21 percent of the women. Less then 10 percent of the subjects were found in the "combination" category, and between 2 and 16 percent of the men, and 4 to 10 percent of the women in the "mainly consequences" category. The "rest" category accounted for the remaining subjects.

TABLE 8

Overview of frequencies regarding five studies with respect to original sample sizes and number of men (M) and women (W), and sample sizes after categorization based on three independent risk definition categories, as well as subjects accounted for in the categorizations and the "rest" category, and missing data

	Original sample			Risk definition category							"Rest" category		Subjects accounted for		
					Prob.		Comb.		Cons.						
Study	(N)[1]	M	W	Total	M	W	M	W	M	W	M	W	M	W	Missing
A	(591)	311	279	141	45	26	14	15	16	25	218	187	293	253	45
B	(465)	215	250	143	51	47	9	6	13	17	132	164	205	23	26
C	(380)	157	223	69	27	16	8	5	3	10	114	181	152	212	16
D	(243)	101	125	83	21	20	6	11	15	10	55	79	97	120	26
E	(236)	196	40	87	61	8	8	3	5	2	117	25	191	38	7

[1] *If the number of men (M) and women (W) does not add to the total number of subjects given this is due to respondents unidentifiable by sex.* **Note**: *The missing column includes strictly missing data and subjects unidentifiable by sex.*

Perception of personal risk

Risk ratings regarding personal risk (PRISK) were available from four studies (the A, B, C and E studies). The ratings were relatively low, i.e. on average, less than 2 on the 6-point scale in the total samples, as well as in the respective sub-samples. (See Table 9). Note the small number of subjects in some categories, in spite of the step 2 procedure of the categorization.

Table 9 shows some variation between the studies. High school students (study C), for example, gave the lowest overall ratings of personal risk, and personnel at nuclear power plants (study E) the highest in this comparison, with the two representative samples in between. Men and women rated risks similarly, and there was no systematic differences with respect to sex or risk definition category in any of the studies on the basis of the used categorization.

TABLE 9

Mean values, standard deviations and number of subjects in four studies with respect to personal risk ratings, the PRISK indices, the total sample, and the sub-samples divided by risk definition category and sex

Study		Total sample	Sub sample	Prob. All	Prob. Men	Prob. Women	Comb. All	Comb. Men	Comb. Women	Cons. All	Cons. Men	Cons. Women
A	Mean	1.87	1.87	1.86	1.94	1.71	1.77	1.81	1.72	1.98	2.02	1.95
	SD	0.72	0.69	0.69	0.72	0.61	0.85	0.74	0.96	0.58	0.67	0.52
	N	579	139	71	45	26	29	14	15	39	15	24
B	Mean	1.98	1.84	1.78	1.75	1.81	1.76	1.62	1.93	2.07	2.08	2.07
	SD	0.79	0.80	0.78	0.69	0.89	0.55	0.61	0.45	0.94	0.83	1.04
	N	463	142	98	51	47	14	8	6	30	13	17
C	Mean	1.66	1.47	1.33	1.13	1.66	1.55	1.55	1.56	1.88	1.80	1.90
	SD	0.65	0.71	0.62	0.51	0.66	0.91	0.97	0.93	0.64	1.06	0.54
	N	380	69	43	27	16	13	8	5	13	3	10
E	Mean	1.98	1.99	2.00	2.01	1.94	1.57	1.53	1.67	2.54	2.75	2.00
	SD	0.70	0.72	0.66	0.67	0.66	0.46	0.47	0.52	1.24	1.40	0.71
	N	236	87	69	61	8	11	8	3	7	5	2

Risks including radiation

Two studies (A and C) included ratings of personal risk using items containing the aspect of injury due to radioactivity. The same three items were used in both studies and they included natural background radiation, radiation due to leakage from a nuclear waste disposal site, and radiation due to accidents in the handling of radioactive waste. Figure 3 shows mean values for the RADI indices of the two samples, and includes for comparison reasons also ratings of personal risk (the PRISK indices), which did not include the radiation aspect, rated by the same subjects. The subjects are furthermore grouped in the risk definition categories.

The figure shows that risks including radiation were rated higher than risks which did not involve this aspect, and that the risk ratings were especially high in the groups of subjects who defined risk in terms of mainly consequences. The A-study showed a highly significant sex difference regarding the RADI index, $F(1,134)=15.04$, $p<0.0005$, as well as regarding the risk definition category, $F(2,134)=7.50$, $p<0.001$. There were no significant group differences with respect to the RADI index in the C-study.

Repeated measurement analyses of for the respective studies, with sex and risk definition category as grouping variables, showed the within subjects differences of the two kinds of ratings to be significant: $F(1,132)=13.62$, $p<0.0005$, for the A-study, and $F(1,63)=15.80$, $p<0.0005$, with respect to the C-study.

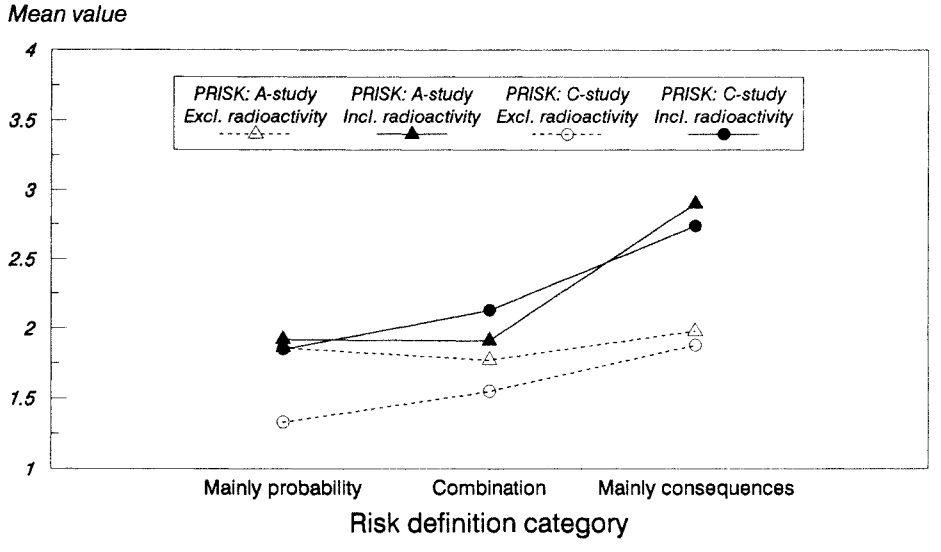

FIGURE 3. Ratings of personal risk including and excluding aspects of radioactivity, two samples, by risk definition category.

Other indices including the radiation aspect were available in the same studies (the A and C studies). These, the ACC indices, concerned the risk of serious accidents in the handling and disposal of radioactive waste. The same eleven items were included in both studies. Figure 4 shows the mean ratings of the ACC indices in the studies, again in comparison with ratings of the personal risk indices (PRISK), which did not include the radiation aspect.

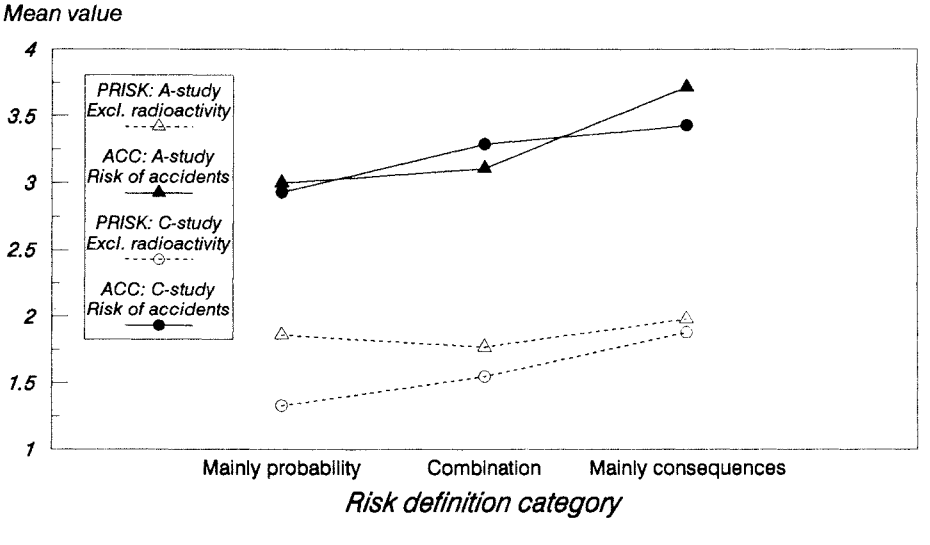

FIGURE 4. Ratings of risks of serious accidents involving nuclear waste, and personal risk without radiation aspects, two samples.

The figure shows that the perceived risk for serious accidents in the handling and disposal of radioactive waste was overall judged as rather high, and that subjects who defined risk in terms of consequences rated the risk especially high. The difference between risk definition categories was significant in the A study, $F(2,131)=3.41, p<0.04$, as was the sex difference, $F(1,131)=16.29, p<0.0005$, in a two-way ANOVA. Only the sex difference was statistically significant in the C-study, $F(1,63)=4.54, p<0.04$.

The testing of differences between the two kinds of ratings in the respective studies (repeated measurement with sex and risk definition category as grouping factors) resulted in considerable F-ratios: $F(1,129)=211.69, p<0.0005$, regarding the A-study, and $F(1,63)=130.48, p<0.0005$, in the C-study.

Compared to Figure 3 above, which also used the personal risk indices (PRISK) for comparison, Figure 4 shows that ratings of accident risks in a context of radioactive waste were rated higher than personal risks of injury due to radiation (the RADI indices). The results indicate that the inclusion of ratings of risk related to radioactivity increases the ratings, and more so in a general framework than in relation to the own person.

Personal versus general risk

In only one sample were ratings of personal risks collected together with corresponding ratings of risk for people in general (the B study). Figure 5 shows the results of risk ratings in groups of sex and risk definition category regarding the indices PRISK and ALLRISK. Each index contained 5 items.

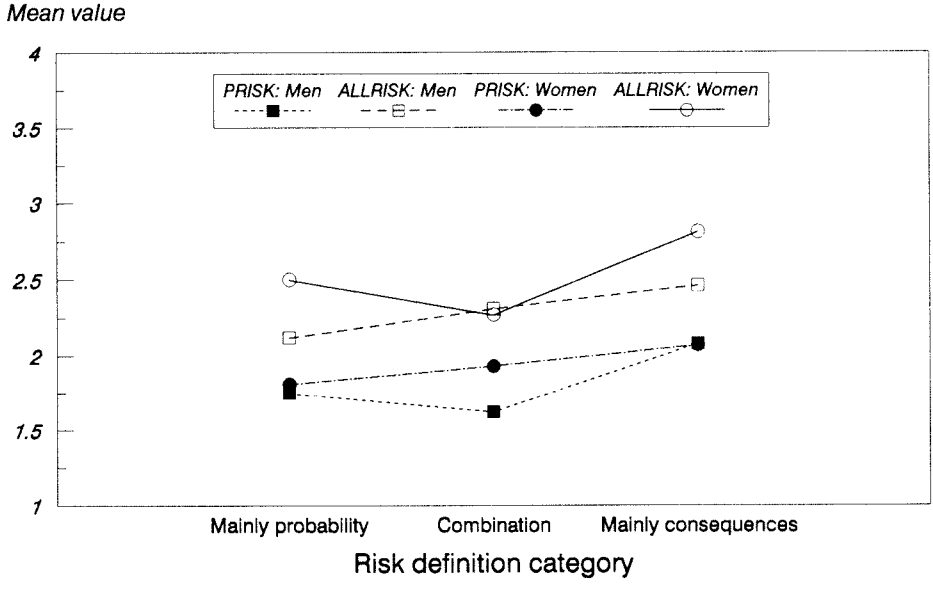

FIGURE 5. Ratings of personal risk and of risk to people generally, the indices PRISK and ALLRISK, the B-study by men and women.

The figure shows that personal risks were rated lower than risks for people generally, and that ratings of subjects who used a consequence definition of risk tended to be higher compared to those who used a probability definition. This tendency approached significance only with respect to risk for people in general on the basis of a two-way ANOVA, $F(2,137)=2.67, p<0.08$). There were no significant sex differences. (For a comparison to the ratings of personal risk, the PRISK index of other studies, see for example Figure 4).

An analysis of the between group difference in a repeated measurement design, however, showed the risk definition categories to be significantly different $F(2,136)=3.33, p<0.05$, with no sex differences. The within subjects difference was large, $F(1,136)=24.40, p<0.0005$, indicating significantly different risk estimations of personal and general risks.

Threats to society

Four studies included ratings of the same six possible threats to society; environmental pollution, the AIDS disease, foreign submarines, abuse of alcohol and narcotics, violent crime, and nuclear power. These ratings were included in the respective THREAT indices of the four studies (A-D). There were no significant differences with respect to risk definition category, and the influence of the sex differences were strong (p at least <0.02 in all studies). A weak tendency towards an effect due to risk definition was discernable, however, as can be seen in Table 10.

