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Biological Effects of Low Level Exposures

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RISK COMMUNICATION AND THE CHALLENGE OF HORMESIS

INTRODUCTION

Current approaches for estimating risk utilize various assumptions concerning the nature of the dose-response relationship. The two most prominent dose response models involve the traditional threshold model which has been typically applied to agents considered non-carcinogens and the low dose linearity model which has been applied to carcinogens. Risk communication strategies have been designed around the estimates of risk derived from such biostatistical models. The concept of hormesis challenges both the threshold and linear models by claiming that the fundamental shape of the dose response relationship is U-shaped. Acceptance of hormesis suggests that low doses of toxic/carcinogenic agents may reduce the incidence of adverse effects. While the debate over which model is the most correct continues, it is timely that a more serious exploration of the risk communication implications of hormesis be undertaken. Consequently, this issue of the BELLE Newsletter is devoted to a detailed evaluation of how the concept of hormesis impacts risk communication strategies and conversely how risk communication concepts and methods impact thinking concerning hormesis. Professor Ortwin Renn was invited to develop a broad and integrative white paper on hormesis and risk communication. Once his paper was received it was independently critiqued by 5 scientists of international reputation. Finally, Professor Renn was given the opportunity to respond to these eight invited critiques of his white paper. The entire package of Professor Renn's white paper, expert critiques and his final rejoinder now follow.

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HORMESIS AND RISK COMMUNICATION

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1. INTRODUCTION

Risks from chemicals and physical hazards such as radiation may influence the physical, natural and human environment. Comparative cross-cultural studies (Rohrmann and Renn 2000) confirm that people all over the world are concerned about the health risks, environmental impacts and the safety of chemical and physical hazards. Risks from these sources are difficult to communicate because they are usually effective only over a longer time period, may induce negative impacts only in combination with other risk factors (such as lifestyle and nutrition) and can hardly be detected by human senses (Peltu 1988). Risk communication in this area needs to address the following major challenges:

- to explain the concept of probability and stochastic effects;
- to cope with long-term effects:
- to provide an understanding of synergistic effects;
- to improve the credibility of the agencies and institutions that provide risk information (which is crucial in situations in which personal experience is lacking and people depend on neutral and disinterested information).

Given these circumstances, risk communication is a necessary and demanded activity, which is partly prescribed by governmental laws and regulations, partly required by public pressure and stakeholder demand (stakeholder are socially organized groups that are or perceive themselves as being affected by the decision). In the light of new activism by consumer and environmental groups, private companies as well as governmental agencies feel obliged to provide more information and guidelines for consumers, workers and bystanders. This new challenge is embedded in a new industrial and political paradigm of openness and "right to know" policy framework (Baram 1984). In addition, globalization and international trade make it mandatory that risky activities are identified and regulated, hazardous facilities licensed and risk-bearing products properly labeled. All people exposed to risks should have sufficient information to cope with risk situations.

There are different sources for potential human or environmental damage that have been associated with the use of chemical and physical hazards. Among them are:

- endocrine disrupters (pseudo-estrogens)
- pesticides and herbicides
- softeners
- POPs
- Genetically engineered products
- Carcinogenic substances
- Complex mixtures
- Ionizing and non-ionizing radiation
- Exposure to electromagnetic fields

The risks associated with these hazardous side effects of industrial production and consumption are subject to the risk assessment activities undertaken by scientists within industry, universities and regulatory agencies. The normal assessment process follows a well-defined protocol of toxicological or epidemiological procedures, which ensure that regulatory or other management actions are based on significant evidence of a potential damage (National Research Council 1983). Until recently, the common wisdom of risk assessors in the field of chemicals have been that it is prudent to distinguish two types of chemicals: the first groups includes potentially toxic substances that may cause physical damages to human being or the environment above a certain threshold of exposure or intake. Risk management agencies are therefore advised to make sure that the concentration levels would never reach or even surpass these thresholds. With respect to human health, additional safety factors (of 10 or 100 or more) have been applied to adjust for remaining uncertainties and inter-individual variation. The second class of chemicals is believed to cause harm at any level above zero (stochastic effects). The regulator has been advised to minimize exposure of people to these stochastic risks and define a level of tolerable risk based on probabilistic risk assessment (such as defining a level of 10 to the minus 6 per year for a tolerable risk level for the general population). This conventional view of toxicity and risk has been challenged by the recent investigation about potential beneficial effects of exposure to otherwise hazardous substances at very low levels of concentration. These effects have been subsumed under the heading of hormesis (Calabrese et al. 1999).

Hormesis has been defined as a dose-response relationship in which there is a stimulatory response at low doses, but an inhibiting response at high doses, resulting in a U- or inverted U-shaped dose response (Calabrese and Baldwin 2001). This hormesis effects have been studied for more than two decades (see for example Stebbing 1998). Toxic agents that are detrimental to human health above certain threshold levels may induce positive effects at a dose that is significantly lower than the NOAEL level. Man recent publications (including those collected in this volume) provide impressive evidence for the existence of such positive stimulatory

effects of low dose exposure. Calabrese and Baldwin report that 19.5% of 1089 samples showed a clear positive hormesis effect, in 80% of the cases such hormesis effect could not be statistically proven (no significant difference to the control group), yet only 0.6% turned out to be false-positive candidates (Calabrese and Baldwin 2001, p. 350). In spite of the evidence for hormesis effects, the topic is still a matter of high controversy among toxicologists.

The picture becomes even more complicated if one combines hormesis with stochastic risk agents. Most dose-response models assume a finite probability for developing a detrimental health effect (most often carcinogenic and/or mutagenic effect) as a result of any exposure above zero. These stochastic effects are due to the possibility of irreversible damage to the DNA at an exposure level of a single molecule. If the hormesis hypothesis would also hold true for carcinogenic substances or radiation, the probability for a tumor inhibition may outweigh the probability of a tumor induction. Under these circumstances the situation might occur that a single individual may develop a tumor as a result of an exposure to a very small dose of a carcinogen, while the majority of people may experience positive inhibitory effects. Similar dilemmas can also occur with simple toxic substances if individuals vary in their sensibility towards the beneficial range of exposure in which the positive effects are observed. One individual may experience the positive effects at a different dose range compared to another more sensitive individual. How should a regulator evaluate such a situation? Is it justified to endorse exposure to small concentrations of a proven carcinogenic or toxic substance if there is a chance that a small number of people will probably be negatively affected while the majority enjoys the potential benefits? This question raises equity concerns and leads to difficult policy dilemmas.

Until now, regulatory agencies have not addressed this new challenge or adjusted their routines for regulating such substances. All regulatory regimes in the world are still based on the traditional risk model: either to define a standard based on thresholds modified by appropriate safety factors or to define tolerable risk levels for stochastic risks caused by chemicals or physical agents (such as radiation). If the hormesis thesis were to be recognized by the scientific community as the new valid paradigm of does-effect relationships, regulatory systems would be in need for new management rules to deal with the potentially positive effects of low dose exposure.

If we turn to the public, the effect of the debate on public opinion so far is confusion. Most people simply demand healthy and safe products and like to act on the assumption "better safe than sorry" (Lee 1981). This attitude is likely to encourage regulators to err on the safe side and continue to "ignore" potential hormesis effects. At the same time, however, people as consumers have an interest in a large variety of products, low prices and job opportunities. Unless risk information explicitly addresses aspects of potential benefits and social needs, it will not correspond to the expressed and revealed preferences of the people it is supposed to serve. For this reason, it is important to address the issue of how to communicate this complex picture to stakeholder groups as well as to the public at large even if risk regulators at this point hesitate to draw any conclusions or regulatory implications from the studies demonstrating hormesis effects.

The question is: How should risk communication be arranged in a situation of high confusion, lack of empirical certainty about the effects, major policy dilemmas and significant equity problems? In 1998 I published a paper on the implications of hormesis on risk perception and communication (Renn 1998a). This paper started with the statement: "According to my knowledge the implications of hormesis for risk communication have not been addressed in the social science literature to this date. ...Empirical studies on the perception of hormesis are needed; so far one can only draw analogies to similar situations, such as the perception of instructions on drug use, the evaluation of homeopathic doses, or the insights from psychosomatic investigations". In the time between 1998 and 2002 this gap has not been closed. The situation has remained unchanged. Empirical studies on the perception of hormesis among different groups of society or on preferred management options under the assumption of hormesis being effective are still missing.

This is why this article relies as much as its predecessor on analogies and deductions from theoretical deductions and analogies from empirical studies on risk perception and communication in general. Insights from a wealth of empirical investigations about risk perception and risk communication might shed some light on how people are likely to respond to hormesis and what kind of risk communication should or could be implemented It is important to deal with risk communication problems before the scientific community has made up its mind and either confirmed or rejected the hormesis hypothesis. First, the scientific community may never be able to provide sufficient proof for one side or the other. Society has no other choice but to live with ambiguities. Second, the structure of pluralist societies implies that major scientific controversies will find their way into the public debate before the issues are resolved in the scientific community. For both reasons, it may be valuable to analyze the potential perceptions and responses to the hormesis thesis and to draw some inferences about risk communication needs.

This paper summarizes the main results of risk communication research and applies these results to the question of hormesis. First, the paper addresses the main context variables that impact on the success or failure of any risk communication program. Those refer to the (i) levels of the risk debate, (ii) the socio-political style of regulation, (iii) different types of audiences, and (iv) subcultural prototypes. Second, the paper will deal with the major functions of risk communication: (i) dealing with public perception, (ii) gaining trust and credibility,

(iii) involving stakeholders in the communication process. The last section will draw some conclusions for improving risk communication on issues of hormesis.

