Session TA- 9: **Radiation policy and society**

Communication on radiation risk as an area of conflict between radiological, sociological and perceptional issues

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Abstract

Risk communication in radiation protection must not be considered as a single discipline, but is based upon an effective interaction of different scientific fields. This implies that radiological and sociological issues as well as risk perception are to be taken into account. However, communication is not straightforward, as the fields have different objectives, are different in terminology, apply different approaches to solve problems, and are using different languages. Issues to be addressed in this paper are among others: possible meanings and definitions of the term "risk", handling of uncertainty and variability of parameters as risk factors, importance of doses delivered in the far future, reasonable application of the dose commitment concept, and perception of small numbers. Other issues are sociological issues as interests of stakeholders and involved parties, importance of public opinion, media and cultural prototypes, bias in different groups of advocate. As communication will become effective only if the different contributing parties adjust their way of thinking and their language to the requirements of others without modification of their knowledge, guidance for interaction is important. The paper will review possible approaches suitable for better communication.

1. General issues in communication on Radiation Risk

Very small problems in communication in consequence of radiation exposure arose in the beginning of the age of awareness of radiation effects soon after 1895. This is because there was an apparent biological effect easily to be observed soon after exposure even under unknown scientific background of nature of radiation, dose and effect, termed today as 'tissue reactions'. Fortunately, this period is over, and today we have to handle a "stochastic" relation between exposure and effects, in addition occasionally to be weighted with a probability of the occurrence of the initiating event. The development in radiation protection led to scientifically well proven and sophisticated models and concepts on this issue, but practitioners were mainly trained just to obey constraints as dose limits. When the limit was neither exceeded nor approached, everyone was happy. However, as knowledge developed, limits were questioned, optimization came up and the simple compliance with limits was sufficient to comply with regulations, but no longer to convince the public of the safe operation of radiation sources. Although the radiation protection community has successfully learned to assess the "risk of exposure by ionizing radiation" in our own language, we are to a much less extent able to communicate on this issue with other groups. However, this becomes necessary because development led to involvement of other groups than the radiation protection scientific community and the administration. Although a sustainable communication can not be achieved without professional expertise, the contribution of involved groups of people must not be disregarded. Therefore, a broader consensus internally in the scientific community is needed as well as implementation of thinking in broader terms. "Risk management' has become increasingly politicized and debatable. Polarized views, controversy and conflict have become pervasive. Research in fields other than radiation protection has begun to provide a new perspective on the problem of demonstrating the complexity of the concept ‘‘risk’’ and the inadequacies of the traditional view of risk assessment as a purely scientific enterprise /Sl 99/. Recent developments indicate great progress in all fields of concern, but a common denominator is still missing. For example, there are many terms in use with different meanings, even the key term “risk”. However, this paper can not claim to solve all problems, but aims rather to direct the view of the radiation protection community to brainwork of groups dealing with related questions with the objective of a perhaps more beneficial communication.

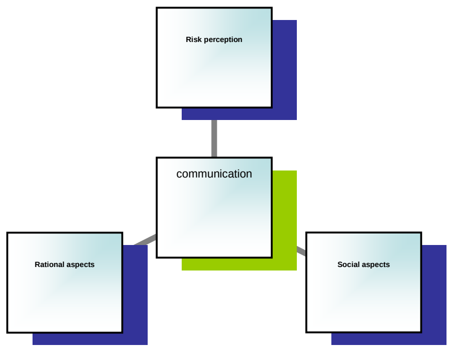


Fig .1: Relation between different scientific fields

Fig.1 shows schematically major views interfering in risk considerations, where a common denominator has to be found. It has, however, to be taken into account that each subject in turn consists of a fine structure of concerns of cultural prototypes, groups in risk debates, memes, and involved parties. (see 5.).

2. Rational aspects

Two examples are shown below to demonstrate the importance of rational aspects and it is quite evident that issues like this have to provide the basis for the other aspects as they are the only quantitative components in this consideration.

2.1 Biological issues
Risk factors are assigned by the ICRP for protection purposes, but frequently used for risk assessment, although basic UNSCEAR information would be more appropriate for this purpose. Regulators and the public might have the impression that the risk factors are well proved. However, the basic sources as /Ra 06, UN 00/ show clearly that there is a substantial uncertainty in these factors, in addition to a possible variability of individual response. The new concept of the ICRP takes this issue into account by implementing “bands of concern”, in-stead of single numbers. Another uncertainty is associated with the dose/effect relation-ship, which is reasonably well proved for higher doses, but the quality of data in the inter-esting range just above natural background is still on the level of a hypothesis /Ts 00/. On the other hand, one has to be aware that the knowledge of the relation between radiation dose and radiation effects is generally much more proven than for most other environmental agents.