TABLE 10

Ratings of possible threats to society (the THREAT indices) in four studies, the total sample, the sub-sample divided in groups of sex and risk definition category

Study		Total sample	Sub sample	Prob. All	Prob. Men	Prob. Women	Comb. All	Comb. Men	Comb. Women	Cons. All	Cons. Men	Cons. Women
A	Mean	3.30	3.30	3.22	3.14	3.37	3.29	3.01	3.55	3.44	2.89	3.78
	SD	0.86	0.90	0.90	0.93	0.84	0.87	0.84	0.83	0.93	1.03	0.69
	N	583	140	71	45	26	29	14	15	40	15	25
B	Mean	3.20	3.10	3.02	2.83	3.23	3.36	3.26	3.50	3.23	3.00	3.40
	SD	0.71	0.68	0.65	0.61	0.64	0.58	0.51	0.70	0.77	0.88	0.65
	N	461	143	98	51	47	15	9	6	30	13	17
C	Mean	3.08	2.96	2.82	2.52	3.34	3.08	2.73	3.63	3.30	3.00	3.38
	SD	0.78	0.78	0.74	0.66	0.56	0.95	1.07	0.27	0.69	0.93	0.64
	N	379	69	43	27	16	13	8	5	13	3	10
D	Mean	2.97	2.87	2.77	2.55	3.11	2.86	2.47	3.09	3.04	2.89	3.23
	SD	0.74	0.76	0.79	0.81	0.63	0.73	0.51	0.79	0.74	0.79	0.67
	N	240	90	46	21	20	18	6	11	26	15	10

In summing up this section of the paper, four points deserve attention: (a) the overall pattern to rate personal risk lower than risk related to a larger framework, (b) the higher risk ratings which were obtained when aspects of radiation were included, (c) the considerable sex differences in ratings of risk in larger frameworks, and the absence of strong sex differences regarding personal risk, and (d) the persistent tendency of higher risk ratings among subjects who defined risk in terms of consequences compared to those who defined risk as mainly a question of probability.

A more complex pattern of results was obtained from the subjects who combined probability and consequences in their definition of risk. Ratings of subjects in this category were sometimes lower and sometimes higher than the ratings of subjects in the other two categories, and sometimes found in the expected range between them. A clear pattern of the ratings of this category group was not possible to establish. The issue will be further discussed below.

Residuals

The categorization of subjects into independent risk definition categories caused a large loss of subjects. Although it might not be unexpected that people respond "illogically", the large number of subjects excluded by the categorization was somewhat puzzling. Table 11 gives an account of the subjects "included" in the risk definition categories, as well as those "excluded" from the first categorization.

Table 11 shows three risk definition groups, and three additional "rest" groups of subjects: those who agreed to all three risk definitions, those who agreed to none of them and those who gave "uncertain" answers. It can be seen in the table that approximately a quarter to a third of the subjects of the total samples agreed to all three definitions of risk. About a third of the subjects gave some "uncertain" response. In the youngest sample (Study C), more than half of the subjects gave an "uncertain" response. Among personnel at nuclear power plants (study E) only 19% responded in this way. Very few subjects rejected all three risk definitions. In all, apart from the subjects who agreed to all three definitions, a large proportion of the "rest" group was found to be "uncertain". This large "rest" proportion was therefore caused by the very strict criteria of the risk definition categorization. The next part of the paper attends to yet another kind of categorization, which allowed more of the "uncertain" responses to be included in the obtained categories.

TABLE 11

Percentages of subjects, by sex, of six independent groups in five different studies with respect to three risk definition categories, and categorization of the "rest" subjects into groups of those who agreed to all three definitions, those who agreed to none of them, and those who gave an indication of uncertainty, frequencies of subjects accounted for in the categories, missing data and original sample size

		Study				
Group		*A*	*B*	*C*	*D*	*E*
	Included in risk definition categories					
Mainly probability definition	*Men*	15.4	24.9	17.8	21.6	31.9
	Women	10.3	20.1	7.5	16.7	21.0
Combining probability and consequences	*Men*	4.8	4.4	5.3	6.2	4.2
	Women	5.9	2.6	2.4	9.2	7.9
Mainly consequences definition	*Men*	5.5	6.3	2.0	15.5	2.6
	Women	9.9	7.3	4.7	8.3	5.3
	Excluded from the first categorization					
Agreed to all three definitions	*Men*	35.5	24.4	27.6	22.7	43.4
	Women	37.5	27.8	27.4	28.3	39.5
Agreed to none of the three definitions	*Men*	0.7	0.5	0.6	0.0	0.0
	Women	1.2	1.3	0.0	2.5	0.0
Uncertain to any of the three definitions	*Men*	38.2	39.5	46.7	34.0	17.8
	Women	35.2	41.0	58.0	35.0	26.3
	Frequencies					
TOTAL; accounted for subjects	*Men*	293	205	152	97	191
	Women	253	234	212	120	38
Unidentifiable by sex	*All*	1	0	0	17	0
Missing	*Men*	18	10	5	4	6
	Women	26	16	11	5	1
Total sample	*All*	591	465	380	243	236

A second categorization of risk definitions

In this categorization of the risk definitions, 15 independent groups of respondents were extracted[8]. The fourth risk statement "The meaning of the concept of risk is entirely based on the nature of the event" was included in the categorization, as were the "uncertain" responses. The new categorization aimed to lessen the heavy

[8] These groups were used because data were distributed over them.

loss of subjects which occurred in the first categorization, and to study the influence of the inclusion of "uncertain" responses, as well as the fourth risk statement on the expected trend of higher risk ratings among subjects in the "consequence" condition. Table 12 shows the design of the categorization. Those who agreed ("Yes, absolutely" and "Yes, maybe") to the four respective statements are represented in the table with an A. Those who disagreed ("No, maybe" and "No, absolutely not") are denoted with a D. "Uncertain" responses are represented by U, and omitted responses are represented by an M. The text will refer to the four risk statements as the "probability", the "combination", the "consequences", and the "nature" statements or risk definitions. The table also shows the grouping of the five first categories into three. This step was again taken to increase the number of subjects in the respective categories, and for achieving some comparability to the first categorization. Only these three categories were subsequently used in the analyses, and in comparisons with the results of the first categorization.

TABLE 12
A theoretical categorization of four statements of risk into 15 independent groups of respondents, and risk categories subsequently used in the analyses

Group	*Risk as probability*	*Risk as combination*	*Risk as consequence*	*Meaning due to nature of event*	*Risk categories in analyses*
1	*A*	*D or M*	*D or M*	*D or M*	*1*
2	*A*	*A or D or M*	*D or M*	*A or D or M*	*1*
3	*D or M*	*A*	*D or M*	*D or M*	*2*
4	*D or M*	*A or D or M*	*A*	*A or D or M*	*3*
5	*D or M*	*D or M*	*A*	*D or M*	*3*
6	*D or M*	*D or M*	*D or M*	*A*	-
7	*A*	*A*	*A*	*A*	-
8	*D*	*D*	*D*	*D*	-
9	*A*	*A*	*A*	*D or M*	-
10	*D or M*	*A*	*D or M*	*A*	-
11	*A*	*D or M*	*A*	*D or M*	-
12	*U*	*U*	*U*	*U*	-
13	*M*	*M*	*M*	*M*	-
14	*A*	*U or M*	*A*	*A*	-
15	*Includes subjects who did not fit into groups 1-14*				-

Group 1 included the subjects who only agreed to the probability statement. *Group 2* included those who agreed to the probability statement, plus possibly the combination statement, or the statement that the meaning of risk is entirely based on the nature of the event, or both of the latter. Subjects of *group 3* agreed only

to the definition of risk as a combination of probability and consequences. *Group 4* agreed to the consequences definition, and possibly to the combination statement, or the "nature of the event" statement, or both of the latter. *Group 5* agreed only to the consequences definition of risk. *Group 6* agreed only to the statement that the meaning of the risk concept depends on the nature of the event. *Group 7* agreed to all four statements, and *group 8* disagreed with all. *Group 9* included subjects who agreed with three statements, but rejected that the meaning of risk is based on the nature of the event, or omitted a response to this statement. *Group 10* agreed to the combination definition, and the "nature of event" statement, and disagreed with, or omitted, the other two. *Group 11* agreed to risk as mainly the probability, and as mainly the consequences of an event, and rejected the other two statements. *Group 12* was "uncertain" of all four definitions. *Group 13* consisted of subjects giving missing data, i.e. the subjects who totally omitted their responses with respect to the section of risk statements. *Group 14* was "uncertain" with respect to risk as a combination of probability and consequences, or omitted their response with respect to that statement, and agreed to the other three statements. *Group 15* collected the rest of the subjects, i.e. those who did not fit into any of the categories 1-14. This group consisted of only some 0-3 percent of the total sample. See Table 13.

TABLE 13

Percentage representation of subjects in thirteen category groups in five different studies

			Category group												
Study		*Sex(N)*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*9*	*10*	*11*	*12*	*14*	*15*
A	*Men*	*(301)*	14.0	12.6	4.3	13.0	2.6	2.3	23.9	10.6	5.6	4.3	1.3	2.6	2.6
	Women	*(266)*	9.3	13.5	7.1	12.8	4.5	4.5	24.8	10.9	3.0	5.3	0.8	2.2	1.1
B	*Men*	*(210)*	24.3	21.4	7.6	11.4	1.4	0.5	3.8	20.0	1.0	4.8	1.9	1.0	1.0
	Women	*(238)*	20.2	14.3	3.4	11.8	6.7	0.8	7.6	19.7	1.3	5.9	2.1	3.8	2.5
C	*Men*	*(155)*	12.9	21.3	3.9	8.4	3.2	2.6	7.7	19.4	5.2	5.2	3.2	7.1	0.0
	Women	*(217)*	8.8	14.3	5.5	18.0	5.5	2.8	11.5	15.2	3.2	5.1	0.5	7.8	1.8
D	*Men*	*(99)*	16.2	20.2	6.1	22.2	1.0	4.0	12.1	10.1	3.0	3.0	0.0	0.0	2.0
	Women	*(120)*	10.0	20.0	4.2	15.0	0.8	6.7	15.8	12.5	8.3	2.5	0.0	3.3	0.8
E	*Men*	*(193)*	18.6	19.7	3.1	7.8	0.0	1.0	26.9	16.1	2.1	2.6	0.0	1.6	0.5
	Women	*(39)*	7.7	23.1	7.7	7.7	0.0	0.0	28.2	10.2	7.7	5.1	0.0	2.6	0.0
Mean %	*Men*		17.2	19.0	5.0	12.6	1.6	2.1	14.9	15.2	3.4	4.0	1.3	2.5	1.2
all studies	*Women*		11.2	17.0	5.6	13.1	3.5	3.0	17.6	13.7	4.7	4.8	0.7	3.9	1.2

In applying the presented complete categorization to the data of our five studies, the results showed that no subject rejected all four risk statements. The

category group 8 was therefore excluded. Men and women were unequally represented in the studies, and are therefore presented separately. Table 13 shows response percentages from five different studies with respect to the categorization of the risk statements presented above, excluding missing data, i.e. group 13 and subjects unidentifiable by sex.

Table 13 shows that the largest response percentages, over all five studies, were found in the category groups 1, 2, 4, 7 and 9, although the rank order varied among samples and for men and women. Overall, men showed a preference for the probability statements, as presented in groups 2 and 1, followed by the groups 9, 7 and 4. Women, on the other hand, showed an overall high ranking of group 7 (agree all), closely followed by group 2, and groups 9, 4 and 1. The table shows that between 3.8 and 28.2 percent of the respondents agreed to all four risk statements (group 7), and that another 10.1-20.0 percent agreed to three risk definitions and either disagreed with or omitted their response to the statement that the meaning of risk is based on the nature of the event (group 9). A fair amount of the subjects used a "mainly probability" definition of risk (group 1: 7.7-24.3, and group 2: 12.6-23.1 percent), whereas few subjects agreed only to the combination definition (group 3: 3.1-7.7), or the "nature of event" (group 6:0.0-6.7 percent) definitions. The consequence categories (groups 4 and 5) collected 7.7-22.2 and 0.0-6.7 percent of the respondents, respectively.

In all, the table presents a very diverse picture of how subjects' "normally" conceive of risk. On the basis of the categorization above there is no support for an assertion that the subjects generally used a logical approach to the task presented them, neither is there good evidence for an assumption that subjects normally use a probability or a "combination" basis for risk estimations. On the contrary, based on the second categorization it can be seen in Table 13 that only approximately 50% (46.2-66.1%) of the subjects in the different groups of men and women "normally" apply one of the first five categories when they are confronted with the concept of risk. It should be remembered that these categories included uncertain answers and the fourth risk statement, which was considered of dubious value as a definition of risk. The more strictly defined categories of the first categorization had excluded approximately two-thirds of the subjects, as can be seen in Table 11.