2. CONTEXT MATTERS: RISK COMMUNICATION IN PERSPECTIVE

2.1 The three levels of risk debates

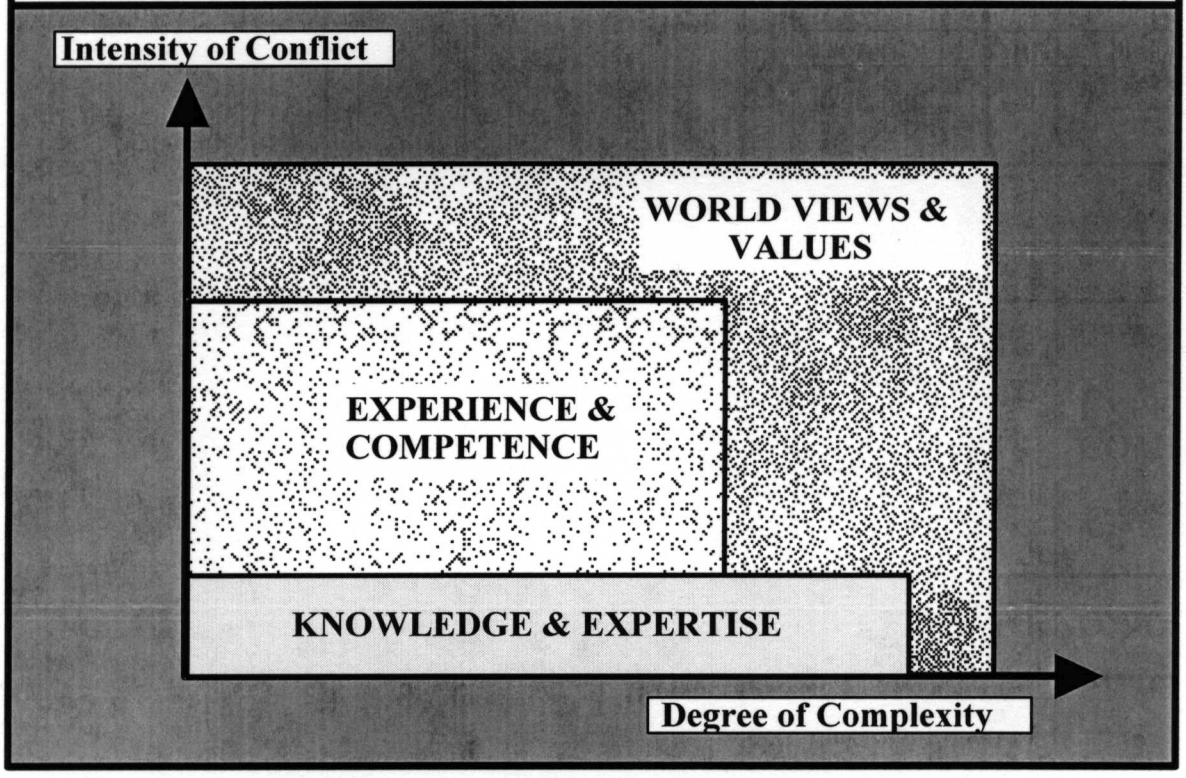
One of the major goals of all risk communication programs is to reconcile the legitimate intention of the communicator to get a message across with the equally legitimate set of concerns and perceptions that each persons associates with the risk agent. It is obvious that technical experts try to communicate the extent of their expertise while most observers are less interested in the technical details but want to communicate about the likely impacts of the exposure to the risk for their health and well-being. Regardless of the intension of the communicator, the first step in any communication effort is to find a common denominator, a common language, on which the communication can proceed and develop.

Finding a common denominator or a common wavelength requires a good understanding of the needs of the audience. Having investigated many different types of audiences and issues, our own research has lead us to a classification of typical communication levels that are normally addressed during a risk debate (based on: Funtowicz and Ravetz 1985, Rayner and Cantor 1987, first published in Renn and Levine 1991; refinement in Renn 2001). These levels refer to:

- factual evidence and probabilities;
- institutional performance, expertise, and experience;
- conflicts about worldviews and value systems.

Figure 1 is a graphical representation of this model using a modified version of the original categories. An overview of the three levels of risk debate and their requirements (including elements for evaluation) is also illustrated in Table 1. The first level involves factual arguments about probabilities, exposure levels, dose-response-relationships and the extent of potential damage. This level also includes the possibility to communicate about the technical aspects of hormesis. One could draw analogies to known positive effects of food ingredients (such as trace elements) and extend this discussion to other substances that have not been associated with positive effects so far. The function of communication on the first level is to provide the most accurate picture of factual knowledge including the remaining uncertainties and ambiguities. Even if the objective here is to transfer knowledge or create a common understanding of the problem, an attempt of

Fig. 1: The Three Levels of Concern in Risk Debates



two-way-communication is needed to make sure that the message has been understood and that the technical concerns of the audience have all been addressed.

The second, more intense, level of debate concerns institutional competence to deal with the risks. At this level the focus of the debate is on the distribution of risks and benefits, and the trustworthiness of the risk management institutions. This type of debate does not rely on technical expertise, although reducing scientific uncertainty may help. Risk communication on the second level requires evidence that the risk managers of private institutions as well as public agencies have met their official mandate and that their performance match public expectations. In a complex and multifaceted society such evidence is difficult to provide.

With respect to hormesis, the second level requires permanent assurance that risk management agencies are capable and willing to restrict exposure to hazardous materials or substances when concentration levels are above NOAEL levels, while allowing or even promoting such an exposure when levels reach concentrations that are likely to trigger positive stimulations. Many people may doubt the capability of management institutions to be reliable in making this distinction even if they believe in the hormesis effect. They lack trust in the management performance of the regulator and may opt to retreat to the old paradigm of numerical intervention standards for the sole reason that standards based on threshold and maximum intake provide clear and rigid guidelines for controlling and supervising the performance of risk agencies (Slovic 1993). Gaining institutional trust in such situations requires a continuous dialogue between risk managers, stakeholders, and representatives of the public. In such dialogues, trust can be gained by showing that the risk management institution has been and continues to be competent, effective, and open to public demands. This will be a major challenge in today's climate of distrust in regulatory agencies when it comes to a sophisticated protocol for incorporating hormesis effects into the regulatory framework.

At the third level the conflict is defined along different social values, cultural lifestyles, and their impact on risk management. In this case, neither technical expertise nor institutional competence and openness are adequate conditions for risk communication. Dealing with values and lifestyles requires a fundamental consensus on the issues that underlie the risk debate. This implies that the communication requirements of the first and second level, i.e. risk information or involvement in a two-way dialogue, are insufficient to find a solution that is acceptable to all or most parties. With respect to hormesis, third level debates may focus on the suspicion that the hormesis thesis comes across as a convenient strategy for industry to refuse responsibility and accountability for

TABLE 1: The three levels of risk debate and their communication needs and evaluation criteria

Levels	Issue of Conflict	Communication Needs	Evaluation Criteria
1	Technical expertise	Information transfer	- access to audience - comprehensibility - attention to public concerns - acknowledgment of framing problems
2	Experience, trustworthiness	Dialogue with stakeholders and the public	- match between performance and public expectations - openness to public demands - regular consultations - commonly agreed procedures for crisis situations
3	Values, Worldviews	Dialogue, Mediation	- fair representation of all affected parties - voluntary agreement to obey rules of rational discourse - inclusion of best available expertise - clear mandate and legitimization

negative impacts of pollution. By re-interpreting pollution as having some positive effects on human health, they can avoid costly control technologies and defer compensation payments or legal litigation. Many risk analysts from environmental groups have been alerted to this potential interpretation of hormesis and have rejected the idea basically on the ground that it might provide a free rider position to potential polluters. This interpretation of hormesis may or may not be accurate or adequate, the main point here is that it triggers a debate on the third level and fuels (and reinvigorates) the old controversy between the right and the left, between industrialists and environmentalists and other value-driven groups (compare Calabrese and Baldwin 2000).

Third level debates require new unconventional forms of stakeholder involvement such as mediation, citizen panels, open forums with special groups and others. The main task of such exercises is to reflect on the relevant values that apply to the situation; to search for solutions that all participants find acceptable or at least tolerable and to build an atmosphere of mutual trust and respect.

There is a strong tendency for risk management agencies to re-frame higher level conflicts into lower levels ones: third level conflicts are presented as first or second level conflicts, and second level conflicts as first level. This is an attempt to focus the discussion on technical evidence, in which the risk management agency is fluent. Stakeholders who participate in the discourse are thus forced to use first level (factual) arguments to rationalize their value concerns. Unfortunately, risk managers often misunderstand this as "irrationality" on the part of the public. Frustrated, the public retreats to direct action and protest rituals. At the end there are only disillusion and distrust of the system.

2.2 The socio-political context

One of the most important context variables in risk management and communication refers to the socio-cultural conditions under which the risk communication program is launched. But cultural diversity is less of a challenge than many social scientists claim. Most analysts agree that many of the cognitive factors that govern risk perception are similar throughout the world (Renn and Rohrmann 2000). In addition, risk management styles are also becoming more homogenous as the world becomes more globalized. To a large extent this is due to the role of science in proposing and justifying regulatory standards. Research establishments as well as universities have evolved into multinational and cosmopolitan institutions that speak identical or at least similar languages throughout the world and exchange ideas on worldwide communication networks (Cadiou 2001). This is not to say that national culture and heritage have not formed individual scientists and influenced their style of research and writing. As a collective enterprise, however, science has become one of the most powerful and effective global agents for providing a universal base for generating and evaluating systematic knowledge. If "hard" evidence is needed anywhere in the world, one can be sure that scientists will be involved in providing the expertise, and that this expertise will be constructed and challenged on the ground of internationally accepted rules of inquiry.

In this sense, any new scientific results on hormesis will be disseminated through out the world and absorbed by risk scientists and risk managers alike. The international science community forms a unique body of cross-cultural and global players for framing and designing knowledge questions as well as establishing norms for judging evidence and proof. In addition, if a subject is a seasonal topic within the scientific community, it will reach public domain almost instantly. Hormesis will either remain a subject of a small group of dedicated scientists, or —once established in the respective communities- become a global theme. That means: all regulatory regimes in the world will be forced to deal with the issue.

In spite of all tendencies towards global scientific practices, risk management depends, not only on scientific input. It rather rests on three components: knowledge, legally prescribed procedures and social values. Even if the same knowledge is processed by different regulatory styles, the prescriptions may differ in many aspects concerning selection rules, interpretative frames, different action plans for dealing with evidence, and others (Brickman et al. 1985). National culture, political traditions, and social norms influence the mechanisms and institutions for integrating knowledge and expertise in the policy arenas. Policy analysts have developed a classification of governmental styles that highlight different clusters in applying these four sets of rules (O'Riodan and Wynne 1987; Renn 1995). These styles have been labeled inconsistently in the literature, but they refer to common procedures in different nations. These styles are summarized in Table 2.

An open forum in which different actors compete for social and political influence in the respective policy arena characterizes the 'adversarial' approach. The actors in such an arena use and need scientific evidence to support their position. Policy makers place specific attention to formal proofs of evidence because social groups on the basis of insufficient use or negligence of scientific knowledge can challenge their decisions.