2.2 Physical issues

At consideration of long lived radionuclides in waste management, the use of the concept of dose commitment is of paramount importance, but care has to be taken that the concept is properly used to avoid irrational numbers of future doses /UN 00/.

The term *dose commitment* is basically defined as $\int_0^\infty \dot{D}dt$, or alternatively as $\sum_l \sum_i k_{i,l} \int_0^\infty A_i dt$ by integration over a fictive dose rate $\dot{D}$ or incorporation of activity A resulting from a certain practice, where $k_{i,j}$ ….conversion factor dose per unit intake of a radionuclide i in a certain pathway j.

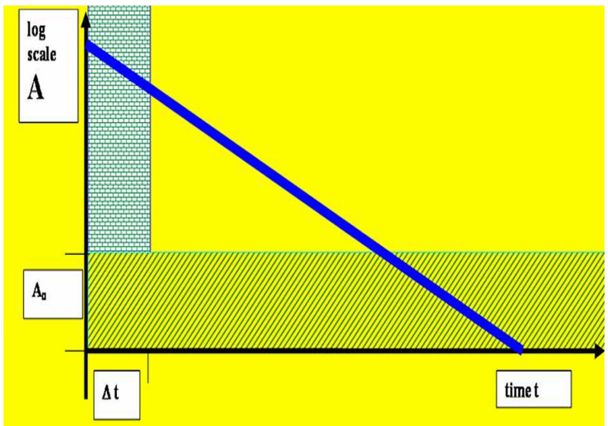


Fig.2 Schematic diagram, dose commitment: dose rate vs time, in terms of activity intake presented semi-logarithmic for convenience. The area below the line corresponds to the dose commitment. Two constraints have to be applied in most cases reducing the figure substantially: the area on the left side corresponds to the dose not becoming incurred because of retention at the disposal site during Δt, and the area at the bottom is corresponding to an activity concentration lower than the variation of natural background
More details on this consideration can be found in /Ts 05/.

3. Communication in handling numbers with given uncertainty and variability

It is important to clarify the concept of uncertainty by distinguishing uncertainty and variability. Even though both aspects have the same effect of making the prediction of actual health consequences for individuals difficult, a distinction is crucial, in particular for communication efforts and to forward understanding of the problem.

Uncertainty describes a lack of fundamental knowledge.

Variability describes the heterogeneity with respect to some “risk”-related characteristic.

Another description that clarifies these concepts is following/Vo 00/:

- **Uncertainty** is the assessor’s lack of knowledge (level of ignorance) about the parameters that characterize the physical system that is being modelled. Uncertainty is by definition subjective since it is a function of the assessor, but there are techniques available to allow one to be “objectively subjective.”
- **Variability** is the effect of chance and is a function of the system. It is not reducible through either study or further measurement, but may be reduced through changing the physical system.

Table 1 gives an overview of the different sources of uncertainty and variability.

Table 1: Sources of uncertainty and variability

Sources of uncertainty	**Sources of variability**
Lack of scientific data	Variability of dose rate or contamination in space/time
Imperfect or incomplete knowledge about parameters	Variability of exposure conditions across the population (e.g. individual shielding and living habits, meteorological conditions)
Lack of confidence in available science	Duration of follow-up
Definition of assessed response	Variable individual sensitivity to radiation
Latency period of health effects	Exposure of different age groups
Problems in sampling like insufficient sample representativeness	Inherent randomness of the world

It is important to be aware that uncertainty is subject of improvement, variability is not. These considerations apply in general, but the key parameters are dependent on the exposure mode, where continuous and short term exposure are to be considered. In emergency conditions, additional constraints apply. The probability of occurrence of an accident introduces obviously an additional uncertainty into the consideration of both the probability that the accident occurs at all to the prediction of exposure conditions and consequences. In addition, decisions on possible countermeasures are often not just yes/no but also yes/no/wait for better knowledge to reduce unacceptable uncertainties.