The first five categories of the second categorization will be further studied below in the form of the three categories shown in Table 12, in another look at the risk ratings of the indices of the five studies A-E. The objective was again to investigate whether subjects who used a probability definition of risk rated risks lower, compared to those who used a definition including, or based on, the consequences of an event. The group of subjects who maintained that the meaning of the risk concept is entirely based on the nature of an event were also considered in the context. Table 14 shows mean values of the same indices as presented above, by men and women in the category groups 1-3 from the second step of the categorization presented in Table 12. The table also presents mean values of the groups of men and women who were categorized in the "only nature" group.

TABLE 14

Mean values of indices of personal risk (PRISK), threat to society (THREAT), radiation risk (RADI), and risk of accidents in handling and disposal of radioactive waste (ACC) from five studies by sex and the categories of (a) mainly probability, and probability/ combination/ nature, (b) only combination, (c) consequences/ combination/ nature, and mainly consequences, and, separately, (d) the only nature category

Study	Index	Sex	N	(a) Mainly Probability	(b) Only Combination	(c) Mainly Consequences	(N)	(d) Only Nature
A	PRISK	Men	(139)	1.79	1.63	1.92	(7)	1.91
		Women	(126)	1.70	1.78	1.90	(12)	1.97
B	PRISK	Men	(138)	1.78	1.64	2.07	(1)	2.40
		Women	(133)	1.85	2.00	2.13	(2)	1.90
C	PRISK	Men	(77)	1.34	1.53	1.48	(4)	1.15
		Women	(113)	1.82	1.60	1.96	(6)	1.07
E	PRISK	Men	(95)	2.07	1.42	2.37	(2)	1.38
		Women	(18)	1.65	2.17	1.92	(0)	--
A	THREAT	Men	(139)	3.04	2.72	2.89	(7)	3.02
		Women	(126)	3.39	3.58	3.58	(12)	3.75
B	THREAT	Men	(139)	2.88	3.04	3.06	(1)	3.33
		Women	(134)	3.23	3.33	3.52	(2)	3.50
C	THREAT	Men	(77)	2.65	2.72	2.84	(4)	2.67
		Women	(113)	3.36	3.62	3.29	(6)	2.78
D	THREAT	Men	(65)	2.63	2.64	2.81	(4)	3.00
		Women	(60)	3.14	3.57	3.35	(8)	3.27
A	RADI	Men	(138)	1.69	1.36	1.95	(7)	2.56
		Women	(126)	2.57	2.54	2.81	(12)	2.46
C	RADI	Men	(77)	1.51	1.72	1.93	(4)	1.67
		Women	(113)	2.52	2.19	2.58	(6)	1.39
A	ACC	Men	(139)	2.84	2.49	2.92	(7)	3.10
		Women	(122)	3.47	3.53	3.74	(12)	3.83
C	ACC	Men	(77)	2.75	3.06	3.20	(4)	2.91
		Women	(112)	3.51	3.80	3.62	(6)	2.64

In comparing the mean values of the "mainly probability" and the "mainly consequences" groups, a quite consistent tendency of higher ratings can be seen in the latter group. The tendency is evident in 22 of the 24 instances. Two exceptions can be noted, however, and they concern men in the probability category (the A-study) who gave higher ratings of the THREAT index than subjects in the other categories, and women in the consequence category (the C-study) who rated the THREAT index lower than others of the same study. The table clearly shows the often considerably higher ratings by women compared to those of men regarding risks outside the personal domain. With respect to the "only combination" category it can be seen that if this rating is higher than the ratings in the other two categories, it is attributable to a female group of subjects, and if it is lower, men

answer for five of the eight low ratings. The ratings of the "only nature" category were distributed rather equally with respect to high and low risk ratings relative the ratings of the other categories. Thus there was no reason to suspect this group to differ systematically from the others.

Two-way ANOVAs were computed with sex and risk definition category as independent variables, using the categories 1-3. Table 15 presents these results together with the results of the two-way ANOVAs carried out previously using the first categorization of the risk statements in a rough comparison of results of the two categorizations. (See Table 15).

TABLE 15

Results of two-way ANOVAs with sex and category as independent variables with respect to indices of five studies on the basis of two separate categorizations of risk statements

		First categorization		*Second categorization*	
Study	*Dependent Variable*	*Sex*	*Category*	*Sex*	*Category*
A	*THREAT*	$F(1,134)=11.91$, $p<0.001$	*ns*	$F(1,259)=22.99$ $p<0.0005$	*ns*
B	*THREAT*	$F(1,137)=5.62$ $p<0.02$	*ns*	$F(1,267)=10.69$ $p<0.001$	$F(2,267)=3.28$, $p<0.04$
C	*THREAT*	$F(1,63)=11.10$ $p<0.001$	*ns*	$F(1,184)=24.54$ $p<0.0005$	*ns*
D	*THREAT*	$F(1,77)=8.38$ $p<0.005$	*ns*	$F(1,119)=18.20$ $p<0.0005$	*ns*
A	*PRISK*	*ns*	*ns*	*ns*	*ns*
B	*PRISK*	*ns*	*ns*	*ns*	$F(2,265)=3.09$ $p<0.05$
C	*PRISK*	*ns*	*ns*	$F(1,184)=7.33$ $p<0.007$	*ns*
E	*PRISK*	*ns*	*ns*	*ns*	*ns*
A	*RADI*	$F(1,134)=15.04$ $p<0.0005$	$F(2,134)=7.50$ $p<0.001$	$F(1,258)=30.73$ $p<0.0005$	*ns*
C	*RADI*	*ns*	*ns*	$F(1,184)=9.27$ $p<0.003$	*ns*
A	*ACC*	$F(1,131)=16.29$ $p<0.0005$	$F(2,131)=3.41$ $p<0.04$	$F(1,255)=27.69$ $p<0.0005$	*ns*
C	*ACC*	$F(1,63)=4.54$ $p<0.04$	*ns*	$F(1,183)=16.38$ $p<0.0005$	$F(2,183)=2.74$ $p<0.07$

The table shows results of two-way analyses of variance with sex and category (either the three categories of the first categorization or the three categories of the second categorization) as independent variables. The results indicate that sex differences account for a lion's share of the group differences, and that they generally were highly significant. There were no interaction effects. Some significant differences regarding risk definition category also resulted from the

analyses. The B-study revealed significant group differences with respect to the risk statement category regarding the personal risk index, and together with sex also of the THREAT index. Study C showed a result approaching significance with respect to the ACC index. The mean values showed that the ratings of the risk definition categories were in the expected direction, i.e. of the highest risk ratings in the category of consequences.

A rough comparison between the two categorizations based on the results of the ANOVAs revealed that the sex differences became more accentuated in the second categorization, and that the latter categorization resulted in significant sex differences also of the PRISK and the RADI indices of the C-study. With respect to the risk definition categorizations, the second one resulted in significant differences between risk definition category of the THREAT and PRISK indices of the B-study, but gave no significant difference regarding the RADI or ACC indices of the A-study, which was the case in the first categorization.

The number of subjects included in the two respective categorizations was still small considering the six cells in the matrix, although it was increased in the latter categorization. Table 16 presents a comparison of the representation of subjects (in percent) of the two categorizations. Since the second categorization utilized a larger number of categories, not all were necessary for the comparison and the presented percentages do therefore not add to 100. It should be kept in mind that only three categories of the first categorization and three of the second one (groups 1-5) were used in the previous analyses.

Rough comparisons could be made between the "mainly probability" category of the first categorization and groups 1 and 2 of the second categorization. The "combination" category of the first categorization was compared to the "only combination" of the second (group 3). The "mainly consequence" category of the first categorization was likewise compared to groups 4 and 5 of the second categorization. Respondents who agreed to all three risk definitions of the first categorization were compared to those who agreed to three or four of the risk statements (groups 7 and 9) in the second categorization. A similar comparison was made with respect to subjects who did not agree to any of the three or four, respectively, risk statements of the two categorizations. "Uncertain" responses of the two categorizations are also presented. The percentages are based on the original sample sizes, excluding missing data and subjects unidentifiable by sex. (See Table 16).

It can be seen in the table that the use of the second categorization substantially increased the proportion of subjects who agreed to a probability based definition of risk, as well as increased the proportion of subjects in the consequences category. The "combination" category remained roughly the same. These changes were of course related to allowing the "uncertain" responses to enter the second categorization, together with the responses to the fourth risk statement. Although the first categorization produced a more pronounced logical structure for investigating the formulated hypothesis, it also excluded a large number of subjects who did not meet the conditions. The second categorization, on the other hand, allowed a larger number of subjects to enter the more meaningful first five response groups, but also presented conceptually less clear categories. In spite of the attempt to include more subjects in the categorization,

only half of the subjects in the original sample could be accounted for, approximately. A number of subjects produced responses which were hard not to denote as illogical, e.g. the groups which agreed to all three or four definitions, those who agreed to all statements except the combination, etc. If these subjects had any clear conceptualization of risk it was nevertheless at odds with the presented alternatives, or they chose to respond according to an idiosyncratic meaning of "definition" or risk. Interview data might possibly shed some light on this matter.

TABLE 16

Comparisons between two kinds of categorizations including three and four risk statements, respectively, in five studies, percentages of men and women relative the total number of respondents, excluding missing data and subjects unidentifiable by sex

Study (N)	Subjects included in comparison First/Second Sex (N)	Categories used in analyses Prob 1+2	Comb 3	Cons 4+5	Nature 6	"Rest" categories All 7+9	None 8	Un-certain 12	Total
A (591)	M (293/301)	15.4/26.6	4.8/4.3	5.5/15.6	0.0/2.3	35.5/34.5	0.7/0.0	38.2/1.3	100/84.6
	W (253/266)	10.3/22.8	5.9/7.1	9.9/17.3	0.0/4.5	37.5/35.7	1.2/0.0	35.2/0.8	100/88.2
B (465)	M (205/210)	24.9/45.7	4.4/7.6	6.3/12.8	0.0/0.5	24.4/23.8	0.5/0.0	39.5/1.9	100/92.3
	W (234/238)	20.1/34.5	2.6/3.4	7.3/18.5	0.0/0.8	27.8/27.3	1.3/0.0	41.0/2.1	100/86.6
C (380)	M (152/155)	17.8/34.2	5.3/3.9	2.0/11.6	0.0/2.6	27.6/27.1	0.6/0.0	46.7/3.2	100/82.6
	W (212/217)	7.5/23.1	2.4/5.5	4.7/23.5	0.0/2.8	27.4/26.7	0.0/0.0	58.0/0.5	100/82.1
D (243)	M (97/99)	21.6/36.4	6.2/6.1	15.5/23.2	0.0/4.0	22.7/22.2	0.0/0.0	34.0/0.0	100/91.9
	W (120/120)	16.7/30.0	9.2/4.2	8.3/15.8	0.0/6.7	28.3/28.3	2.5/0.0	35.0/0.0	100/85.0
E (236)	M (191/193)	31.9/38.3	4.2/3.1	2.6/7.8	0.0/1.0	43.4/43.0	0.0/0.0	17.8/0.0	100/93.2
	W (38/39)	21.0/30.8	7.9/7.7	5.3/7.7	0.0/0.0	39.5/38.4	0.0/0.0	26.3/0.0	100/84.6

The results so far thus lend some support for the hypothesis of higher risk ratings of subjects who used a consequence based definition of risk compared to subjects who based their definition on probabilistic thinking. If the moderate support for the hypothesis is merely due to the restrained power of the analyses on the basis of pronounced inequalities of the distribution of subjects in the matrix, a larger sample would help reveal the expected differences between the risk definition category groups more clearly. In an attempt to test the hypothesis in larger samples, subjects of each sample who gave responses regarding the same index and were included in the respective categorizations were merged together

after standardization of the respective indices[9]. The standardization of dependent variables eliminated the between-study variance, and the remaining variance could be mainly referred to between categories differences. The standardization of means and standard deviations should also have diminished some of the large influence of the sex differences given that they worked in different directions, and thus allowed other effects to appear more clearly. Table 17 shows mean values of the indices in the merged samples after standardization, by sex and risk definition category (first and second categorization).