Risk communication is essential for risk regulation in an adversarial setting. First, all stakeholders regard it as their right to be informed about all potential side effects. Furthermore, they demand to be consulted within the deliberation process. Even if the debate is only about factual issues, stakeholder involvement is a mandatory element of risk management within this socio-political context. Information on hormesis may be particularly difficult to convey in adversarial settings. First, adversarial debates amplify conflict and ambiguity. As long as people have doubts that the positive impacts

TABLE 2: Characteristics of policy making styles

Style	Characteristics	Role of risk communication
Adversarial approach	open to professional and public scrutiny	main emphasis on mutual agreements on scientific evidence and pragmatic knowledge
	need for scientific justification of policy selection	integration of adversarial positions through formal rules (due process)
	precise procedural rules	little emphasis on personal judgment and reflection on the side of the risk managers
	oriented towards producing informed decisions by plural actors	stakeholder involvement essential for reaching communication objectives
Fiduciary approach (patronage)	closed circle of "patrons"	main emphasis on enlightenment and background knowledge through experts
	no public control, but public input	strong reliance on institutional in-house "expertise"
	hardly any procedural rules	emphasis on demonstrating trustworthiness
	oriented towards producing faith in the system	communication focused on institutional performance and "good record"
Consensual approach	open to members of the "club"	reputation most important attribute
	negotiations behind closed doors	strong reliance on key social actors (also non-scientific experts)
	flexible procedural rules	emphasis on demonstrating social consensus
	oriented towards producing solidarity with the club	communication focused on support by key actors
Corporatist approach	open to interest groups and experts	main emphasis on expert judgment and demonstrating political prudence
	limited public control, but high visibility	strong reliance on impartiality of risk information and evaluation
	strict procedural rules outside of negotiating table	integration by bargaining within scientifically determined limits
	oriented towards sustaining trust to the decision making body	communication focused on fair representation of major societal interests

may not materialize, they will rather opt for the "better safe than sorry" attitude. Secondly, adversarial settings facilitate distrust and skepticism with respect to institutional performance. It is clear that people will refuse risk management agencies to perform the complex task of measuring exposure and making the complicated decision on negative or positive impacts if they have no confidence in the competence and trustworthiness of the respective agency. Thirdly, an adversarial setting tends to stereotype the different positions. Hormesis lends itself to ideological debates. There is no doubt that this debate will take place once it becomes a new paradigm in risk assessment and risk management circles.

The strongest contrast to the adversarial approach is provided by the fiduciary style. The decision making process is confined to a group of patrons who are obliged to make the "common good" the guiding principle of their action. Public scrutiny or involvement of the affected public are alien to this approach. The public can provide input to and arguments for the patrons but is not allowed to be part of the negotiation or policy formulation process. The system relies on producing faith in the competence and the fairness of the patrons involved in the decision making process. Advisors are selected according to national prestige or personal affiliations. In this political context, stakeholder involvement may even be regarded as a sign of weakness or a denial of personal accountability. Risk communication in this context should be focused on the second level of the risk debate: to ensure the public that the risk management agencies have the scientific potential, the institutional means and the societal credibility to deal with all risk effectively. With respect to hormesis, one can infer that the fiduciary style would have the least problems with communicating the message of hormesis. If people trust their management agencies, they would also accept the idea that the wise managers will provide the right amount of a beneficial dose of an otherwise problematic substance. One could think in this respect of the analogy to fluoridation of drinking water: As Mazur has shown, this measure has been highly rejected in adversarial settings but was welcomed in high fiduciary contexts.

The two remaining styles are similar in their structure but they are not identical. The consensual approach is based on a closed circle of influential actors who negotiate behind closed doors. Social groups and scientists work together to reach a predefined goal. Controversy is not present and conflicts are reconciled on a one-to-one basis before formal negotiations take place. Risk communication in this context serves two major goals: it is supposed to reassure the public that the "club" acts in the best interest of the public good and to convey the feeling that the relevant voices have been heard and adequately considered. Stakeholder participation is only required to the extent that the club needs further insides from the affected groups or that the composition of the club is challenged.

The corporatist style is similar to the consensual approach, but is far more formalized. Well-known experts are invited to join a group of carefully selected policy makers representing the major forces in society (such as the employers, the unions, the churches, the professional associations, the environmentalists). Similar to the consensual approach, risk communication is mainly addressed to the outsiders: they should gain the impression that the club is open to all "reasonable" pubic demands and that it tries to find a fair compromise between protection and innovation. Often the groups represented within the club are asked to organize their own risk communication programs as a means to enhance the credibility of the whole management process. In this style all three levels of risk debates are often present with a strong emphasis on institutional credibility.

With respect to hormesis, both the consensual as well as the corporatist style will face series communication problems when trying to convey the message to the outside world. First, it may be difficult to reach a consensus even within the clubs, because the members represent strong constituencies to which hormesis may be difficult to sell. Second, the outside world is rather suspicious about the bargaining that occurs behind closed doors. Since hormesis is difficult to explain, the skeptics will find rich ground for using the hormesis debate as a battleground for more ideological struggles. In contrast to the adversarial approach, however, major agents in corporatist society have the position and the social recognition to act as catalysts for resolving these immanent conflicts.

These four styles cannot be found in pure form in any country. However, using such prototypes is helpful in characterizing and analyzing different approaches to policy making. The American system is oriented towards the adversarial style; the Japanese system is characterized by a strong consensual mode of using expertise. The policy style of northern Europe comes closest to the corporatist approach, whereas most southern European countries exercise a fiduciary approach. All these systems are in transition, however. Fiduciary systems tend to become more corporatist, and corporatist styles tend to become more adversarial. Interesting is the fact that the United States is trying to incorporate more consensual policies into its adversarial system, while Japan is faced with increasing demands for more public involvement in the policy process.

2.3 Different risk cultures

For risk communication to be effective, one needs to be aware not only of the regulatory climate and style of different societies, but also of the various subcultures within a society. It is therefore essential to tailor the content of the communication process to the interests and concerns of the different social and cultural groups within a society. Risk communication must refer to the arguments and cognitive maps that the different types of audiences understand and find "acceptable" or "reasonable". Often few words inserted in a conversation without

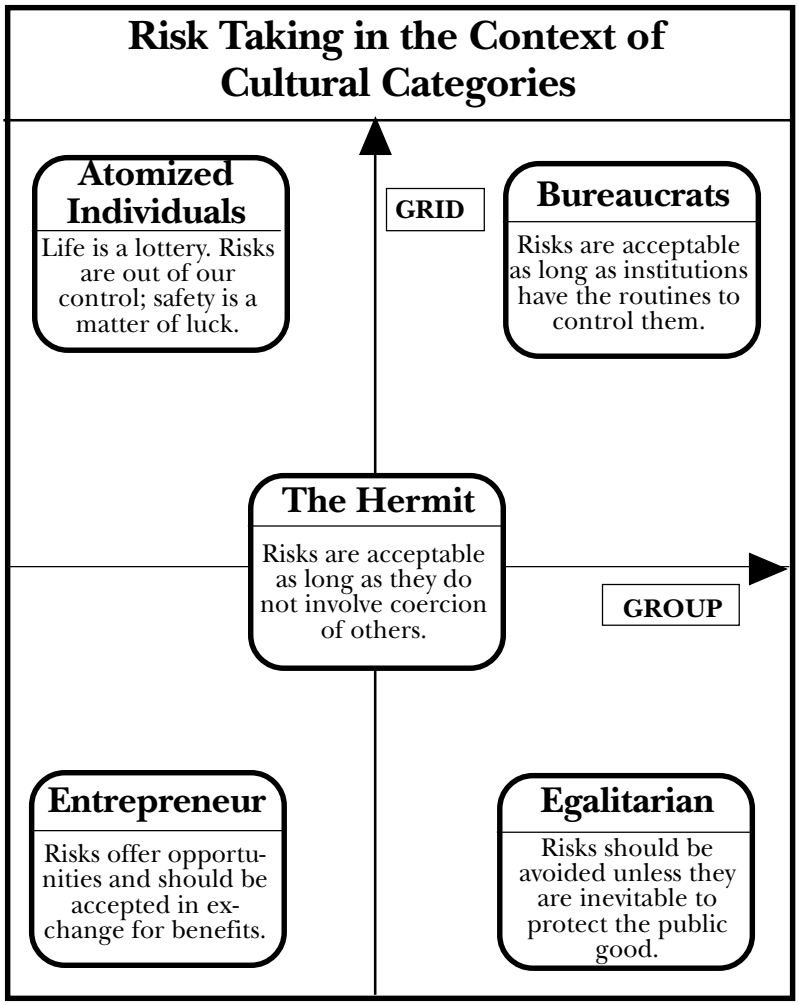
much further thought might ignite public outrage, whereas long arguments may not even be followed by those who are interested in the subject. Again it is futile to find a classification that provides a full representation of all potential audience types. But is has been helpful to work with a classification that has been labeled (in m understanding mislabeled) as cultural approach to risk.

A group of distinguished anthropologists and cultural sociologists such as Aaron Wildavsky, Mary Douglas or Michael Thompson, have investigated the social response to risk and have identified four or five patterns of value clusters that separate different groups in society from each other (Douglas and Wildavsky 1982; Rayner 1990; Thompson et al. 1990; Wildavsky and Dake 1990; Schwarz and Thompson 1990). These different groups have formed specific positions on risk topics and have developed corresponding attitudes and strategies. They differ in the degree of *group* cohesiveness (the extent to which someone finds identity in a social group), and the degree of *grid* (the extent to which someone accepts and respects a formal system of hierarchy and procedural rules).

These groups are: the entrepreneurs, the egalitarians, the bureaucrats, the stratified individuals, and -added in some publications-the group of the hermits. They can be localized within the group-grid space (see Figure 2). Organizations or social groups belonging to the *entrepreneurial* prototype perceive risk taking as an opportunity to succeed in a competitive market and to pursue their personal goals. They are characterized by a low degree of hierarchy and a low degree of cohesion. They are less concerned about equity issues and would like the government to refrain from extensive regulation or risk management efforts. This group contrasts most with organizations or groups belonging to the *egalitarian* prototype, which emphasizes cooperation and equality rather than competition and freedom. Egalitarians are also characterized by low hierarchy, but have developed a strong sense of group cohesiveness and solidarity. When facing risks they tend to focus on long-term effects of human activities and are more likely to abandon an activity (even if they perceive it as beneficial to them) than to take chances. They are particularly concerned about equity.

The third prototype, i.e. the *bureaucrats*, relies on rules and procedures to cope with uncertainty. Bureaucrats are both, hierarchical and cohesive in their group relations. As long as risks are managed by a capable institution and coping strategies have been provided for all eventualities, there is no need to worry about risks.