4. Risk perception and modes of express risk

4.1 Definition

Unfortunately, there is no agreed general definition of the term “risk”, which has a large number of meanings ranging from qualitative statements to the expression of certain numbers, see /Li 94/. In the following, the term “risk” is used as associated that some consequence might happen with a certain probability, and that a numerical value can be given.
In general, the term “risk” was implemented generally into discussion in the mid-1970s, mainly in association with nuclear energy /Wi 05/. However, the ICRP implemented already in /IC66/ the concept of risk including “The acceptable risk”. The term was not defined too precisely, just as:

> “*that any exposure to radiation may carry some risk for the development of somatic effects, including leukaemia and other malignancies, and of hereditary effects”*

Some more insight in this issue can be found in / Li 96/.

4.2 Different meaning of absolute and relative risk

The risk arising from a given practice can be expressed as a single number or with reference to a common practice**.** The two possibilities have some peculiar properties, where the most important are that the first gives no chance to establish a relation and hence an impression to other practices and hence conceivability. This is important as a “zero” risk is not existing, and the second provides a relation, but the reference risk is also uncertain.

Table 2: Example: possible consequence of single radiological examinations. This example is taken for easy comparability and because the procedures are standardized and there are only a

small number of influencing parameters. The table shows both relative (in relation to a chest standard investigation and natural background) and absolute risk as well as categories in order of magnitude/Ts 97/

Investigation	effektive dose [mSv]	Risk[1] [2]	Safety[2]	Equivalent of chest X-ray	Equivalent duration of natural background of 3 mSv/a
Enteroklysma	12,5	$0,9.10^{-3}$	0,9991	250	4 y
		1/1000	**0,9990**		
CT abdomen	10	7.10^{-4}	0,9993	200	3 y
NATURAL BACKGROUND	3 mSv/a				1
Thorax, fluoroscopy	0,6	42.10^{-6}		12	70 d
		1/100000	**0,999990**		
Skull	0,06	7.10^{-6}	0,999996	1,2	7 days
THORAX	0,05			1	6 days
limbs and joints	0,002	$< 2.10^{-6}$	0,9999998	0,05	< 1 day

[1]) cancer risk, single event probability, male patients, mortality
[2]) Risk and Safety are related by "framing". This term is used to express a logically equivalent information in different ways /Sl 96, Gi 03/. Communication in terms of "safety" might be advantageous to avoid the use of small numbers which approaches the border of perception. Although frequently used, the prediction of hypothetical "number of death" derived by a certain exposure in a certain population by applying "risk factors" is purely striking and not to be used, see 2.1. Another but different meaning of absolute and relative risk is shown in 5. Some recent papers discuss the question whether it is reasonable at all to include numbers in risk communication /Ed 02, Sj 00, Sj 02, Ap 04/. However, this approach is obviously not always appreciated by natural scientists.

5. Perspectives on "risk" and "risk communication" introduced by parties in the risk debate /Ta 04a/

Risk communication is most commonly perceived, on the one side, as the process of conveying the scientific background of risk decisions, and on the other side, as a synonym for participation. Risk communication is usually aimed either at increasing risk acceptability or decreasing the risk. Other aims, usually not mentioned in the sphere of natural sciences, include the control of the technology in concern, redistributive ends, and all kinds of political outcomes. Thus one is dealing with a teleological concept. The aims being highly diverse and contradictory, the field of risk communication finds itself, ironically, under sometimes fierce debate. It is concluded that: "a neutral definition of the objective of risk communication and its tasks hardly can be given, since they depend on different and sometimes conflicting interests and motivations of those who communicate." The issue is further aggravated by the prevailing gap between natural and social sciences. Futile are the mutual accusations of irrationality: frequently also natural scientists have been accused in these terms for their alleged one-sidedness in focusing only on what is quantifiable. Futile, because a multifaceted phenomenon calls for plural approaches, not the singling out of disciplines as inappropriate. "There must be only a very few real problem areas that can be adequately treated within the confines of a single discipline, and the subject of technological risk … is certainly not one of them."

Table 3. Risk perspectives.

	objective risk	subjective risk	constructivist risk
meaning	potential harm	potential cost	social code word
measure	probability × consequences	expected utility (preferences)	extent of debate
disciplines of origin	natural sciences	economics, psychology	social sciences
applied in	insurance, law, politics	law, politics	politics
uncertainty	lack of knowledge	limitation of perception	necessity of value judgments
variability	inherent limitation of precision	problem of aggregation	social relativism

In the literature, three entirely different and to a certain extent contradictory perspectives can be identified. In table 3 they are compared, in particular according to the meaning and consequence of uncertainty and variability within these perspectives. Table 4 shows concers of cultural prototypes.