TABLE 17

Mean values, by sex, of indices after standardization of the dependent variables, on the basis of subjects included in the respective categorizations and who responded to the same indices merged into samples, and results of two-way analyses of variance

Standardized Index	*N*	*Sex*	*Mainly probability*	*Only combination*	*Mainly consequences*	*2-way ANOVA Group: (df) F p*
				First categorization		
THREAT						
	227	*M*	*-0.37*	*-0.22*	*-0.19*	*Cat: F(2,429)=2.44, p<0.09*
	208	*W*	*0.22*	*0.40*	*0.50*	*Sex: F(1,429)=37.49, p<0.0005*
PRISK						
	258	*M*	*-0.07*	*-0.20*	*0.38*	*Cat: F(2,431)=5.64, p<0.004*
	179	*W*	*-0.04*	*-0.11*	*0.26*	*Sex: ns*
RADI						
	112	*M*	*-0.46*	*-0.38*	*0.16*	*Cat: F(2,203)=7.46, p<0.001*
	97	*W*	*0.23*	*0.10*	*0.75*	*Sex: F(1,203)=17.60, p<0.0005*
ACC						
	113	*M*	*-0.44*	*-0.35*	*0.03*	*Cat: F(2,200)=3.24, p<0.04*
	93	*W*	*0.27*	*0.39*	*0.61*	*Sex: F(1,200)=22.50, p<0.0005*
				Second categorization		
THREAT						
	420	*M*	*-0.37*	*-0.36*	*-0.26*	*Cat: F(2,847)=2.78, p<0.07*
	433	*W*	*0.22*	*0.52*	*0.42*	*Sex: F(1,847)=74.58, p<0.0005*
PRISK						
	449	*M*	*-0.12*	*-0.35*	*0.15*	*Cat: F(2,832)=9.18, p<0.0005*
	389	*W*	*-0.04*	*-0.01*	*0.30*	*Sex: F(1,832)=4.44, p<0.04*
RADI						
	215	*M*	*-0.44*	*-0.56*	*-0.18*	*Cat: F(2,448)=2.72, p<0.07*
	239	*W*	*0.31*	*0.19*	*0.42*	*Sex: F(1,448)=39.64, p<0.0005*
ACC						
	216	*M*	*-0.44*	*-0.52*	*-0.20*	*Cat: F(2,444)=2.45, p<0.09*
	234	*W*	*0.25*	*0.42*	*0.44*	*Sex: F(1,444)=46,18, p<0.0005*

[9] One sample per index was constructed. The SYSTAT procedures of 'standardize' (M=0, SD=1) and 'append' were used.

The results presented in the table support the hypothesis regarding higher risk estimates among subjects who included consequences in their definitions of risk compared to those who mainly based their definition on probability. The first categorization showed these trends more clearly than the second categorization. The results furthermore showed the often very large sex differences. Women gave higher risk judgements than men. Figure 6 shows the ratings of men and women in the three risk category groups of the first categorization with respect to the indices of personal risk and threat to society.

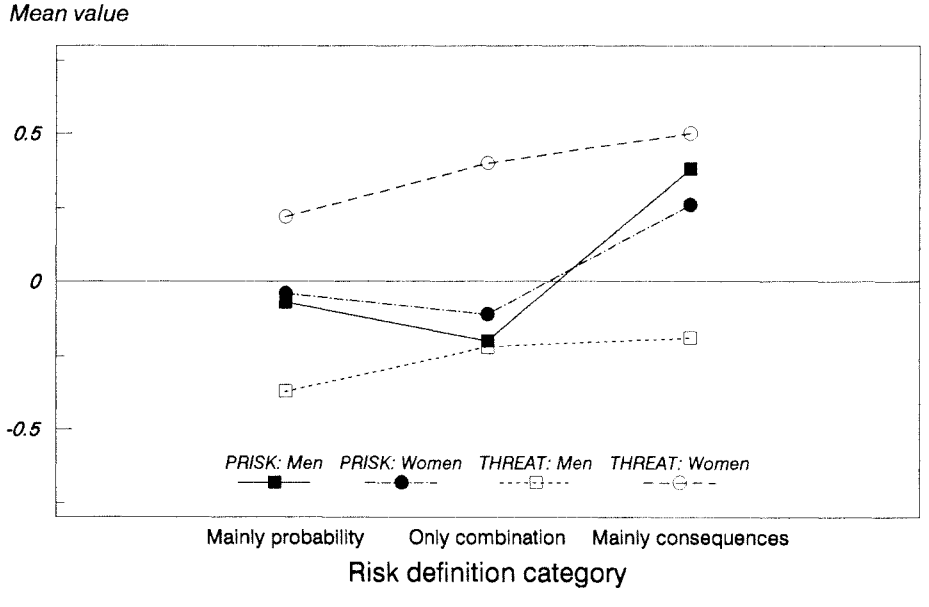

FIGURE 6. Standardized ratings of personal risk and threat to society, men and women in three definition categories.

Comparison to a unidimensional scale

The presentation has so far focused on the definition of risk on the basis of three or four definition statements. The results have shown that categorizations of respondents into independent groups leave a large number of the respondents outside the categorization models. In an attempt to investigate and compare another response format to the results derived from the four risk statements a unidimensional scale was introduced in a recent study.

A sample of high achievers[10] (N=201) of various high school backgrounds responded to a questionnaire about interests and educational choice in 1990. The four risk definition statements presented above were included in the questionnaire, together with a unidimensional scale asking for a single response to how the subject "normally" defined risk. The latter 5-point scale used the response alternatives of 1="Solely the probability of an event", 2="Mainly the probability of an event", 3="A combination of probability and consequences", 4="Mainly the extent of the consequences of an event", and 5="Solely the extent of the consequences of an event".

One hundred and sixty subjects (80% of the total sample) used the unidimensional scale and indicated how they normally defined the concept of risk. Between 161 and 164 subjects also responded to each of the four risk definition statements, which were included among a list of attitude statements in the same questionnaire.

The mean value of the subjects who responded on the 5-point unidimensional scale was 3.06 (SD=0.67)[11]. The result indicated that risk, on average, was defined in terms of the combination of probability and consequences of an event. The mean values of the four risk definition statements, measured on 5-point scales[12] and treated separately here in the order of the "probability", the "combination", the "consequences", and the "nature of event" statements, were 2.78 (SD=1.11), 1.79 (SD=1.00), 2.74 (SD=1.07), and 2.20 (SD=1.13). These results again indicated that subjects' agreed most to the statement that risk is a combination of probability and consequences, followed by agreement to the statements that the meaning of the concept of risk is entirely due to the nature of an event, the probability of an event, and the consequences of an event. Table 18 shows a cross-tabulation of the subjects who responded to the unidimensional scale and who *agreed* ("Yes, absolutely" and "Yes, maybe") to the four respective risk definition statements.

The table shows a fairly good correspondence between the two kinds of ratings. In correspondence with the previous results presentation, the table also shows that subjects agreed to more than one definition. The Pearson correlation coefficient of ratings on the unidimensional scale and ratings of the respective risk definition statements were 0.71, $p<0.0005$ (the probability statement), -0.59,

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[10] Defined in terms of average grade >4.5 in the Swedish grading system, which uses the scale 1-5 with 5 as the highest possible grade. The sample was predominantly male, i.e. 67% men.

[11] Data made available to me by R. Wahlund, Stockholm School of Economics, who included the unidimensional scale in a study of students of economics showed the mean value to be 3.06 (SD=1.01). The proportions of students responding to the five response alternatives, from "Solely probability" to "Solely consequences" were 9.4, 11.9, 50.8, 20.5 and 7.4, excluding missing data. The corresponding proportions of the present study were 3.1, 8.8, 68.8, 18.1 and 1.2.

[12] The same scales as described above, using the response alternatives of 1="Yes, absolutely", 2="Yes, maybe", 3="Uncertain", 4="No, maybe not", and 5="No, absolutely not".

$p<0.0005$ (the combination statement), -0.56, $p<0.0005$ (the consequence statement), and -0.38, $p<0.01$ (the "nature of event" statement).

TABLE 18

Cross-tabulation of subjects responding to a unidimensional scale of the definition of risk, and who agreed ("Yes, absolutely" and "Yes, maybe") to four risk definition statements

	Agree to risk definition statement of			
Unidimensional scale	*Probability*	*Combination*	*Consequence*	*Nature*
Solely probability	*3*	*1*	*1*	*1*
Mainly probability	*14*	*6*	*1*	*7*
Combination of probability and consequences	*42*	*97*	*47*	*80*
Mainly consequences	*5*	*17*	*23*	*16*
Solely consequences	*0*	*2*	*2*	*2*
Total	*64*	*123*	*74*	*106*
N=	*151*	*152*	*154*	*153*

Fifty subjects fitted into the first categorization model, i.e. approximately 30% of the respondents. The mean values on the unidimensional scale of the subjects included in the three categorization groups were 2.08, 3.12 and 3.56. There was a highly significant difference between the category groups, $F(2,40)=11.64$, $p<0.0005$, but no sex difference.

The second categorization model allowed 88 subjects into the three main categories (excluding the "rest" categories), which corresponded in kind to the ones used in the first categorization, i.e. approximately 55% of the respondents were included here. The mean value of responses of these respondent groups to the unidimensional scale were 2.38, 3.08 and 3.54. Again the categories were significantly different, $F(2,75)=16.78$, $p<0.0005$, without a sex difference. A cross-tabulation of the ratings of the unidimensional scale[13] and the responses to the risk definition statements after applying the two types of categorizations, respectively, is shown in Table 19 below. Observe that the fourth risk statement and the "uncertain" responses were included in the second categorization only. Note also that some subjects were lost in the cross-tabulation, since they did not respond to both kinds of ratings.

[13] The unidimensional scale was grouped into three response categories, corresponding to "mainly probability" (response alternative 1 and 2), "combination" (response alternative 3), and "mainly consequences" (response alternative 4 and 5).

TABLE 19

A cross-tabulation of respondents regarding a unidimensional scale measuring how subjects "normally" defined risk, and respondents of two types of categorizations of risk definition statements, and "rest" categories regarding agreement to all definitions, none of them, and "uncertain" responses

	Frequencies of first/second categorization			*"Rest" categories*			
Unidimensional scale	*Mainly probability*	*Only combination*	*Mainly consequences*	*Only "nature"*	*Agree all*	*Agree none*	*Un-certain*
Mainly probability	*9/16*	*0/0*	*0/1*	*0/0*	*0/0*	*0/0*	*9/8*
Combination	*4/12*	*15/12*	*8/17*	*0/5*	*29/23*	*1/0*	*49/29*
Mainly Consequences	*0/1*	*2/1*	*8/21*	*0/1*	*4/2*	*0/0*	*15/15*
N=	*13/29*	*17/13*	*16/39*	*0/6*	*33/25*	*1/0*	*73/52*

The results thus indicated a good agreement between the two kinds of ratings with respect to respondents included in the respective categorizations. The table also shows, however, that many subjects were "uncertain" or agreed to all (three or four) risk definitions. These subjects tended to choose the middle response alternative of the unidimensional scale. This implies that using only a unidimensional scale when measuring what meaning subjects normally assign to the risk concept would tend to result in an average definition of risk in terms of the combination alternative, as was shown above. The table shows, however, that such a result might simply be due to the fact that "uncertain" subjects, and subjects who agree to most statements, tend to choose the middle response alternative of the available scale.

Knowledge and education

It could be assumed that the definition of the risk concept is related to knowledge, i.e. educational level and kind of education. Educational level might also influence the degree to which subjects were included in the categorizations. Only the first categorization was considered here. Analyses of educational background relative the "included" and "excluded" division of subjects, and only regarding the subjects "included" in the categorization were conducted. Only the A and B studies were considered for these analyses, since they were representative samples of the age groups of 18-66, and 30-45, respectively.

The results showed no significant differences with respect to the representation of men and women in the "included" and "excluded" sub-samples. Subjects in the risk definition categorization tended to be higher educated, however. The difference of educational levels of the B-study was significant, $x^2(3)=30.02, p<0.0005$, and it approached significance in the A-study, $x^2(8)=13.82$, $p<0.09$. Figure 7 below shows percentages of the subjects "included" in the first

categorization for four educational groups[14], in the A and B studies. The 9 educational groups of the A study were grouped, in the figure, to correspond to the four educational groups of the B study. (See Figure 7).

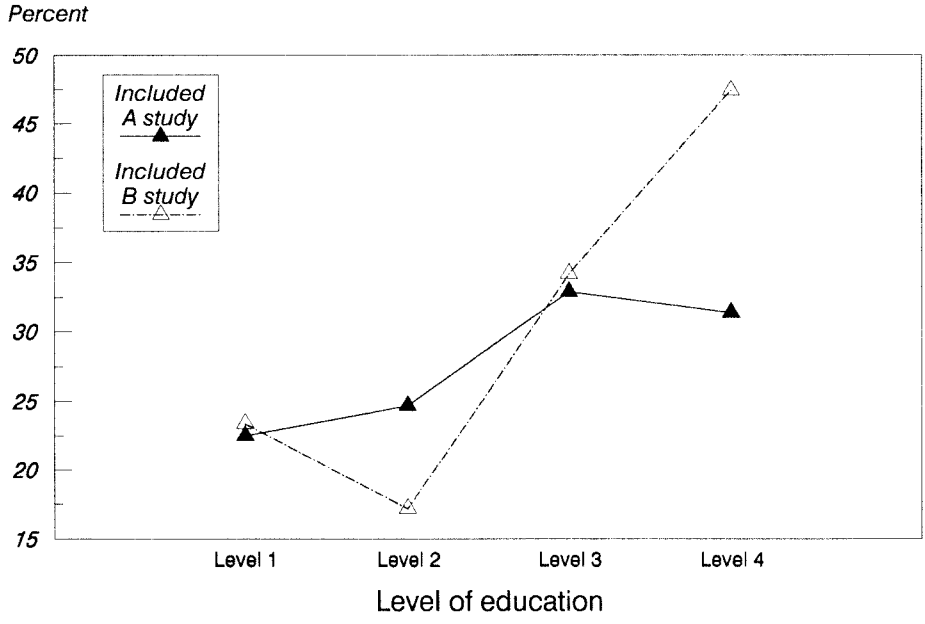

FIGURE 7. Percentages of subjects included in the first categorization of the A and B studies by four levels of education.