Bureaucrats believe in the effectiveness of organiza-



tional skills and practices and regard a problem as solved when a procedure to deal with its institutional management is in place. The fourth prototype, the group of *atomized or stratified individuals*, principally believes in hierarchy, but they do not identify with the hierarchy to which they belong. These people trust only themselves, are often confused about risk issues, and are likely to take high risks for themselves, but oppose any risk that they feel is imposed on them. At the same time, however, they see life as a lottery and are often unable to link harm to a concrete cause. In addition to the four prototypes, there may be a hybrid group called the *autonomous individuals or the hermit* who can be grouped at in the center of the group-grid coordinates. Thompson describes autonomous individuals as self-centered hermits and short-term risk evaluators. They may be also referred to as potential mediators in risk conflicts, since they build multiple alliances to the four other groups and believe in hierarchy only if they can relate the authority to superior performance or knowledge

This theory has been criticized on several grounds (Nelkin 1982; Sjˆberg 1997). This is not the place to review the critical remarks and the counter-evidence provided by many scholars. The debate is still proceeding without a clear consensus in sight. Most risk communicators have assured us, however, that this classification has helped them tremendously in preparing communication programs for different audiences. There is sufficient anecdotal evidence that people with an entrepreneurial attitude react very differently to specific arguments compared to people with an egalitarian or bureaucratic attitude. For example, a reference to cost-benefit ratios makes perfect sense when presented to an audience of entrepreneurs but would trigger outrage when being referred to in a group of egalitarians.

The relevance of the five groups distinction for communicating hormesis is obvious: Entrepreneurs will probably welcome this new evidence because it is a strong proof for their conviction that taking limited risks makes life exciting and provides strong benefits to the risk taker in the long run. If, at the end, this risk seeking turns out to be even beneficial for one's health, one could not get a better argument for pursuing the entrepreneurial path to "happiness". The opposite is true for the egalitarians: They strongly believe that nothing can be beneficial in low doses what is bad in large doses. Specifically they will argue that it is wise to avoid a risk if there is even a chance that it might be detrimental to one's health. Egalitarians also tend to be very suspicious towards risk management agencies because they believe these agencies are influenced by powerful interest groups (in particular those who pursue the entrepreneurial ideas). Bureaucrats would see hormesis as a major challenge, since it makes management much more difficult. Yet if they were able to see a consistent and implementable path to incorporate hormesis into the dominant regulatory regime, they might be less reluctant to avoid the issue (Bureaucrats hate to fight, they rather ignore issues when they don't like them). The two remaining groups are of less relevance here: they see risk as a manifestation of fate and would probably be not attentive to any hormesis debate.

2.4 Different types of audiences

The last context variable that is important to mention here is the interest of the target audience in the issue. As pointed out before, the group of the atomized individuals will have little if any interest in the debate on hormesis. For practical purposes of preparing risk communication programs, it is helpful to have a classification of potential audiences at hand, even if each audience is certainly unique. The classification that is offered here refers to two dimensions: the interest of the audience in the subject and the type of arguments that different audiences may find appealing or, at the other end of the spectrum, appalling. For the first classification, i.e. specifying different degrees of interest, our preferred choice is the "elaboration-likelihood model of persuasion," developed by Petty and Cacioppo (1986). The major component of the model is the distinction between the *central or peripheral route of persuasion*. The central route refers to a communication process in which the receiver examines each argument carefully and balances the pros and cons in order to form a well-structured attitude. The peripheral route refers to a faster and less laborious strategy to form an attitude by

TABLE 3: Clues relevant for peripheral communication

Type	***Examples***
Source-related	credibility, reputation, social attractiveness, perceived impartiality
Message-related	length, number of arguments, package such as color, paper, graphical appeal, illustrations, layout), presence of highly appreciated symbolic signals
Transmitter-related	perceived neutrality, past performance of transmitter, perceived credibility, reputation
Context-related	crisis situation, conflict situation, dependence on "zeitgeist", social and cultural setting, circumstances of transmission

using specific cues or simple heuristics.

When is a receiver likely to take the central route and when the peripheral route? According to the two authors, route selection depends on two factors: *ability and motivation*. *Ability* refers to the physical availability of the receiver to follow the message without distraction, *motivation* to the readiness and interest of the receiver to process the message. The central route is taken when the receiver is able and highly motivated to listen to the information; the *peripheral route* is taken when the issue is less relevant for the receiver and/or the communication context is inadequate to get the message across. In this case, the receiver is less inclined to deal with each argument, but forms an opinion or even an attitude on the basis of simple cues and heuristics. One can order the cues into four categories: *source-related, message-related, transmitter-related, and context-related cues*. These are illustrated in Table 3 (adopted from Renn and Levine 1991)

Within each route, the mental process of forming an attitude follows a different procedure. The central route is characterized by a systematic procedure of selecting arguments, evaluating their content, balancing the pros and cons, and forming an attitude. The peripheral route, however, bypasses the systematic approach and assigns credibility to a message by referring to the presence of cues.

Unfortunately, the communication process is more complex than the model implies. First, the audience of a communicator may be mixed and consist of persons with central and peripheral interests in the subject. Many cues that are deliberately used to stir peripheral interest (e.g., using advertising methods for risk communication) can be offensive for people with a central interest in the subject. Second, most people are not predisposed to exercise a central or peripheral interest in a subject. Rather, it may depend on the message itself whether it can trigger central interest or not. Third, and most important, the two routes are prototypes of attitude formation and change, and therefore only analytically separable. In reality, the two routes are intertwined: persons may tend to respond primarily to the cues or primarily to the arguments presented, but they will not exclusively pursue one route or the other.

An effective risk communication program must therefore contain a sufficient number of peripheral cues to initiate interest in the message, but also enough "rational" argumentation to satisfy the audience with central interest in the subject. The problem is how to avoid anger and rejection by centrally interested persons if they are confronted with "superficial" cues, such as advertising gimmicks, and how to sustain the interest of the peripherally interested persons if they are confronted with lengthy arguments. The problem can be resolved if the message eschews "obvious" cues, but includes cues that are acceptable for both types of audiences.

What cues in the hormesis debate are acceptable for both audiences? First, cues that make information easier to understand, digest, and apply are always appreciated by both audiences. It is crucial to find intuitively reasonable and mind-blowing examples that provide the famous "aha" effect when presented to a skeptical audience. Second, cues that relate to commonly shared beliefs and values will enhance the interest of the centrally concerned receiver and improves the chance for finding attention among the peripherally concerned receivers. In the hormesis debate it might be beneficial to relate to risk management agencies prime mandate to protect people's health and that they are obliged by law and mandate to absorb and examine new evidence that has direct relevance to their major goals. Third, cues that link highly esteemed individuals, groups, or institutions to the issue will normally be welcomed by both groups, unless the link appears unnatural (for example having a well-known football player advertise the practice of low dose exposure).

2.5 Synopsis

Where does this discussion of the context variables leave us in the analysis of risk communication with respect to the hormesis hypothesis? When designing risk communication programs, one should deliberately review the four major context variables: levels of debate, styles of regulation, type of risk culture, and type of audience.

What is the appropriate level of the debate? Are conflicts on the first level (factual dissent), the second level (institutional performance) or on the third level (values and worldviews)? Which of the three levels is most important for the communicator, which for the audience? Depending on the answer to these questions, different risk strategies are demanded. With respect to hormesis, I suspect that the debate will occur on all three levels simultaneously. It may be wise, however, to design arenas for communication that distinguish between three types of discourses: those that lead to more epistemological orientation (evidence for hormesis and scientific implications); those that help risk managers to find effective and credible measures to incorporate hormesis in the regulatory regimes on the premise that the overall health protection level is not compromised; and those that bring different subcultural groups together to reach out for a consensus on the degree of precaution that society would like to invest in making use of the insights on hormesis.

With respect to the cultural styles of regulatory regimes, one needs to design different communication packages for each style. It is essential to provide sufficient stakeholder participation in adversarial and also corporatist regulatory regimes, while consensual and fiduciary systems needs to assure that sufficient trust-building elements are in place in order to assure the continuation of public confidence in the risk management capabilities of the respective agencies. In addition, it is necessary to find the right cues to get the public interested in the debate and foster an exchange of arguments rather than the clustering of the debate around well-established ideological camps.

3. RESPONDING TO RISK COMMUNICATION NEEDS

3.1 Functions of Risk Communication

The field of risk communication developed initially as a means to investigate how best expert assessments could be communicated to the public so that the tension between public perceptions and expert judgment could be bridged. In the course of time, this original objective to educate the public about risks has been modified and even reversed when the professional risk community realized that most members of the public refused to become "educated" by the experts but rather insisted that alternative positions and risk management practices should be selected by the professional community in their attempt to reduce and manage the risks of modern technology (Plough and Krimsky 1987). Both sides claimed to educate each other without being willing to be educated themselves.

In a thorough review of the risk communication literature, William Leiss distinguished three phases in the evolution of risk communication practices (Leiss 1996: 85ff). The first phase of risk communication emphasized the necessity to convey probabilistic thinking to the general public and to educate the laypersons to acknowledge and accept the risk management practices of the respective institutions. The most prominent instrument of risk communication in phase I was the application of risk comparisons. If anyone was willing to accept x fatalities as a result of a voluntary activities, she or he should be obliged to accept another voluntary activity with less than x fatalities. However, this logic did not convince most audiences. People were unwilling to abstract from the context of risk-taking and the social conditions and to rely on expected values as only yardsticks for evaluating risks. When this attempt of communication failed, a second phase was initiated that emphasized persuasion and focused on public-relations-efforts to convince people that some of their behavior was unacceptable (such as smoking and drinking) since it exposed them to high risk levels, whereas public worries and concerns about many technological and environmental risks (such as nuclear installations, liquid gas tanks, or food additives) were regarded as overcautious due to the absence of any significant risk level. This communication process resulted in some behavioral changes at the personal level since many people started to quit some unhealthy habits, but it did not convince most people that the current risk management practices for most of the technological facilities and environmental risks were indeed the politically appropriate response to risk. The one-way communication process of conveying a message to the public nicely wrapped in persuasive "gift" paper produced little effect. Most respondents were appalled by this approach or simply did not believe the message regardless how well is packaged. So a third phase evolved. This current phase of risk communication stresses the two-way communication process in which not only members of the public are expected to engage in a social learning process but the risk managers as well. The objective of this communication effort is to build mutual trust by responding to the concerns of the public and to modify risk management practices in accordance with public input.