Table 4. Concerns of cultural prototypes.

Prototype	Concern	attribute
Hierarchy	is it a threat to the social order?	subversive
Fatalism	is it a threat to the natural order?	immoral
egalitarianism	is it a threat to social equity?	unjust
individualism	is it a threat to individual rights?	coercive

Meaning of “Objective”and “Subjective” as social perspective

“Objective” risk refers to the numerical determination of probability values and consequences in terms of incidence. “Subjective” risk describes the individual assignment of a cost to potential harm and thus includes personal factors not covered in the prior concept like stress, fear, and all kinds of value preferences. Finally, according to the concept of “constructivist” risk, risks are regarded as social constructs, i.e. phenomena that appear mainly due to social processes. The risks that are ascribed to certain technologies would thus not merely be a representation of manifest probabilities, nor reducible to individual preferences, but would represent cultural constructs to deal with problems of decision making under uncertainty about technologies. The term “constructivist” may not find unanimous acceptance, for it is often regarded as a denial of the reality of risks. This is why the perspective on risk as a social construct receives little attention among natural scientists and engineers, which as a consequence leads to lack of interdisciplinary exchange and thus to misunderstanding, typically even more so on the side of social scientists. Both sides often fall constructivist risk was an alternative for assessment and evaluation. On the contrary, it is an answer to an entirely different question. Natural scientists are not biased in measuring potential harm through manifest consequences, as mortality and morbidity, rather than

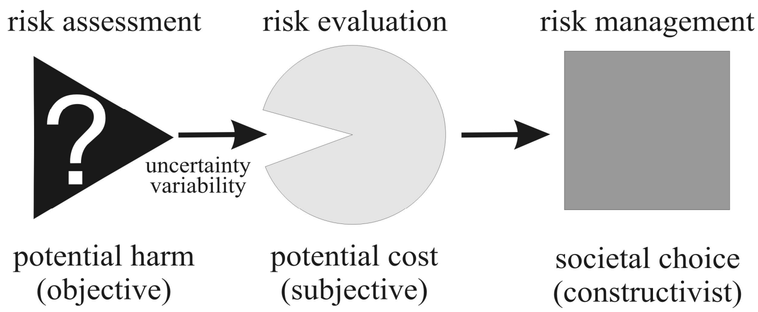


Fig. 3. Stage model for risk perspectives

through sociological surveys on the amount of media coverage. At the same time, social scientists are not necessarily unscientific in explaining the social phenomenon of risk not through epidemiology but through cultural patterns. The view that results from a first effort to combine the above perspectives into one consistent stage model is illustrated in Fig. 3. This linear model tries to incorporate insights from all disciplines at the corresponding stage. Risk assessment involves hazard identification and the quantification of probabilities (risk estimation). Risk evaluation involves a judgement of the risk by comparison with other risks and of costs and benefits. This relies on subjective values and preferences. Finally, risk management involves a decision about the technology in concern, a “public choice.” This relies on socially constructed notions of “acceptability.” Uncertainty and variability are included as factors that blur causal relationships. Risk communication is regarded as the instrument to smooth the succession of these stages and reduce uncertain and conflicting views to bimodal decision alternatives. What we learn from this concept is that the debate on whether risks are “objective” or “subjective,” and whether perception is determined by “nature” (innate human heuristics) or “nurture” (culturally acquired heuristics) is pointless. Nevertheless, the above concept has many flaws, in particular regarding the role of uncertainty and variability. Causal relationships are not only blurred but actually loosened. Efforts to link objective harm and subjective perception have largely failed, risks are not only socially amplified but their perception is too variable to establish significant relationships at all. In addition, the link between individual preferences and societal choices is in no way as clear as naïve views on democracy suggest. Arrow demonstrated that the aggregation of individual preferences may lead to inconsistent value structures and thus indecisive situations. It has often been attempted to fix these loosened causal relationships by introducing subjective and constructivist aspects as additional uncertainties in objective formalisms. Rowe is a remarkable example for a comprehensive approach along these lines. However, these efforts are bound to fail and may even be subject to derision, when the scientist takes the criticism for an “objective” approach and puts it into a variable at the end of a neat formula.
Table 5 shows some important advocate groups in “risk debates.”