The figure shows, for example, that almost 50% of the university educated subjects of the B-study were included in the categorization. The figure also shows that about 75% of the subjects in the lowest educational group were excluded from the categorization in both studies. The results render some support for a conclusion that higher educated subjects responded more logically consistent. There was no support, however, for a conclusion that higher educated subjects, within the categorization, preferred a specific definition of risk $\{x^2(6)=5.11, p<0.53$ in the A-study, and $x^2(6)=6.65, p<0.36$, in the B-study$\}$.

DISCUSSION

The first conclusion of the present paper is that risk estimates derived from different perspectives are quite different, and that explicit rating instructions therefore are important. Just "estimate the risk of..." does not suffice, but is often used. Especially unclear and imprecise procedures can be found in the instruments

[14] Each educational level group was treated separately, thus "included" and "excluded" subjects of each level add to 100%. Only the "included" subjects are shown in the figure. Level 1= Grade school, vocational school, Level 2= senior high school 2 years (in Swedish realskola), Level 3= Senior high school 3 or 4 years, Level 4= started or completed university education.

used and in the results presentation of commercial survey institutes. An example of sloppy methodology in an opinion poll and its political implications was given by Zeisel (1980).

In reflecting upon the results of the lower perceived personal risk compared to risks to others, these seem related to findings of, for example, relatively more positive nuclear power attitudes[15] of subjects living close to a nuclear power plant compared to subjects living at a greater distance (van der Pligt, Eiser & Spears, 1986). The authors also pointed out that relatively low risk estimates regarding nuclear power plants were more pronounced in relation to a power plant in the local vicinity than with respect to power plants elsewhere. The authors interpreted the findings in terms of experience of living close to a nuclear power plant, dissonance reduction (Festinger, 1957), and choice of residence area.

Although these results were based on data collected after the TMI accident, it should be noted that residents of the TMI-area have reported less perceived control over their environment, greater feelings of helplessness, and provided higher levels of stress hormones in their urine compared to control subjects more than six years after the accident (Baum, 1987). In addition, Baum, Gatchel and Schaeffer (1983) presented results which showed the specificity of effects of residents of the TMI area, i.e. an area where an accident had actually occurred. There were no similar stress reactions among residents living near an undamaged nuclear power plant. The latter residents were similar in their reactions to people living close to a fossil-fuel plant or to no plant at all. Thus it seems that the finding of lower perceived personal risk compared to risk for people generally, would not necessarily apply to subjects who actually have been exposed to an accident.

On the other hand, there is the increasingly obvious phenomenon of NIMBY (i.e. Not In My Back Yard), which especially concerns constructions of new nuclear and chemical plants, and waste disposal. Local residents protest against such constructions. This is not exclusively a Western phenomenon. Faragó, Vári and Vescenyi (1989) reported a growing environmental concern in Eastern Europe. Residents tend to be relatively more in favor of such facilities the farther away from the own community they are suggested to be located. Freudenburg and Baxter (1984) predicted increased negative attitudes towards new nuclear power installations in the U.S., and showed a distinct drop in acceptability attitudes of *host communities* of nuclear power installations after the TMI accident in 1979.

How can the strong NIMBY reactions be reconciled with perceptions of low personal risk? I suggest that the NIMBY syndrome, its name notwithstanding, reflects concern over one's community, and thus general rather than personal risk. Possibly, reactions to a strong and truly personal risk may involve individualized escape from the imminent threat rather than the coordinated collective action so typical of NIMBY movements. Future investigations should include the task of examining the content of the different "perspectives", and to find their determinants to test this hypothesis.

It is hence possible that the NIMBY-behavior should be interpreted in a societal perspective rather than an individualistic one, i.e. that people involve themselves and act for the benefit of some "higher" cause in an altruistic framework rather than for personal safety reasons. People may attempt to help

[15] There is generally a substantive correlation between attitude to and perceived risk of the same phenomena. See for example Sjöberg and Drottz (1988).

create a better world for future generations rather than aim at private safety or gain, and if so, such altruistic motives might result in a relative disregarding of personal risk.

Chess and Hance (1988), for example, pointed to the perplexing phenomenon of strong reactions against radon on a municipal level, but very little concern with respect to the radon risk in the own home. (See also Fisher and Sjöberg, 1990). In a study of reactions to the Chernobyl accident (Drottz-Sjöberg & Sjöberg, 1990), "hope for the future" gained the highest beta-weight among several life values in predicting nuclear power attitude. Sjöberg and Winroth (1986) presented results concerning risk acceptability regressed on moral value with respect to personal and societal risk. They found a highly significant intercept difference between the two ratings, and that "individual actions were judged as less risky and more acceptable than societal actions" (p. 204). These findings may stimulate risk researchers to look for aspects of moral standard, faith, life values, and perceived personal significance as factors influencing risk ratings.

It could easily be assumed that oneself is the reference person in ratings of personal risk, but what is included in the conception of "people in general"? Similarly, which are the salient representations of "society" in peoples' minds? Does it include neighbors, people like oneself, or institutions, or authorities, or all? To what extent are future generations included in the conception of a society? To what extent does "industry" represent society? The risk ratings reported in the present study showed that risks related to society were perceived as higher than similar risks related to one's person or to people generally. Does this result imply that more people or more aspects are considered to be involved in a societal perspective, that the stakes are perceived as higher, or that people are more concerned about others' welfare than their own, or just increasingly concerned with the fate of society at large?

There exists a vast, and growing, literature which shows that people to a rather high extent are concerned with environmental issues, including pollution, radiation, and disposal of toxic waste. Such concerns are usually related to sex, education and interest or involvement in the issues. An OTA paper (1987) reported environmental involvement to be positively correlated with science interest. Walsh and Warland (1983) found activists in the TMI-area to be higher educated and better connected and established in society, i.e. they belonged to higher occupational and income groups.

Anxiety, however, seems to be another matter. On the basis that protest activities often occur in relation to awareness of a risky technology in the vicinity it would be motivated to assume a strong relationship between concern and fear or anxiety on the one hand, and involvement and activity on the other. However, Levi and Holder (1986) did not find any relationship between anxiety and nuclear attitude, measured in relation to the construction of a nuclear power plant, and asserted that "... concern about nuclear power appears to be a widespread issue rather than the irrational fear of a minority" (p. 393). Although the OTA-report (1987) found only 6% of the adult American population actively involved in environmental organizations, the figure was higher than the 4% who reported activity in consumer organizations. The report also stated, in relation to reviewing public concern about environmental issues: "However, for long-range planning,

public awareness of these problems is likely to grow. This increase could expand the size of the populace who are very concerned with these issues" (p. 37).

Increased knowledge was thus expected to increase concern. Increased concern, however, does not seem to be related to personal anxiety or a specific attitude. The OTA-report concluded on environmental activism that "Americans active in environmental concerns are not particularly opposed to technological development, and are equally likely to feel the current rate of technological growth is too slow (8 percent) as to feel it is too fast (7 percent)" (p. 38). Thus there seems to be some support for an assumption that people involve themselves in activities for other reasons than personal risk reduction, and that they act on the basis of very different representations of the situation. How they arrive at risk estimates may very well be related to these representations and the *kind* of knowledge they have acquired.

With respect to the investigation of risk definitions, the results of the present paper demonstrated a complex variety of risk definitions among naive subjects. The second conclusion of the present paper is therefore that perceived "risk" is not based on a homogenous concept. It seemed possible to avoid addressing the implications of this diversity in connection with risk judgements by using a unidimensional rating scale for investigating how subjects used the risk concept. The results based on the four risk statements, however, indicated that such a procedure would only give an incomplete reflection of how subjects defined risk in their ratings. The use of a unidimensional scale for the purpose of investigating subjects' definitions of risk should therefore add the respective response alternatives of "don't know" and "I have another definition of risk".

It could be argued that presenting subjects with several definitions of risk confuses them rather than sheds light on how they define the risk concept. The extent to which such an objection is valid is an empirical question. The five studies investigated here were conducted on the basis of the conventional survey assumption that subjects understand the tasks presented them, and respond to the best of their abilities. If confusion was involved, however, and was a reason for the many "uncertain" responses and illogical combinations of response alternatives, it could very well be the case that it emanated from having to consider something not previously thought about in such a manner. There seems to be a varying meaning content of the risk concept, which draws both on blurred everyday language and very specific, albeit differing, experts' definitions. The use of an open ended response format would have been an alternative approach, but presumably also a considerably more problematic one.

The approach chosen here was to compare the given definitions of risk to a unidimensional scale. The latter also included the extreme response alternatives of "solely" probability and consequences, respectively. The comparison between the two methodological approaches showed than "uncertain" responses often were found in the "combination" response alternative of the unidimensional scale. This response alternative was also the midpoint of the scale. The result implies that subjects using the unidimensional scale had much less possibility to choose a response alternative reflecting their definition than the four risk definitions provided. It also implies that use of a unidimensional scale might contain a huge variation of risk definitions within the middle response alternative. The unidimensional scale gave an average definition of risk in terms of a combination of probability and consequences. The separate definition scales instead showed

subjects, within the categorizations, to favor a definition of risk based mainly on the probability of an event. However, only half or less of the original samples could be accounted for within meaningful and logically consistent risk definition categories.

Risk ratings by the subjects in the categorizations were higher if the subjects included the consequences of an event in their definition than if they used a definition mainly based on the probability of an event. This is the third conclusion of the present paper. The implication of this finding seems to be that the risk definition influences the risk rating. It furthermore supports the assertion that a single and unequivocal definition of risk cannot be taken for granted.

The frequent acceptance of the fourth risk statement, i.e. that risk is entirely due to the nature of an event, was unexpected and deserves some comment. A possible interpretation of this result is related to the fact that risks are discussed with respect to so many, and so various, present and future, situations, technologies and actions. Baum (1987) described the problems amounting when trying to define a disaster. He stressed that the definition bears on the effects of an event, with an emphasis on the damage caused by the event: "What makes a disaster a disaster is the extent of damage done" (p. 13). The damage, however, can take many different forms, e.g. physical, economic, social, psychological, etc. One of its important characteristics is to produce social dysfunctioning irrespective of physical damage. A disaster has sudden impact, is powerful and outside the range of everyday experience and beyond personal control. It's characteristics include exposure to terror or horror, intense feeling, etc, for a certain time period.

One could perhaps exchange the term 'disaster' with 'risk' above, and conclude that the definition of risk depends entirely on the nature of the event. This would especially be the case for people who include consequences of an event into their definition of risk. The results presented in the cross-tabulation also showed that the "nature of the event" responses were found in the "combination" and the "consequences" categories of the unidimensional scale. One should not disregard that reality to many of us means the psychological reality, which includes beliefs, wishes, values, fantasies and emotions, all intertwined and sometimes projected on others and the outside world. To estimate risk excluding the consequences of an event might therefore be considered a professional skill, not a naive approach. In Otway's (1988) review of Morone's and Woodhouse's book "Averting Catastrophe: Strategies of Regulating Risky Technologies", he observed that the authors implicitly defined risk as mortality risk. He stated very clearly that people's perceptions of risk matters in the process of risk estimation, and that these include also other aspects than quantitative estimates.

There are studies which have related attitudes and risk perception to salient features of the rated action or technology. In an article on attitudes to nuclear energy published in 1982 by van der Pligt, van der Linden and Ester they stated that: "... individual's attitudes towards nuclear energy are closely related to their perceptions of its potential consequences" (p. 229). In a later work it was stated that "... individuals with opposing attitudes tend to disagree not only over the likelihood of the various possible consequences but also over their importance" (p. 77) (van der Pligt, Eiser & Spears, 1986). This implies that individuals perceive different features of a phenomenon as salient, and form an opinion and a conception of the risks involved on the basis of such salient features. Results of the present paper showed that ratings of personal risk which included the aspect of

injury due to radiation were rated *higher* than were personal risks which did not make this reference. It can easily be argued that, for example, the risk of being involved in a car accident is much higher than the risk of radiation exposure due to leakage from a nuclear waste disposal site. The results of the ratings indicate, however, that 'radiation' is a salient feature of quite another potency than frequency of common individual accidents.