Only few observers of the risk arena would probably disagree with William Leiss' recollection of the risk communication history. A similar, though more sophisticated analysis of the evolution of risk communication was published in Risk Analysis by Baruch Fischhoff (Fischhoff 1995). Fischhoff started out with the notion that risk communicators wanted to convey the correct numbers. This approach obviously failed. So risk communication practices evolved over six stages of changing paradigms, until the professional risk community came to the conclusion that risk communication means to make the public a partner in the mutual attempt to manage risks. A report by the National Academy of Sciences echoes this new understanding of risk communication and encourages risk professionals to foster citizen participation and involvement in risk management (Stern and Fineberg 1996). The report emphasizes the need for a combination of assessment and dialogue which the authors have framed the "analytic-deliberative" approach. The new keywords are trust building, community development, and co-determination.

The popularity associated with the concepts of two-way-communication, trust building, and citizen participation, however, obscures the challenge of how to put these noble goals into practice and how to ensure that risk management reflects competence, efficiency, and fair burden sharing (Renn 2001). How can and should risk managers collect public preferences, integrate public input into the management process, and assign the appropriate roles to technical experts, stakeholders and members of the public? Who represents the public? The elected politicians, administrators, stakeholders, or all persons who will be affected by the risk? There is a large amount of individual variance when laypersons are asked to give their best risk estimate (Dottz-Sjˆberg 1991; Dake 1991; Boholm 1998). Which estimate should be used for risk management? Which concerns are legitimate for being used in decisions that may determine life or death of many people?

There are no simple answers to these questions. Defining risk as a combination of hazard and outrage may well describe the general situation, but does not provide any clue of how to combine scientific assessments with public perceptions (Sandman 1989). The well-meant advice to encourage two-way communication and to promote public involvement does not help risk managers to improve the decision making process.

This is even more pronounced when the debate includes the hormesis hypothesis. How can one communicate that little is good and much is bad? Even in the familiar cases of food, it has become a major challenge to communicate that some potentially toxic materials such as alcohol may be beneficial in small quantities and very harmful in larger volumes. How can one succeed in

communicating mixed messages about substances that are commonly regarded as harmful or at least as undesirable?

In order to respond to these questions it may be useful to structure the complex task of risk communication into several components. The variety of objectives that one can associate with risk communication can be summarized in three general categories (cf. Covello et al. 1986; National Research Council 1989; Renn 1992):

- to foster understanding of risks among different constituencies (customers, workers, consumers, interest groups, environmental groups, and the general public), including risks pertaining to human health and the environment taking into account the dominant risk perception patterns of the target audiences *(enlightenment function)*;

- to promote trust and credibility towards those institutions that handle or regulate risks *(trust-building function)*;

- to provide procedures for dialogue and alternate methods of conflict resolution as well as effective and democratic planning for the management and regulation of risks *(participative function)*.

TABLE 4: The four semantic images of risk in public perception

1. ***Pending Danger***
   - artificial risk source
   - large catastrophic potential
   - inequitable risk-benefit distribution
   - perception of randomness as a threat

2. ***Slow Agents***
   - (artificial) ingredient in food, water, or air
   - delayed effects; non-catastrophic
   - contingent on information rather than experience
   - quest for deterministic risk management
   - strong incentive for blame

3. ***Cost-benefit Ratio***
   - confined to monetary gains and losses
   - orientation towards variance of distribution rather than expected value
   - asymmetry between risks and gains
   - dominance of probabilistic thinking

4. ***Avocational Thrill***
   - personal control over degree of risk
   - personal skills necessary to master danger
   - voluntary activity
   - non-catastrophic consequences

The first objective relies on a better understanding of peoples concerns and perceptions of risk. Section 3.2 will deal with this issue. The following section will cover the communicational means to promote trust and credibility. The last section in this chapter will deal with the possibilities of organizing effective and fair forms of dialogue with the various stakeholders and representatives of the public(s).

3.2 Function 1: Coping with risk perception

Today's society provides an abundance of information, much more than any individual can digest Most information to which the average person is exposed will be ignored. This is not a malicious act but a sheer necessity in order to reduce the amount of information a person can process in a given time. Once information has been received, common sense mechanisms process the information and help the receiver to draw inferences. These processes are called intuitive heuristics (Kahneman and Tversky 1979; Slovic 1987). They are particularly important for risk perception, since they relate to the mechanisms of processing probabilistic information. One example of an intuitive strategy to evaluate risks is to use the mini-max rule for making decisions, a rule that many consumers and people exposed to chemical hazards prefer to apply (Lopez 1983). This rule implies that people try to minimize post-decisional regret by choosing the option that has the least potential for a disaster regardless of probabilities. The use of this rule is not irrational. It has evolved over a long evolution of human behavior as a fairly successful strategy to cope with uncertainty (better safe than sorry). It is not too speculative to infer that the application of the mini-max strategy would imply that the insights of hormesis research would be ignored as long as it is assured that each potentially affected person is better off if hormesis is incorporated in the regulatory regimes.

This heuristic rule of thumb is probably the most powerful factor for rejecting or downplaying information on risks. If any exposure above zero or above a defined threshold (minus safety factor) is regarded as negative, the simple and intuitively reasonable rule to minimize exposure makes perfect sense. Most regulatory regimes are based on this simple rule (Morgan 1990) ranging from the ALARA principle to the application of the best available control technology (BACT). Such principles imply that any exposure might be negative so that avoidance is the most prudent reaction.

Psychological research has revealed different meanings of risk depending on the context in which the term is used (review in Slovic 1992; Boholm 1998; Rohrmann and Renn 2000; Jaeger et al 2001). Whereas in the technical sciences the term risk denotes the probability of adverse effects, the everyday use of risk has different connotations. With respect to human-induced risks Table 4 illustrates the main semantic images (Renn 1990).

Risks associated with substances that could be associated with hormesis effects are mostly to be found in

the category of slow agents. This has far-reaching implications. Most agents belonging to this category are regarded as potentially harmful substances that defy human senses and "poison" people without their knowledge. Risks associated with food additives, air pollutants, water impurities, and other chemical agents are mostly invisible to the person exposed. They require warning by regulators or scientists. Food additives, chemicals or pharmaceuticals are always associated with negative side effects. Along with that image people tend to believe that toxicity depends less on the dose than on the characteristics of the substance. Hence they demand a deterministic regulatory approach when it comes to controlling chemicals in the environment. This is probably the strongest perceptive mechanism explaining the overall skeptical reaction of public groups and regulators to include hormesis in their risk considerations.

Most surveys show that people demand zero-risk-levels, at least as the ideal target line (Sjˆberg 2000). Chemical risks, which are characterized by high ubiquity, high persistency and high irreversibility, hence trigger responses of avoidance and desires for strict regulatory prohibitions. The former US food regulations (the so called Delaney clause) reflect this public sentiment. Something that is regarded as truly bad and vicious is almost impossible to link with a positive connotation. The only exception may be the exposure to "natural" agents. Most people believe that anything that exists in nature cannot be harmful for people if consumed in modest amounts. That is why alleged natural drugs are associated with fewer or even none negative side effects compared to alleged chemical drugs. The perceptions of natural toxins as benign reflect the modern impression or myth of "Mother Nature" who offers an invaluable set of beneficial resources to humankind in response for taking good care of Her. Chemical compounds, however, are associated with artificiality and seen as threats to human health independent of dose. That means: The only pathway to find a common understanding of hormesis is to use analogies from natural food items where common sense and experience have educated people about the ambivalent effects of ingredients depending on dose rather than on hazards.

In addition to the images that are linked to different risk contexts, the type of risk involved and its situational characteristics shape individual risk estimations and evaluations (Slovic et al. 1981). Psychometric methods have been employed to explore these qualitative characteristics of risks (Slovic 1992). Table 5 lists the major qualitative characteristics and their influence on risk perception.

Furthermore, the perception of risk is often part of an attitude that a person holds about the cause of the risk, i.e. industrial activity, consumption of food, production method (such as genetic engineering) and others. Attitudes encompass a series of beliefs about the nature, consequences, history, and justifiability of a risk cause. Due to the tendency to avoid cognitive dissonance, i.e. emotional stress caused by conflicting beliefs, most people are inclined to perceive risks as more serious and threatening if the other beliefs contain negative connotations and vice versa. Often risk perception is a product of these underlying beliefs rather than the cause for these beliefs (Renn 1990).

With respect to the qualitative characteristics, one would expect that risk-bearing substances are associated

TABLE 5: List of important qualitative risk characteristics

Qualitative Characteristics	*Direction of Influence*
1. Personal control	increases risk tolerance
2. Institutional control	depends on confidence in institutional performance
3. Voluntariness	increases risk tolerance
4. Familiarity	increases risk tolerance
5. Dread	decreases risk tolerance
6. Inequitable distribution of risks and benefits	depends on individual utility, strong social incentive for rejecting risks
7. Artificiality of risk source	amplifies attention to risk, often decreases risk tolerance
8. Blame	increases quest for social and political responses

with many of the negative qualitative characteristics. First, most of these substances are associated with negative risk characteristics such as dread, lack of personal control, and artificiality. These characteristics make people even more concerned about the negative impacts than warranted by the predicted health effects alone. Second, the beliefs associated with the risk source, for example industry, center around greed, profit-seeking and alleged disrespect for public health. Fourth, the possibility of consumers being exposed to risks without their consent touches upon serious equity concerns if susceptibility to these risks varies considerably among individuals or relies upon probabilistic balancing. Again the hormesis thesis is likely to stimulate skeptical responses because it reverses the common understanding of the public that all chemicals are "evil by nature" but tolerable only because of the benefits they produce in terms of economic advantages and comfort.

3.2 Function 2: Enhancing trust and credibility

With the advent of ever more complex technologies and the progression of scientific methods to detect even smallest quantities of harmful substances, personal experience of risk has been more and more replaced by information about risks and individual control over risk by institutional risk management. As a consequence, people rely more than ever on the credibility and sincerity of those from whom they receive information about risk (Barber 1983). Thus, trust in institutional performance has been a major key for risk responses (Earle and Cvetkovich 1995). Trust in control institutions is able to compensate for even a negative risk perception and distrust may lead people to oppose risks even when they are perceived as small. Indeed, some research shows clearly that there is a direct correlation between low perceived risk and public trust and vice versa (Kasperson et al. 1992).