Table 5: Important advocate groups in “risk debates.”

advocates	**dominant bias**	**interests**
scientists	Order	prestige, career
institutions	Collective	career, life and growth of bureaucracy
activists	Individual	“not in my backyard!”
journalists	choice (= challenge the order)	market share of media, news-value

Politics is not included in the table as it has some influence to all groups, and sometimes groups such as scientists serve as political tools. In Austria, a university institute was founded just to support the opinion of the government, as expressed by the competent minister in a press release.

Tab. 6: Exemplary successful memes.

Group of advocates	**exemplary successful memes**
Scientists	"everything is connected to everything else"
Institutions	"market failure"
Activists	"small is beautiful"

The first problem of uncertainty and variability in emergency situations is that uncertainty in assessment and in the prediction of consequences tends to increase public concern, as shown by the psychometric theory of risk perception (see for example /Ka 91/

Table 7: Main advocates in risk communication.

advocates	**dominant bias**	**interests**	**exemplary successful memes**
scientists	order	prestige, career	"everything is connected to everything else"
institutions	collective	career, life and growth of bureaucracy	"market failure"
activists	individual	"not in my backyard!"	"small is beautiful"
journalists	choice (challenge authority)	market share of media	"big business and big government are not accountable or trustworthy"

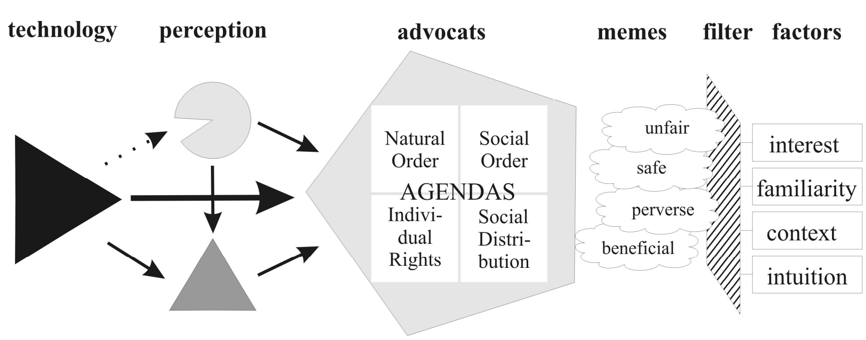


Fig. 4:. The selection of memes in risk communication.

6. Irrational issues

As an example, even somewhat irrational issues have to be taken into account in communication as fear of acronyms, see http://www.sirc.org/articles/fear_of_acronyms.shtml

7. Recent developments

7.1 Terms of Communication

An impressive number of papers were published recently which focus the question at hand mainly applied in medicine, addressing a wide range of issues as frequency of certain side effects after prescription of a drug, mammography versus breast cancer, hormone therapy, etc. Some interesting issues are suggested and thoroughly discussed as "Impact numbers INs" /He 02, He03 / as "PIN", population impact number, or "DIN", disease impact number". It might be challenging to adopt this development with modifications and constraints as required in radiation protection, but issues addressed in 6. have also to be taken into account.

7.2 Probability

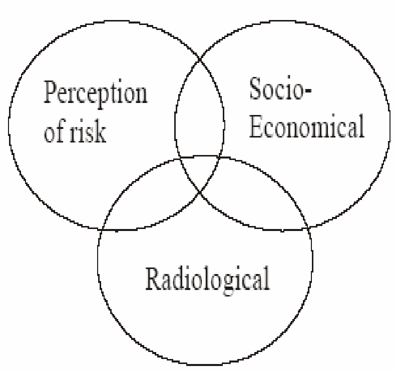
Different numerical expressions might foster confusion in communication:/Gi 03/

- Single event probabilities (used by frequentists)
- Conditional probabilities (used by Bayesians)
- Relative risks (used in a sense to refer to a specifically selected reference population)

It is therefore necessary to develop the concept of risk in a more advanced way than by single event probability.

8. Conclusions and outlook

This paper presented an overview on some issues which might be taken into account in improvement of risk communication. Risk communication in the future can be managed effectively only when the different contributing parties adjust their way of thinking and their language. This requires from all parties a departure from a well established and hence rutty mode of thinking. This can be done with some good will, provided that recent developments are taken into account, as well as the requirements of others parties. This can be managed without abandoning the own professional background. This paper cannot give guidance for this, but addressed some issues to be taken into account. Simple presentations of risk can help professionals and the public move from innumeracy to insight. Instruction in efficient communication of statistical information should be part of advanced radiation protection training, instead of submissive obeying to predefined limits. After some time, eventually, the overlapping area of the three fields in the figure left will become gradually larger.



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