In the present study, more subjects with a higher education were included in the risk definition categories than subjects of lower educational levels. This could indicate that higher educated persons have more explicitly defined risk concepts, or they respond more logically and consistently to risk statements, or both. There were no differences of risk definition preferences, however, between subjects of different educational levels included in the categorization. Subjects included in the categorizations nevertheless tended to favor a probability based definition of risk. This is in accordance with some of the risk definition statements cited from researchers in the introduction. Urquhart (1988) favored the "pricing definition" of risk, and asserted that there was a general shift in the technological opinion towards this definition. If this is a fact, it may be possible that the differences obtained between experts' and novices' risk ratings in other studies could be attributed, at least partly, to different, as well as to clear versus diffuse risk definitions.

There is another implication of the presented results, which was not addressed in the study, but which might be of general interest to risk perception research in different areas. The studies presented here were all related to risks to health and life, i.e. to very important values. They all belonged to a domain of low probability and high consequences scenarios. In contrast to research of this domain there currently exists a lively research activity in marketing, where researchers investigate consumers' risk perception. This domain also investigates risks of high probability and low consequences, e.g. risks related to products in everyday shopping, and studies "risk relievers" in this context (Derbaix, 1983), and the relationship between risk reduction behaviors and information search (Gemünden, 1985).

Diamond (1988) reported experimental data of information processing in a high probability/low consequences condition, as well as a low probability/high consequences condition. He related his research to prospect theory (e.g. Kahneman & Tversky, 1984), but suggested that people disregard low probabilities and concentrate on consequences in the low probability/high consequences case, whereas the reverse should apply to the high probability/low consequences situation. The results of the study gave some support for this view. Based on retrospective explicit listing of the decision rules used in the risk judgements by the subjects, Diamond could furthermore show that "compensatory processing" (evaluation including both probability and consequences of an event) was more frequently used by subjects in the high probability/low consequences condition (49% vs. 19%), whereas subjects in the low probability/high consequences condition more than twice as often than others (38% vs. 15%) described their decision rules in terms of "odd compensatory processing", i.e. using either probability or consequences. Diamond concluded that consumers in corresponding types of risky purchase situations might differ accordingly in their emphasis regarding focus on probability and consequences.

The example suggests that more effort should be put into research which considers risk ratings of both high probability/low consequences and low probability/high consequences scenarios, and which also investigates the results with respect to information processing and the perceived content of the risk concept. Regarding Diamond's hypothesis, the present study showed that subjects rating risks in the low probability/high consequences domain most often *did* consider the probability of an event in their risk judgement, given that they met the conditions of the categorizations of the risk statements.

It may be argued that estimates of risk, and the risk concept, are well understood within the respective areas in which they are used, and that, for example, definition problems arise when results of such areas are related to each other, and that attempts to bridge the areas and to compare the results therefore should be avoided. The view presented here assumes quite on the contrary that stimulating new knowledge would result from a cross examination of methods and results of different areas.

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RISK: CONCEPTIONS, REACTIONS AND COMMUNICATION

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ABSTRACT

This paper presents a discussion of risks in modern society. Risks are becoming increasingly important in management and everyday life and communication problems are abundant. How are risks perceived? How do people react to risks? How can communication be improved? It is pointed out that risks pertaining to people in general are usually perceived as much larger than those for one's own person. Furthermore, the concept of risk is interpreted in different ways by different persons. Those who stress consequences tend to give higher risk ratings. Implications for risk communication and for the measurement of risk perception are discussed.

Introduction

In the early historic times, natural catastrophes and diseases were the major causes of multiple fatality events. Modern society has since then developed an impressive arsenal of self-made potential hazards and catastrophes (Clifton, 1990). Risks are becoming an increasingly important theme in management and everyday life (cf. Sjöberg, 1987). Problems are abundant. How are risks perceived? Are there different kinds of risks and reactions to risks? What is the basis of strong emotional reactions to risk? How can different points of view be reconciled?

In this paper I will address perception of risk, communication of meanings, attitudes and values, and reactions to risk exposure. And I will use these elements to interpret public reactions to novel technologies.

Catastrophes and disasters

An important initial distinction is that between natural and man-made risks. People react in different ways to natural catastrophes and man-made disasters. Baum (1987) noted that disasters may have common features in terms of direct impact, but that they vary along dimensions which define how the events are experienced. One such characteristic is the (sometimes present) lack of visible damage, e.g. toxic substances and radioactivity. This distinction can also be expressed as the difference between destruction and contamination.

Another differing feature concerns the origin, and in that respect the responsibility, of a disaster. Nobody is responsible for a natural catastrophe, whereas a technological disaster may be perceived as due to an insufficiently developed safety policy. Furthermore, a natural disaster is often preceded by warnings, e.g. in the cases of flood or severe storm. A man-made disaster may occur without warning, and in the case of invisible effects, warnings to the public may be delayed until the scope and severity of the effects have been recognized and examined by experts. A fourth and psychologically very important difference between natural and man-made disasters is the occurrence of a "low point", which indicates that the worst has passed. Baum (1987) described this low point as the moment when recovery starts and life slowly goes back to normal, if the community where one lived is otherwise intact. The prolonged stress effects, which have been measured more than six years after the Three Mile Island (TMI) accident (Baum, 1987), point to a situation lacking a "low point".

The results presented below show that there exists both perceived benefits and risks to events, activities and technologies. Furthermore, that there are substantial differences with respect to perceived risk for one's own person and the perceived risk for people in general, and that heightened worry and stronger negative attitudes among the public can be measured after accidents have occurred.

Risk and benefit

Accidents are unintended side effects of a continuous and progressive scientific, technological and industrial development which otherwise has had considerable positive impacts on human standards of living and life expectancy. Nevertheless, the possibilities of accidents and catastrophes produce concern and worry among the same people who in other respects welcome the benefits of science and technology. Some representative studies of the issue will be mentioned.

Slovic *et al.* (1989) compared 29 items, covering pharmaceutical products, medical procedures or devices, and some nonmedical items, such as airplanes and nuclear power, with respect to perceived risk and perceived benefit using a Swedish sample. The correlation between risk and benefit ratings was -0.23. The authors found some items to be high on benefit and low on risk, e.g. appendectomy, while others showed the opposite pattern, e.g. cigarette smoking. Antidepressants and nuclear power achieved close to a zero value on net benefit (perceived risk minus perceived benefit).

A French study (Bastide *et al.*, 1989) measured perceived frequencies of 30 mortality causes, and "danger" of 52 activities and technologies. The authors found risk perception to be influenced by two components: a global feeling of security, and perceived social legitimacy. The first component concerned the general feeling of the security society provides its members. (Cp. the "peace of mind" concept, van der Pligt *et al.*, 1986). A weak social position and lack of social relationships were described by the authors to be related to overestimation of risk. Perceived "danger" of activities and technologies varied on a dimension of social legitimization of actions.

An OTA report (1987) presented results from a sample of the American public with respect to perceived benefit and perceived risk regarding the future developments of science and technology[1]. The results are shown in Figure 1.

The figure shows that the American public expected quite a lot of benefit from the development of science and technology in the forthcoming two decades, but that it also expected risks due to that development. The results of the surveys by Slovic *et al.* (1989) and Bastide *et al.* (1989), however, indicated that the public's perception of risks and benefits vary substantially with respect to the *type* of event or situation considered, and that there is a social legitimacy dimension involved in risk perception.

[1] The exact wording of the two questions were: "How much benefit do you expect you and your family to get from developments in science and technology in the next 20 years - a lot of benefit, some benefit, little benefit, or no benefit?", and "How much risk to you and your family do you think developments in science and technology will cause in the next 20 years - a lot of risk, some risk, little risk, or no risk?" (p. 26 and 27).

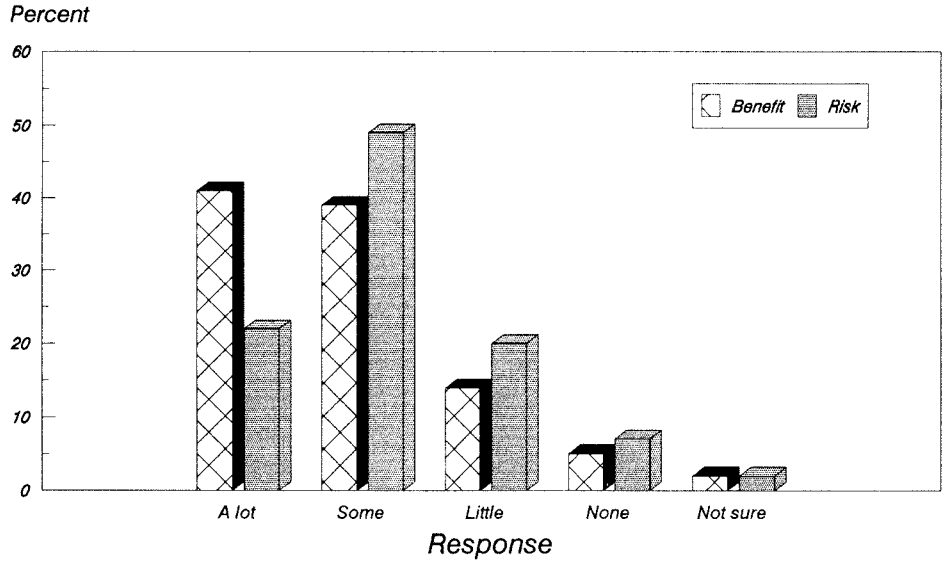

FIGURE 1. Percentages of perceived risk and perceived benefit of the developments of science and technology in twenty years time, an American sample.

The three examples show that the overall public expectation with respect to developments in science and technology is positive, but that the perceived net benefit nevertheless can vary substantially over specific areas.

Exposure to toxic substances and radioactivity belong to the most feared threats. They are also the topics of active personal involvement, and sometimes the theme of protest activities, as in the NIMBY (Not in My Back Yard) phenomenon. The component of *dread* involved in invisible dangers is often mentioned. There are also other reasons for strong public reactions to pollution and contamination. One of them is that these events are seen to threaten the very foundation of human survival in a longer time perspective (Drottz-Sjöberg & Sjöberg, 1990). Another is that they threaten the individual's freedom and ability to guard and protect their lives by themselves. I will develop these notions further below.

Perception of personal and general risk

A very important distinction is whether a risk is perceived as pertaining to people in general or to oneself. People tend to rate the general risk of a phenomenon higher than the corresponding risk related to their own person. Figure 2 presents data from one study (Sjöberg, 1990; Drottz-Sjöberg, 1990) in which subjects rated personal risk and risk for people generally with respect to being assaulted and to fall ill with AIDS. The subjects also rated the risk of violent crime and the AIDS

disease with respect to how they perceived these as threats to society. The figure presents mean values of ratings of men and women.

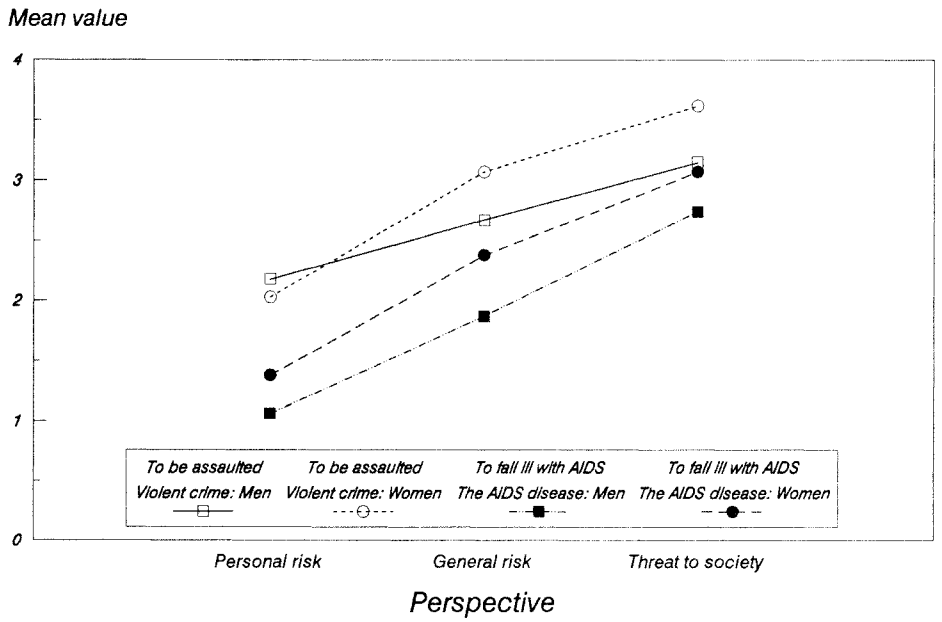

FIGURE 2. Mean values of ratings of personal risk, and risk to people in general with respect to being assaulted and to fall ill with AIDS, and threat to society regarding violent crime and the AIDS disease, men and women.

The figure shows that the perceived risk increased when rated in more general frameworks, i.e. risk to society was perceived as higher than risk to people generally and especially high compared to the perceived personal risk. The difference between the three ratings was highly significant. The figure also shows that women usually gave higher risk ratings than men, a common finding in the risk perception literature.

To my knowledge there exists no corresponding study where experts on risk assessment have judged various events with respect to perceived risk to themselves, to people in general and to the society at large. On the basis of the suggestion made by Thedéen (1979) of the close connection between risk and decision, such a project could be worth an effort. See also Sjöberg (1980) on differences in risk estimates made by experts and the public.