Trust can be divided in six components (Renn and Levine 1991). These components are listed and explained in Table 6. Trust relies on all six components, but a lack of compliance in one attribute can be compensated for by a surplus of goal attainment in another attribute. If objectivity or disinterestedness is impossible to accomplish, fairness of the message and faith in the good intention of the source may serve as substitutes. Competence may also be compensated by faith and vice versa. Consistency is not always essential in gaining trust, but persistent inconsistencies destroy the common expectations and role models for behavioral responses.

In risk debates, issues of trust evolve around institutions and their representatives. People's responses to risk depend, among others, on their confidence that they have in risk initiating and controlling institutions (Slovic et al. 1991). Since the notion of risk implies that random events may trigger accidents or losses, risk management institutions are always forced to legitimate their action or inaction when faced with a negative health effect such as cancer or infertility. On one hand, they can cover up mismanagement by referring to the alleged randomness of the event (labeling it as unpredictable or an act of God), on the other hand they may be blamed for events for which they could not possibly provide protective actions in advance (Luhmann 1998; 1990).

The stochastic nature of risk demands trustful relationships between risk managers and risk bearers, since single events do not prove nor disprove management failures; at the same time they provoke suspicion and doubt. This delicate balance would even be more difficult to keep if risk regulators were about to incorporate hormesis effects into their regimes and allow or even promote exposure to low levels of the respective substance. The slightest mistake by a risk management agency would then be sufficient to destroy the delicate balance of trust.

The handling of risk by private corporations and governmental agencies has been crucial for explaining the mobilization rate of individuals for taking actions.

TABLE 6: Components of trust

Components	***Description***
Perceived competence	degree of technical expertise in meeting institutional mandate
Objectivity	lack of biases in information and performance as perceived by others
Fairness	acknowledgment and adequate representation of all relevant points of view
Consistency	predictability of arguments and behavior based on past experience and previous communication efforts
Sincerity	honesty and openness
Faith	perception of "good will" in performance and communication

The more individuals believe that risks are not properly handled (in addition to being perceived as serious threats) the higher is the likelihood of them becoming politically active. It has been shown that in the nuclear case the disillusionment of the US population with the nuclear option as well as the number of people becoming political advocates of antinuclear policies grew simultaneously with the growing distrust in the nuclear regulatory agency (Baum et al. 1983). Negative attitudes are a necessary but by far not a sufficient reason for behavioral responses. Public confidence in institutional performance is another and even more important element in triggering behavioral responses.

Establishing and gaining trust is a complex task that cannot be accomplished simply by applying certain operational guidelines (such as declaring empathy) in a mechanical fashion. There is no simple formula for producing trust. *Trust grows with the experience of trustworthiness.* Nobody will read a brochure, attend a lecture, or participate in a dialogue if the purpose is solely to enhance trust in the communicator. Trust is the invisible product of a successful and effective communication on issues and concerns. The less the word is being alluded to in a communication, the more likely is that it is either sustained or generated. *There is only one general rule for building trust: listening to public concerns and, if demanded, getting involved in two-way communication.* Information alone will never suffice to build or sustain trust. Without systematic feedback and dialogue there will be no atmosphere in which trust can grow (Morgan et al.2001). This is even more pronounced in the case of hormesis where all potential concerns of the people affected need to be processed and satisfactory answers given. One should be rather reluctant to incorporate hormesis in regulatory regimes than risk to lose public confidence. A slow, reflexive and iterative process of introducing this "new" notion into the regulatory frameworks would probably the best strategy for sustaining public confidence. If confidence is already at risk or even scattered, one would need to establish a more complex risk communication program centered on different forms of stakeholder involvement and public participation. Such a program is outlined in the next section.

3.3 Function 3: Communicating with Stakeholders

Stakeholder involvement and public participation in the risk management process helps to improve the quality of decision-making and to avoid damaging and time-consuming confrontations later on the decision-making process although involvement is not a guarantee that such confrontations and challenges will not take place even if consultations with stakeholders had been organized in advance (Yosie and Herbst 1998). The intensity and scope of stakeholder involvement depends on the issue and the extent of controversy. What can risk managers expect from stakeholder participation? Depending on the context and the level of controversy stakeholder participation can assist risk managers in (Webler and Renn 1995):

- providing data for the analysis or bringing anecdotal evidence to the table;
- providing background information about past experiences with the risk;
- balancing benefits and risks and arriving at a judgment of acceptability;
- providing information on preferences between different types of risks and benefits (trade-offs);
- commenting on distributional and equity issues; and
- participating in the formulation of outputs, thus enhancing the credibility of the decision-making process.

The timing of stakeholder involvement is crucial factors in determining whether stakeholders can and will effectively participate in risk management tasks (Connor 1993). Representatives of organized groups such as NGOs should be addressed at an early stage in the risk management process so that they can prepare themselves for the involvement and provide comments and input at an early stage before final decisions are made. One should be aware that many stakeholder groups meet irregularly and may not have teams in place capable of collecting data and for reviewing documents before the required date. The earlier they are notified the more input the can provide. A slightly different timing strategy is required for including affected individuals or neighborhood groups: Opportunities for public participation need to be scheduled at a time when sufficient interest has been generated but decisions are still open for making changes.

In addition, the purpose of the involvement should govern the timing: If the interest is to get more and better knowledge, involvement should be organized in the beginning of the process starting with risk characterization and assessment. If the involvement is meant to assist risk managers in balancing the pros and cons and choosing the right management options, the involvement should take place directly after the assessment has been completed. If representatives of groups or individuals who might be affected by the consequences of the decision are targeted for the involvement, timing depends on the intensity of the controversy. If the whole activity is controversial (such as one would expect if hormesis effects are taken into account), an early stage of involvement is recommended. If the ambiguities refer to management options (such as promoting low dose exposure), the time of generating and evaluating options is obviously the best spot for the participatory exercise.

In addition to timing, the selection of participants is a major task that demands sensitivity to the potential participants' needs and feelings and the right balance between efficiency and openness (Chess et al. 1998). For participation to become effective, groups of more than 30 people are not advisable. If more stakeholders want to be included, one can form alliances among groups with

similar goals and perspectives or form special subgroups with additional memberships that report to the main body of involvement. Who should be consulted in risk management decisions? Here a list of potential invitees:

- people who might bring additional expertise or relevant experience to the decision-making process;
- representatives of those public interest groups that are affected by the outcome of the risk decision;
- people who might be directly affected as individuals by the outcomes of the decision-making process regardless whether they are organized or not;
- people who could represent those who are unable to attend or otherwise excluded from the process (such as the next generation; or interests of animals).

A more detailed approach to stakeholder involvement and public participation has been developed by the author with respect to complex or systemic risk management (Renn 2001; in press). The starting point for this approach is the distinction of three phenomenological components of any risk debate. These are the challenges of complexity, uncertainty and ambiguity. Complexity refers to the difficulty of identifying and quantifying causal links between a multitude of potential candidates and specific adverse effects. The nature of this difficulty may be traced back to interactive effects among these candidates (synergism and antagonisms), long delay periods between cause and effect, inter-individual variation, intervening variables, and others. It is precisely these complexities that make sophisticated scientific investigations necessary since the cause-effect relationship is neither obvious nor directly observable. Complexity requires scientific assessment procedures and the incorporation of mathematical settings such as extrapolation, nonlinear regression and/or fuzzy set theory. To communicate complexity, scientific expertise and technical skills are needed.

Uncertainty is different from complexity. It is obvious that probabilities themselves represent only an approximation to predict uncertain events. These predictions are characterized by additional components of uncertainty that have been labeled with a variety of terms in the literature such as ignorance, indeterminacy, incertitude, and others. All these different elements have one feature in common: uncertainty reduces the strength of confidence in the estimated cause and effect chain. If complexity cannot be resolved by scientific methods, uncertainty increases. Even simple relationships, however, may be associated with high uncertainty if either the knowledge base is missing or the effect is stochastic by its own nature. If uncertainty plays a large role, in particular indeterminacy or lack of knowledge, the public becomes concerned about the possible impacts of the risk. These concerns express themselves in the request to be consulted when choosing management options.

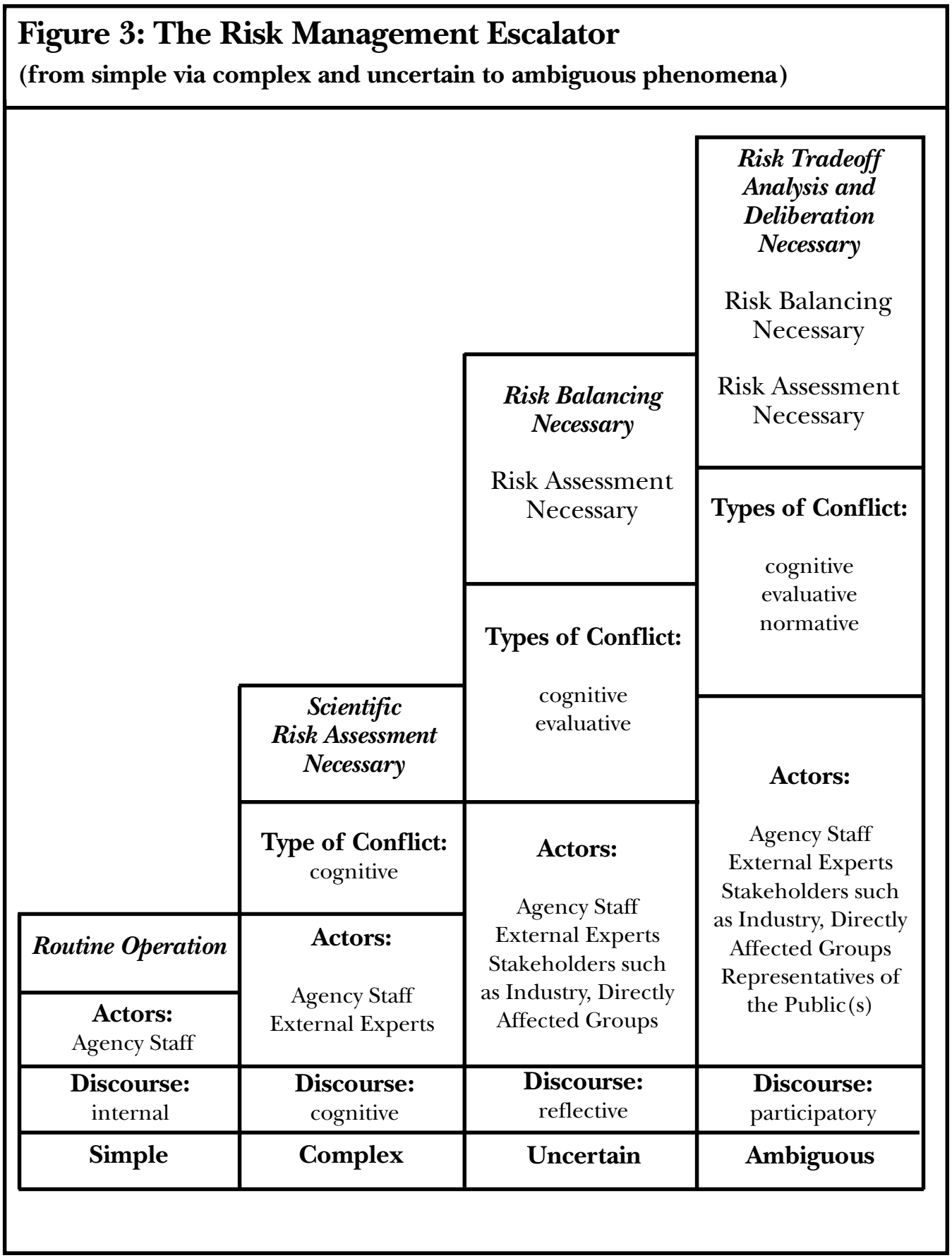
The last term in this context is ambiguity or ambivalence. This term denotes the variability of (legitimate) interpretations based on identical observations or data assessments. Most of the scientific disputes in the fields of risk analysis and management do nor refer to differences in methodology, measurements or dose-response functions, but to the question of what all this means for human health and environmental protection. Hazard data is hardly disputed. Most experts debate, however, whether a specific hazard poses a serious threat to the environment or to human health.

How can risk communicators deal with complexity, uncertainty and ambiguity in risk communication, in particular if there are signs of dissent and conflict concerning one or all three components of risk? Needed are different types of disciurse for each of the three components (Renn 1999a). The first challenge is complexity: Resolving conflicts of complexity requires deliberation among experts. This type of deliberation may be entitled “epistemological discourse”. Within an epistemological discourse that is focused on cognition, experts (not necessarily scientists) argue over the factual assessment with respect to the criteria that are proposed. The objective of such a discourse is the most adequate description or explanation of a phenomenon (for example the question, which consequences should be labeled as adverse and which labeled as beneficial or neutral). The more complex, the more multi-disciplinary and the more uncertain a phenomenon appears to be, the more necessary is a communicative exchange of arguments among experts. With respect to hormesis, one would organize epistemological discourses on the questions of empirical evidence, the nature of potentially positive effects, the problem of a potential co-existence of positive and negative effects at the same dose level, the treatment of stochastic effects, and other open questions of causality and consequence analysis.

If risks are associated with high uncertainty, scientific input is only the first step of a more complex evaluation procedure. It is still essential to compile the relevant data and the various arguments for the positions of the different science camps. In addition, however, coping with uncertainties requires the inclusion of stakeholders and public interest groups provided that there are different views in society about the adequate level of protection. The objective of this discourse is to find the right balance between too little and too much protection. There is no scientific answer to this question and even economic balancing procedures are of limited value, since the stakes are uncertain. This type of deliberation may be coined “reflective discourse”. *Reflective discourse* deals with the clarification of knowledge (similar to the cognition-oriented discourse) and the assessment of trade-offs between the competing extremes of over- and under-protection. Reflective discourses are mainly appropriate as means to decide on risk-averse or risk-prone approaches to innovations and new products. Reflective discourses are particularly important for dealing with hormesis. As long as the evidence is not yet

Figure 3: The Risk Management Escalator

(from simple via complex and uncertain to ambiguous phenomena)



fully conclusive, acting on the premise of hormesis provides an additional risk to those exposed at low levels but also a chance for a positive effect. For both routes there are only scientifically based probability estimates in which agencies may have little or high trust or confidence. In such a situation it is essential to have those stakeholders at the table, who will clearly benefit from the incorporation of hormesis and those who may be at risk. One could imagine, for example, that the application of hormesis in regulation is first contained to cases or regions where the risks to human health are small and reversible. The experiences that one can take from these monitored "field studies" could then be evaluated and re-interpreted by the original participants of the reflective discourse.

The last type of deliberation, which may be called *participatory discourse*, is focused on resolving ambiguities and differences about values (third level debates). Established procedures of legal decision-making, but also novel procedures, such as mediation (procedure of conflict resolution by reconciliation of interests) and direct citizen participation belong to this category. Participatory discourses are mainly appropriate as means to search for solutions that are compatible with the interests and values of the people affected and to resolve conflicts among them. This discourse involves weighting of the evaluative criteria and an interpretation of the results. Issues of fairness and environmental justice, visions on future technological developments and societal change and preferences about desirable lifestyles and community life play a major role in these debates. With respect to hormesis, such a discourse is necessary if hormesis were to become a structuring element for regulating emissions or ambient quality standards. Since member of the public would be affected by such a decision, it is essential to consult with them and get their informed consent or informed rejection.

It is clear that these different types of discourse need to be combined or even integrated when it comes to highly controversial risks. Our experiences, however, have been that it is essential to distinguish the type of discourse that is needed to resolve the issue at question. Cognitive questions such as the right extrapolation method for using animal data should not be resolved in a participatory discourse. Similarly value conflicts should not be resolved in an epistemological discourse setting. It seems advisable to separate the treatment of complexity, uncertainty and ambiguity in different discourse activities since they need other forms of resolution. Often they need different participants, too. We have made an attempt to provide a hybrid model of deliberation called the cooperative discourse model that combines the three discourse types into one connected activity without giving up the analytical separation between the three parts[i] (Renn 1999b).

Figure 3 provides an illustration of a gradually widening process of stakeholder involvement starting with simple risk problems and ending with risk debates centering on complexity, uncertainty and ambiguity. The Figure lists the major tasks and the actors that should be consulted at each step.

Stakeholder involvement and public participation require an organizational or institutional setting in which the various procedures for implementing involvement can be embedded and integrated. It is important that the choice of discourse for enhanced participation matches the organizational capabilities of the organizing institution and fits into the socio-political climate in which the issue is debated. It is therefore essential to do a through context analysis before deciding on any one of the procedures described below. The most important aspect to keep in mind is that stakeholder involvement is a form of risk communication that is done before the final (regulatory) decision is made. Nobody likes to be involved to approve to something that has been predetermined by the organizer. Timing of involvement is therefore a crucial task. Epistemological discourses should be organized in the beginning of the process starting with risk characterization and assessment. Reflective discourses should be placed right after the completion of the assessment process when it comes to balancing the pros and cons and choosing the right management options. Participatory discourses are more difficult to fit into the risk assessment and management schedule. It depends here on the nature of the ambiguity. If the whole activity is controversial (such as the generic decision to incorporate hormesis into the regulatory regime), an early stage of involvement is recommended. If the ambiguities refer to management options (such as labeling products with respect to hormesis effects), the time of generating and evaluating options is obviously the best spot for the participatory exercise.

4. IMPLICATIONS FOR RISK COMMUNICATION ON HORMESIS

The articles in this volume indicate that the evidence collected so far on the hormesis hypothesis justifies a thorough revision of the present paradigms in regulatory philosophy and actions. The minimization principal on which most of the regulations rests would be in need of either replacement or amendments. If public policy is meant to improve public health and not only to prevent negative effects, there would be a necessity to seek exposure to small doses or at least to ensure that such an exposure is not prohibited by the minimization principle. In the case of toxic substances with a clear NOAEL, only little changes in the regulatory system are required. Individuals may then be advised to seek exposure rather than avoid it as long as the NOAEL threshold is not reached.

Carcinogenic substances would require more substantial changes, however. If it is proven that carcinogenic agents have the potential to inhibit as well as induce cancer, new policies would be needed that provide legitimate and equitable trade-offs between individual risk and public health benefits. The popular question "how safe is safe enough?" would not only need the

addition of "how safe is fair enough" but also "what degree of safety implies living less safe than possible". The paradigm of minimization would need to be replaced by a new optimality rule that allows for beneficial effects of low dose exposure. Instruments for reaching this new paradigm are not yet in place and would require more deliberation and policy studies.

The analysis in the previous sections of this paper provided several important insights (see also Renn 1998). First, the level of risk debates will likely be on the factual, institutional and worldview level. The simultaneous debate on all three levels necessitates the organization of all three types of discourse: the epistemological, the reflective and the participative. These three discourses need to be connected to each other, however. If hormesis should be incorporated in the regulatory regimes for risk management, a model of interlinking discourse activities on all three discourse and risk debate levels need to be designed and implemented. It would be an ambitious but probably rewarding task for a major risk management agency such as the US-EPA to start with such an effort. Second, any risk communication on hormesis needs to address the problems faced by risk perception. Although the hormesis thesis can be classified as "good" news and should be welcomed by most people potentially affected by exposure to low doses, it contradicts most of the salient beliefs that people have about chemicals in the environment. Regardless whether individuals prefer industrial or environmental values, their cognitive frame is marked by the concept of chemicals as pollutants and poisons. As pointed out in the section on risk perception, people associate food additives, chemicals or physical pollutants such as noise, electromagnetic fields or ionizing radiation with negative side effects. Along with that image people tend to believe that toxicity depends less on the dose than on the hazardous characteristics of the substance. Hence they demand a deterministic regulatory approach when it comes to controlling chemicals in the environment. This dominant view of "pollution" is even prevalent among the most risk-seeking group, the entrepreneurs. Entrepreneurs and egalitarians differ only in their evaluation of this strongly held belief. The entrepreneurs accept such pollution as a fair price to pay for all the benefits of the industrial society, whereas the environmentalists believe that the trade-offs have been set in the wrong direction and should be corrected towards increased protection. One can expect, however, that people feeling attached to the entrepreneurial thinking will welcome the hormesis thesis, while egalitarians will be appalled even by the idea of a potentially positive effect of "pollution". Third, the dominant philosophy of the regulatory system is based on the conviction that regulators have the duty to broker a fair trade-off between economic benefits and environmental risk. The whole system of balancing the pros and cons might collapse if suddenly a positive side effect of "pollutants" is taken into consideration. As risk management agencies experience even today a loss of trust and credibility when pursuing their old and simple line of minimizing exposure as a means to maximize public health protection, it is rather likely that they will prefer to ignore the scientific studies as long as they are able to manage to do so. Lastly, the associations linked with the image of slow killers will likely produce a debate dominated by the old ideological camps where scientific claims are used as best as justification strategies for making points in the public arena.