The results shown in Figure 2 raise the question of why people rate risks to others and to society as higher than the risk to themselves. Let me suggest two interpretations. Firstly, concern about private risks do not have a natural public forum. That is, the individual is personally responsible for guarding his or her private life, family and property from whatever malefactors or disasters there might be. Individuals deal with this responsibility by means of insurance, a social network

and choice of life style. If this is not sufficient, trust is placed in God's hands. Strong concern over, for example, personal assaults, burglary and neighborhood technological disasters result in formation of attitudes which may be expressed in discussions and political action with the general aim to create an overall change of conditions. The higher ratings of risks to others and to society would thus correspond to a conception that the threatening event has reached a level where it includes a significant number of people and that the community or society has to deal with it.

Secondly, and as a complement to the interpretation above, there are possible adverse events which individuals neither can be held responsible for, nor can influence directly, but which might influence personal life as well as life conditions of future generations. The exploiting of wilderness areas, rain forests, pollution, the "greenhouse effect" and radioactive contamination are some examples. High ratings of risk to others and to society seem to include concern over the quality of life of future generations. Personal morality and the adult's responsibilities may request individuals to leave the world in a better shape than they found it. Events perceived as threatening will from this point of view become incentives of concern, involvement and political action. An example from a recently published study follows below.

Moral values and future generations

Kunreuther and Easterling (1990) conducted a survey of residents of Nevada with respect to their attitudes toward a proposed high-level nuclear repository at Yucca Mountain. They asked the respondents whether or not they would vote in favor of a repository if an annual federal tax credit was provided over the following twenty years. The respondents were assigned to three conditions, offering a tax reduction of $1000, $3000 and $5000.

The authors concluded, firstly, that subjects who perceived higher probabilities and consequences of an accident at the repository also were less in favor of voting for it. Secondly, the proportion who would vote in favor ranged between 28 and 32 over the three tax credit conditions. The authors stated that "the increased acceptability of a repository due to rebates is captured almost entirely in the change from $0 to $1000; the next $4000 in compensation elicits no additional support" (p. 255). They thus had a result which pointed to a threshold model, where support increased only as long as the perceived risk was acceptable: "For those respondents where the risk was perceived to be too high, the rebates offered were viewed *not* as inadequate, but as inappropriate" (p. 255). Thirdly, the data showed that *perceived future risk* helped explain the expressed voting behavior, and the authors concluded that the respondents did not discount future consequences of the repository. The perceived risk of a high-level repository thus included potential suffering of future generations. The authors also concluded that residents living nearby must be assured a threshold level of safety, and that they would accept risk assessments only if they *trusted* those responsible for the construction and operation of the facility.

The public obviously does not trust the information they have received so far. Krauskopf (1990) reported that the state of Nevada is "refusing to grant permits even for preliminary surface clearing and drilling" (p. 1232), and that the controversy now is headed for the courts.

Trust and concern

Frontier sciences and novel technologies enter with necessity virgin areas of knowledge. That is the very nature of the state of the art, and a requirement for scientific progress. Development is also associated with uncertainties with respect to riskiness of applications outside the laboratory. In some areas, e.g. DNA research, the scientific process is so fast and ethically complex that regulatory bodies tend to fall behind (Hynes, 1989).

Public knowledge about the latest scientific findings is based on secondary and selective information sources, such as popular magazines, newspapers, TV-documentaries and to some extent books. The popularized documentation of findings and innovations naturally focuses on what is achieved, not on possible adverse events. When a new medicine is approved or a novel technology introduced at a large scale, the public probably takes for granted that risk aspects have been eliminated: "Technology is not supposed to break down" (Baum, 1987).

Innovators and experts often help provide a good image for a product or technology on the basis of the argument that no accident or adverse effects have been recorded so far. Such statements create a boomerang effect do they later turn out to be unjustified. If later development shows that risks to health, life or property are involved, the public reaction will be strong and emotional. I suggest that this reaction in most cases is not due to public ignorance, and neither to the new or suddenly exposed risk itself, but that it fundamentally is a reaction based on perceived misuse of confidence.

In a national survey study in Sweden on nuclear waste issues, trust in different kinds of experts on nuclear power was investigated (Sjöberg & Drottz, 1988). Figure 3 shows the mean values of male and female ratings of their trust in experts' knowledge with respect to handling and disposal of radioactive waste. Four groups of experts were judged: experts at (a) the state authorities, (b) the universities, (c) the nuclear industry, and (d) experts who officially had denounced nuclear power.

It can be seen in the figure that men generally trusted the knowledge or expertise of official authorities more than women did, and that women especially put their trust in experts who officially had denounced nuclear power. Both men and women trusted the experts at the nuclear power industry more than those of state authorities. The main point of the results is that ordinary people can, and do, differentiate between various kinds of experts, and trust them to different degrees.

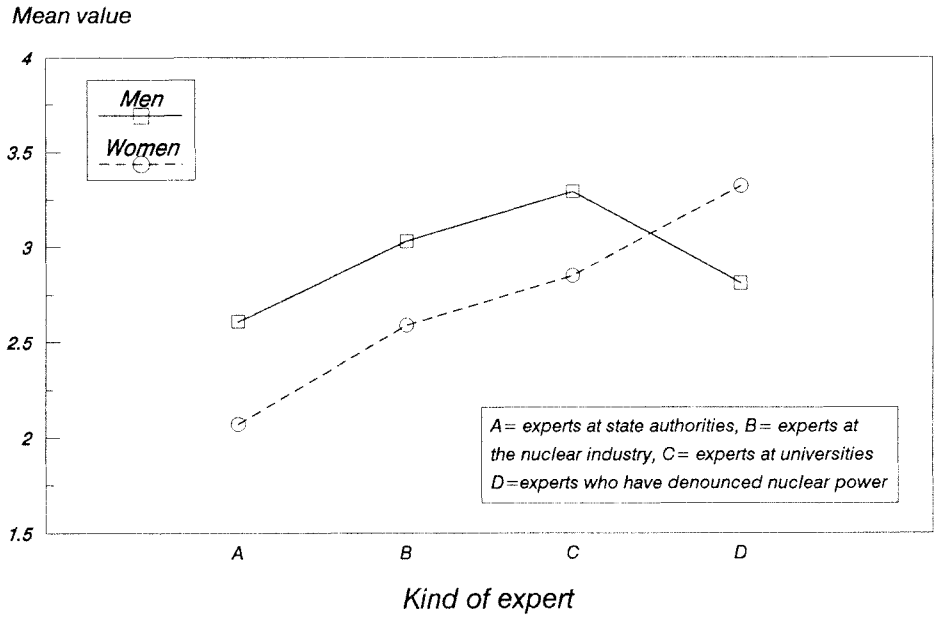

FIGURE 3. Mean values of ratings of trust in experts' knowledge, experts at state authorities, at universities, at the nuclear power industry, and of experts who had denounced nuclar power, men and women.

Different perspectives

Public concern is not easily raised are there no accidents or no information about possible disasters. With respect to man-made disasters it can be shown that public worry and concern rise *after* information about incidents or accidents involving technologies which were assumed to be safe and under control. For example, 57% of an American sample of respondents in an opinion poll in 1960 were confident that the Atomic Energy commission's methods for disposal of atomic waste were safe, 13% had some reservation, and 30% responded that they did not know (Rankin & Nealey, 1978). In 1973 a leak of 110,000 gallons (i.e. 416,350 liters) of radioactive waste was discovered on the Hanford Reservation (Southern Washington). After this event, write Rankin and Nealey, "the disposal of nuclear wastes was seen as a serious problem by the American public" (p. 112). In 1979 a TMI reactor came close to a core melt down. Public concern with respect to nuclear power increased considerably after the fact. Freudenburg and Baxter (1984) could report a distinct drop in acceptability attitudes also in nuclear power host communities after the accident. The public support of nuclear power was still larger after the TMI accident than what could be measured later, after the Chernobyl accident (Renn, 1990).

The other side of the coin show specialists' and authorities' concern about individuals who do not take appropriate action to guard their lives or to diminish personal risks (Fisher & Sjöberg, 1990). These concerns are related to, for example, radon gas in the home, fire protection, drunken driving, and dangerous life-styles, including drug addiction and certain sports activities as well as improper food consumption. The relaxed attitude of the public in these matters of personal safety is not seldom used in comparison to societal risks. For example, smoking causes a much larger exposure to the risk of cancer than radiation from nuclear power plants, private automobile travel causes more yearly fatalities than accidents in the industry, etc. It is nevertheless the socially induced risks which result in heightened worry and organized public protest.

Strong public reactions to low probability disasters are sometimes met with a scornful snort, and dismissed as public ignorance. There are indications, however, pointing to a positive relationship between reactions and severity of threat. With respect to the Chernobyl accident, for example, Hohenemser and Renn (1989) hold that in the Western democracies "both public and government responses were surprisingly rational in that they were proportional to the public's level of exposure" (p. 5-6). Renn (1990) furthermore asserted that coverage in the media reflected the actual events, it did not create them. This implies that if there is uncertainty and confusion surrounding an accident, this is also the general impression transmitted to the public. Emotional reactions and worries often involve a component of actual threat. Imprecise and contradictory information on the effects of an accident or on protective measures do not lessen the worries.

In sum, the overall situation seems to include authorities focusing on and trying to influence individuals' risky life styles, and where those who try to explain the behavior of the public repeatedly finds it ignorant. The public, on the other hand, focuses its attention on authorities and experts, and repeatedly finds them less confident in their forecasts and increasingly less trustworthy. The situation seems to call for a dialogue, but is there some common ground to develop an exchange of views? I suggest three areas where mutual interests should facilitate communication. They concern the prevention of disasters, the need of a common language, and the explicit establishment of common human values.

The cost of the unexpected

It is only human to make mistakes, but it can be extremely expensive. Braithwait (1989) outlined 'the need for a corporate strategy on risk management and risk transfer' and pointed to the human, corporate and environmental costs of accidents and mistakes if they are not prevented by a developed strategy of risk management. The examples of Bhopal, Seveso, Piper Alpha, the oil spill of the Alaskan coastline, Three Mile Island and Chernobyl, among others, tell in plain language about human loss and suffering, huge overall costs, environmental damage and lost goodwill.

Toxic substances and radioactivity in the environment as well as inferior safety standards create concern, as indicated both by public reactions and by the

governmental policies of many countries. And it means real trouble and substantial expenses when accidents occur. It is not sufficient to achieve a safety standard which prevents accidents during 'normal' operations and circumstances. More effort and fantasy is needed to foresee the unpredictable, possible effects of "the human factor". An example of some consequences due to "the human factor" follows below, together with examples of effects of nuclear accidents and of improper waste management.

A theft of a tiny capsule containing Cesium 137 from an abandoned medical clinic in 1987 in Goiania, Brazil, resulted in four deaths and 249 persons suspected of radioactive contamination. Although these figures hardly qualify for international recognition, the total impact of the incident does. Petterson (1988) reported that seven months after public contact with less than 100 grams of "carnival glitter", i.e. the Cesium, 125,800 persons had used monitoring stations to check radioactive contamination (12,5% of the city population). The average economic loss in the whole region due to the contamination was estimated to 7 million U.S. dollars. Care and treatment of victims amounted to approximately 750,000 dollars. The clean-up included taking care of 40 tons contaminated material.

Approximately 200,000 persons left the TMI area after public announcements of the accident and suggestions of certain safety measures. About 13,000 workers were required for the clean-up after the accident during the period of 1980-85 to keep individual radiation doses at acceptable levels (less than 5 rems), although only 1,000 workers were involved in the clean-up at any given time (Carter, 1987). Up to 28,000 excessive cancer fatalities are expected in the USSR and Europe due to the Chernobyl accident (Hohenemser & Renn, 1989). Current media reports tell about requests of Soviet republics to declare vast and fertile land as catastrophe zones due to the accident and years of nuclear testing.

A nine percent loss in revenue from tourists and visitors from 1987 to 1988 was estimated in New Jersey shore communities after the discovery of medical waste on American beaches in the spring of 1988 (Renn & Covello, 1989). Approximately 500,000 persons refrained from visiting the beaches of Long Island and New York City, despite the hottest summer in 44 years. Renn and Covello (1989) related these events to figures of 500% increases of costs in handling of infectious waste at many hospitals. And in addition to the depressing series of events, the authors made the disturbing remark that "incidents involving medical waste on beaches and in public places are likely to reoccur" (p. 16). They pointed to the several potential causes of such reoccurrence, for example "illegal dumping, accidental spills, illegal intravenous drug use, self-medicating patients, ambulant medical services, and overflow of sewer systems" (p. 16).

The examples suggest that both the origin and the extent of effects of accidents are hard to predict. They also show that reality still can outdo expectation. There is an immense challenge involved in our attempts to both eat the cake and keep it.

Language and values

The language used in communication of risks serves several purposes. For example, it includes a message with respect to content, and a message regarding context. The first message will be judged on the basis of its correctness, the second with respect to its appropriateness.

What do people normally mean when they use the term risk? And, if people use different meanings of risk, what are they communicating? Let me start with the first question. In several studies (Drottz & Sjöberg, 1987; Sjöberg & Drottz, 1988; see Drottz-Sjöberg, 1990 for a review), we have suggested four definitions of risk, and asked respondents to indicate their normal use of the risk term. The suggested definitions have been: (a) risk is mainly a question of the probability of an event, (b) risk is a combination of probability and consequences of an event, (c) risk is mainly a question of the consequences of an event, and that (d) the meaning of the risk concept is entirely due to the nature of the event. The respondents indicated their agreement to each of the four suggested definitions on a scale ranging from "(1) Yes, absolutely" to "(5) No, absolutely not". The midpoint of the scale (3) indicated uncertainty.

Concentrating on persons who defined risk as either the probability of an event, the consequences of an event, or as the combination of the two, the results showed that these respondents also rated the risk of the same events differently. See Figure 4.

The figure shows that persons who focused on consequences of an event in defining risk tended to rate the risk of an event higher than subjects who focused on a probability definition. The figure also shows that events which included aspects of radioactivity were rated higher than events which had no such reference[2]. It is furthermore evident from the figure that events which included radioactivity and were rated with respect to people in general, got higher risk assessments than events including radioactivity rated with respect to personal risk. The figure thus shows both the relatively low rating of personal risk, and the highly potent meaning content of 'radioactivity' in addition to the effect of the chosen risk definition.

[2] The figure is based on values of indices. Items of personal risk, *excluding* radioactivity, were for example to drown, to be assaulted and to have a serious traffic accident. Items of personal risk *including* aspects of radioactivity concerned injury due to natural background radiation, due to leakage from nuclear waste disposal and due to an accident in the handling of radioactive waste. The "accident" index was based on 11 items, which included accidents in the handling and disposal of nuclear waste, e.g. transportation, material debilitation and the "human factor".

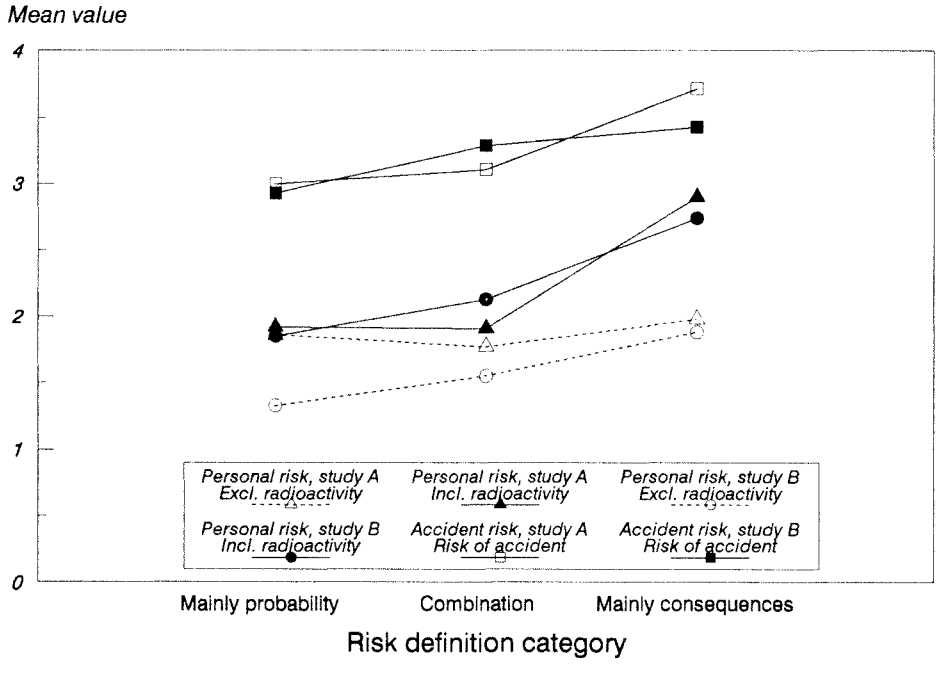

FIGURE 4. Mean values of ratings of personal risk including and excluding aspects of radioactivity, risk of accidents in handling and disposal of radioactive waste, by groups who defined risk in terms of mainly probability, a combination of probability and consequences, and mainly consequences, two separate studies.

We have a Swedish proverb saying that you will get the answers your questions deserve, an often neglected truth, unfortunately, in the opinion poll business. I therefore wanted to test the four suggested risk definitions against a unidimensional scale[3] in a new study, to investigate the importance of the response format (Drottz-Sjöberg, 1990). Subjects indicated their normal use of the term risk by marking one response alternative on a unidimensional scale. Included in a list of attitude statements related to risk were the previously described four risk definitions.

The results indicated that those who *agreed* to any of the first three risk statements also frequently gave a corresponding answer on the unidimensional scale. The results also showed, however, that persons who defined risk as entirely due to the nature of the event did not refrain from answering the unidimensional scale but marked its middle response alternative, i.e. that risk is a combination of probability and consequences. This property of the unidimensional scale of

[3] The unidimensional scale measuring respondents definitions of risk ranged from "(1) Solely probability" to "(5) Solely consequences". The middle response category (3) stated that risk is a combination of probability and consequences of an event. Thus the fourth suggested risk definition saying that risk is entirely due to the nature of the events was omitted.

collecting a great variety of diverging risk definitions was highlighted by the responses of those who indicated that they were uncertain or actually disagreed with the four respective risk definition suggestions. These respondents also marked their definition of risk on the unidimensional scale, and most often chose the middle response category defining risk as a combination of probability and consequences.

The results are important in the context of use of language in risk communication, since they indicate that choice of terminology and methodology is crucial for the results obtained, and that, for example, a single response scale for the tapping of risk definitions may contain a large hidden variation of divergent definitions, especially in the least extreme response category. Furthermore, persons who have an explicit definition of risk still might conceive of risk in different ways, as shown in Figure 4. Such conceptions might influence risk ratings, and they may create profound confusion in risk research and risk communication situations.

The second question stated above asked what people are communicating if they use different conceptions of risk. In many cases risk estimates provide an assessment of the probability of an adverse event based on long-term statistics of, for example, accidents. Such estimates can be made using different units or basis, for example risk of death, risk of injury or reduced life expectancy, per hour or year, etc., in a certain population. The risk term may also be used, however, when the probability of an event is merged together with some specific and estimated consequences of the adverse event, given that the event should occur. For example, possible economic loss or human suffering can in this manner be incorporated in overall risk assessments. The studies mentioned above also indicate that there might be a part of the population who conceive of risk only in terms of consequences of an event.

Imagine two persons discussing the risk of another nuclear accident within the next five years. One of them knows that the possibility exists, but that the probability is very low. The other person knows that accidents have occurred and that there were measurable quantities of radioactivity released. There exists some common ground for these people to agree about what they know, but the odds are higher for them leaving each other in disagreement. One of them because he or she believes people should take account of carefully made risk estimates and because prior mistakes will not be repeated. The other one because of the beliefs that history provides proof enough that the nuclear energy should not have been developed in the first place and that those who deliberately put human lives at risk are immoral. These diverging views often coincide with strong beliefs in progress and human capability versus confident predictions of more and larger catastrophes and an erosion of human survival possibilities in the long run. If these people cannot establish their mutual interest in human well-being, future discussions will be increasingly more frustrating.

The coming of a green era

Concern about risks is increasing, and so are real risks. According to Forsberg (1990) the 1990's will become the decade when the global environment have effects on our everyday life. Chandler (1990), a global resource specialist, addressed the environmental change issue and stated that it is no longer a question of whether or not human activities will alter the climate of the earth, the question now is how much. The present paper has noted some consequences and human reactions to dreaded effects of technology. There are other and more urgent threats than technology to our existence, however. Chandler (1990) holds the population growth to be a major threat because a large and growing number of people demand the necessities of life; necessities, which in turn can be satisfied mainly on the basis of increased food and energy production.

These demands will lead to increased carbon emissions from fossil fuel combustion products, speed up deforestation in the search for new agriculture areas, and aggravate the pollution and waste situation of the planet. Recent carbon emissions amount to more than 5,000 million tons a year. Chandler (1990) held that about half of this amount remains in the atmosphere. The "greenhouse effect", including increased temperatures, increased ultraviolet light intensity and the raising of sea levels, are seriously discussed prospects of the coming century. Before long, the industrialized world will realize the futility of the short-term benefits of dumping their waste in their own back yard, that is, in third world countries and their oceans. The 'coming of a green era', as I named this section, refers more to the growing mental alertness of the amounting problems than to visible effects of current problem solving.

The future indeed seems to promise challenges of quite a formidable nature. Meeting these challenges will require changes with respect to governmental and industrial policies, as well as individuals' behavior. Purely economic criteria of activity and growth will to an increasingly larger extent have to make room for conservation criteria. The future will surely also display a much more international perspective on technological development and problems of pollution and waste, and create more influential regulatory bodies for inspection of industrial operations and risk management.

Aspects of organizational and individual consumption and conservation behaviors are today scientifically addressed in the developing research area of economic psychology (see for example van Raaij, van Veldhoven and Wärneryd, 1988). When matters boil down to concrete action individuals' efforts and sense of responsibility will make a difference, so psychological analysis will be important.

Conclusions

There generally exists a substantial public trust capital in new scientific and technological developments. The occurrence of accidents, however, gradually erodes this trust. Large efforts are required to restore trust in a product or technology which has exposed people to danger. The preferable strategic policy is

therefore to avoid incidents and accidents, to develop adequate risk management strategies and communication channels.

People strive to uphold common human values and the continuity of culture. The meaning of life is to some extent threatened if one cannot imagine it's continuation beyond one's generation. Maturity and wisdom, which Sievers (1990) addressed in an earlier issue of this journal, involves the ability to see and feel beyond oneself and to contribute to the future. Accidents and disasters, especially those which involve risks not detectable by our senses, therefore stir fundamental human reactions of self defence, emotions of fear and hatred, and behaviors aimed to promote survival. The increasing worry of toxic substances and of radioactive contamination will most probably soon be accompanied by public concern over effects of DNA research. People specifically dread harmful agents working from "within" the body over considerable time, and those which can influence the genetic code. Toxic substances, radioactivity and specific genetic manipulations belong to this category. I interpreted the results presented above of higher ratings of risk to others and to society, as compared to personal risk, in terms of the threat they involved to life continuity, to the social network, and to the possible extent of damage. The higher ratings of risks where radioactivity was involved should be seen in this "dreaded" context.

There is also a component of lost individual freedom due to the invisible risks which require expert knowledge and advanced equipment for detection. For the general public this implies that they must trust the specialists with giving the correct and relevant information, and above all, to trust them to react vigilantly and to actually provide the information required in potentially dangerous situations. The issue of trust has therefore become central in communication of risk. Empirical studies often indicate that trust is fading after accidents. A large number of people believe there exists important information known to the experts which is withheld from them. (See for example Sjöberg, 1990, investigating public reactions related to the AIDS disease. Approximately 30% held this view).

It is imperative to keep and restore public trust in industrial enterprise and in authorities. Facts must be presented to the public, knowledgeable persons entrusted with informational tasks and mistakes acknowledged. (See also Otway and Wynne, 1989). Openness, to the extent it is possible, enhance trust and interest. The Swedish nuclear industry, for example, actively informs and invites the public to visit their facilities, and to form their own impressions about the information received, the plants and the working conditions. State authorities have provided a number of information brochures and booklets on nuclear waste and radioactivity.

I have pointed out some important factors in the communication process. They include the use of unambiguous language, declarations of intent and explicit expression of involved moral values. Special attention should be paid to explaining the meaning of the term risk when it is used. If the intended meaning is probability or likelihood of an event the latter term is to be preferred to the former to avoid a breakdown of communication. Handbooks for plant managers are available on how to communicate messages to the public. Hopefully will the near future provide

us with a handbook for the public on who to contact and how to draw attention to circumstances which should be attended to. There must be smoother and less expensive ways to communicate than via the courts.

The restoration of trust and communication does not involve shooting the messengers bringing bad news. We can live without the examples of whistelblowers who are advised to seek advice from psychiatrists and psychologists regarding their mental health. Neither is the world going to be a safer place to live if, for example, nuclear waste is stored "indefinitely" at the plants, or if action is taken to severely restrict scientific research. Democratic values and open communication require acceptance of the free expression of different points of view regardless of the complexity or the ignorance which might be expressed. Different solutions to technological problems must be allowed to be tested.

On the other hand, opinions and attitudes of the public should be acknowledged to carry an important message of some sort. Emotional reactions are not usually attributable to established facts, but to their possible implications and their interpretations, and sometimes to the defense of such interpretations. At times they are simply due to the mere frustration of being human and exposed to dangers in a complex and rapidly changing situation.

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SUBJECT INDEX