What does this complex and difficult situation means for risk communication? What can the scientific community and public educators do to initiate a fair, balanced and open dialogue with stakeholders and the public at large. Obviously it is not sufficient to inform potential stakeholders or the public at large about the hormesis thesis and its implications. Most people will simply ignore the information or reject it. I would recommend the following steps:

- The hormesis thesis should first be introduced in connection with natural agents familiar to most people. It has been public knowledge that small doses of minerals and metals are necessary inputs for humans while larger quantities might be toxic. At the same time, people know about ingredients of medical drugs, which are overall beneficial if taken in small doses. Once the message has been accepted with natural ingredients, the communication program may include substances that are regarded as natural but are normally synthesized in chemical processors. At the end, chemicals that are normally regarded as pollutants may enter the communication program once the principle has been widely accepted on the basis of the natural ingredients.

- Any communication program should avoid linking the hormesis thesis with vested interests in the toxicological arena. Although the thesis may benefit industrial polluters by giving them a perfect excuse to deviate from any minimization concept, it is not clear whether the new regulatory regime of optimization does not require similar or even higher costs for industrial players. For example, regulators might demand a regional ambient air quality profile in order to determine the overall exposure of individuals in a specific region. The combined exposure of all polluters should then be within the average range of beneficial effects. The means to implement such an optimal profile might be more cost-intensive than pursuing the traditional minimization strategy. If hormesis is being perceived in the public as a new strategy of industry to avoid risk reduction measures and to gain points in court, egalitarians and bureaucrats alike will reject the thesis. Rather risk communication programs should stress the potential benefits of a regulatory regime that takes hormesis into account and makes sure that the benefits are equally shared by industrialists, environmentalists,

and the general public. It needs to be proven that public health is served better if hormesis is applied to risk regulation and that the costs are equally shared among the interested parties.

- Such a sophisticated risk communication program requires an approach based on dialogue among the potential stakeholders. It is not sufficient, however, to establish round tables of participants and let them voice their opinions and concerns. Since all three levels of a risk debate are affected at the same time, one needs a more structured approach. First, it is necessary to continue to organize epistemological discourses on the questions of empirical evidence, the nature of potentially positive effects, the problem of a potential co-existence of positive and negative effects at the same dose level, the treatment of stochastic effects, and other open questions of causality and consequence analysis. Once credible answers are provided to these questions, a more reflective discourse is necessary in which stakeholders who will clearly benefit from the incorporation of hormesis and those who may be at risk sit together and discuss the issue of who will be accountable for any problems induced by any regulatory action based on the hormesis thesis. One could imagine, for example, that the benefactors pay for a comprehensive insurance and monitoring program. As soon as the public would be affected by any regulatory changes, a participative discourse is required. The goal here would be for risk analysts and managers to consult with potential victims and benefactors of new regulatory reforms and get their informed consent or informed rejection.

Risk communication will not perform any miracles. It can help to overcome some of the perception biases that I outlined above and make people more susceptible to the potential benefits that lie within the realm of applying the hormesis theory to regulation and risk management. But it should be up to them and the legitimate policy bodies to decide on how to use this new information for policy making and regulation.

5. CONCLUSIONS

The objective of this paper has been twofold: First, it has been aimed at preparing risk communicators with the necessary background knowledge in order to understand the needs and concerns of the target audiences when it comes to communication new risk paradigms such as the hormesis theory. Second, it is designed to provide specific information on the potential problems and barriers for communicating potential changes of risk regulation and management as a result of incorporating hormesis claims.

The main message of this paper is *Risk communication goes beyond public information and public relation*. It needs to be seen as a necessary complement to risk management. Advertisement and packaging of messages can help to improve risk communication, but they will be insufficient to overcome the problems of public distrust in risk management institutions and to cope with the concerns, worries, or complacency of consumers (Bohnenblust and Slovic 1998). The potential remedies to these two problems lie in a *better performance* of all institutions dealing with or regulating risks and in structuring the risk communication program mainly as a *two-way communication process*. With respect to performance, it is well understood that many risk management institutions complain that their specific task is not well understood and that public expectations do not match the mandate or the scope of management options available to these institutions. This is specifically prevalent for any communication program on hormesis effects: First, the issue at stake, health and environment, tops the concerns of the public of all industrialized countries. So people are very concerned when confronted with a challenge of their fundamental belief that all pollution is bad and should be avoided. Second, the probabilistic nature of risk impedes an unambiguous evaluation of management success or failure. This is also true for incorporating hormesis elements into regulatory regimes: If there is a small chance that somebody might experience adverse effects from a lose dose while other may get a positive effects, difficult issues of fairness and equity arise that are almost impossible to resolve. In spite of these difficulties, however, careful management, openness to public demands, and continuous effort to communicate are important conditions for gaining trustworthiness and competence. They cannot guarantee the success, but they make success more probable.

The second most important message is that risk management and risk communication should be seen as parallel activities that complement each other. Risk communication supports the ongoing management efforts as a means to gain credibility and trustworthiness. By carefully reviewing in-house performance, by tailoring the content of the communication to the needs of the final receivers, and by adjusting the messages to the changes in values and preferences, risk communication can convey a basic understanding for the choices and constraints of risk management and thus create the foundations for a trustworthy relationship between the communicator and the audience. Specifically a sequential organization of different discourse models is required to develop a continuous link between public dialogue and further management decisions.

Good risk communication practice also entails to tailor communication according to the needs of the targeted audience and not to the needs of the information source. Information should match public expectations (Mulligan et al. 1998). Many successful programs of the past have turned out inappropriate to address the audience of today. Constant adjustment requires efforts to collect systematic feedback from the community, the relevant stakeholders, and the general public. This calls

for a continuous evaluation program. In particular, one needs to monitor public perception of risk, make a strong effort to collect and process public concerns and to make sure that all communication material is designed to meet public demands (Allen 1987). This is particularly necessary in the case of hormesis, since all perceptive mechanisms imply a skeptical to negative pre-disposition towards making use of this theory in practical management decisions.

The ultimate goal of a risk communication program is not to ensure that everyone in the audience readily accepts and believes all the information given. Instead, it is to enable the receivers to process this information to form a well-balanced judgment in accordance with the factual evidence, the arguments of all sides, and their own interests and preferences. To accomplish this goal, a risk communication program is needed to provide the necessary qualifications to all participants and empower them to be equal partners in making decisions about risk.

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COMMENTS ON ORTWIN RENN'S ARTICLE "HORMESIS AND RISK COMMUNICATION"

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In his article, Ortwin Renn has explored the issue of hormesis and risk communication thoroughly, basing his arguments on a wide-ranging investigation of the large body of literature produced during over thirty years of research.

As the author himself suggests, empirical studies on the perception of hormesis or preferred management options are still lacking. However he has been able to extract as much information and insight as possible from existing research in the fields of risk assessment, perception, management and communication. In particular, he has anticipated future developments in a credible way, drawing inferences from past occurrences and present tendencies, considering both technical and social aspects. Accordingly, he has developed some practical recommendations which can be regarded as useful and far-reaching, given that they are rooted in rigorous hypotheses rather than mythology or wishful thinking.

In my view, the lack of social science research on hormesis is an indicator of the low priority of related programs of risk communication on the agenda of regulators and public administrators, normally in charge of such activities. This is not surprising, as traditionally risk communication activities have been initiated when it was impossible to delay them any further because of mounting public opposition to certain technological innovations. Thus, risk perception research was largely regarded as instrumental for understanding, and consequently defeating, (irrational) public opposition to scientifically based decisions.

Presently, the debate on hormesis is still low-key, except for in very limited circles. Certainly it has not yet reached the public arena. The fact that, despite lack of specific studies, there is a lot one can reasonably foresee

about future developments - as shown by Renn's article - proves that, in regulating hazardous substances and, more generally, in assessing and managing health and environmental risks, the key issue to be addressed are basically the same. Far from being reducible to providing the "right" numbers as results of technical risk assessments, these include considerations about complexity, uncertainty, ignorance, irreversibility, plurality, incommensurability, accountability, quality and equity. Ultimately, problems of risk are strictly and irremediably intertwined with problems of governance (De Marchi 2001; De Marchi and Ravetz 1999).

Rather than adding new elements to what I consider a very inclusive account, I will comment on some aspects that, in my view, have not been fully developed in Ortwin Renn's article. In particular, I will discuss a bit further the relationship between risk, uncertainty and ignorance in risk assessment in general, and subsequently consider some implications for risk communication in the case of hormesis.

The author distinguishes "three phenomenological components of any risk debate. These are the challenges of complexity, uncertainty and ambiguity" (page 17). As for complexity, he seems to argue that it can be resolved by more sophisticated scientific assessment procedures and modelling. Instead, I agree with Funtowicz and Ravetz's (1992) – also quoted by Renn among the authors inspiring his model (page 4) - that it is precisely the complexity of the new problems of risk and the environment which require a shift in paradigm towards Post-Normal Science. The very concept of complexity implies the coexistence of a plurality of *legitimate* perspectives. This novelty (or new recognition) results not only in what Renn calls "ambiguity or ambivalence" denoting "the variability of (legitimate) interpretations based on identical observations or data assessments" (page 28). It also implies different (legitimate) framings of the problem under consideration, and therefore, as we will see, requires not only treatment of uncertainty, but also awareness of ignorance.

Different framings result from different appreciation of a certain problem and lead to different experimental or research designs, with consideration of different elements and causal links, reliance on different models, application of different methods of analysis, setting of different standards for accepting or rejecting hypotheses (e.g. confidence limits). The identification and definition of both the problems to be taken into account and researched and the solutions to be looked for, go well beyond the scope of scientific investigation (Jasanoff 1999). There is nothing strange, nothing new, nothing wrong with that, at least until it is denied that scientists are human beings and that the scientific endeavour is entrenched in historical, social, economic, institutional and cultural context.

Framing is the physiological (not pathological) way in which we approach reality in our daily lives as well as professional activities. The fact that some types of framings are warranted scientific recognition is a guarantee (and a very important one!) that they respect certain accepted conventions, can be submitted to peer review, and may be promoted or rejected under consensual professional standards and codes of good practice. It is to be remembered however, that scientific risk assessment (in this not different from risk perception) does neither examine nor explain reality in its whole, but approaches it by (scientific) methods of approximation and selection. Over time, past framings, models, procedures and paradigms may be abandoned, due to improvements in the scientific endeavour as well as contextual changes.

In his book, Cranor (1993) discusses problems in the statistics of human epidemiological studies and animal bioassays. He distinguishes between risk and uncertainty, and argues that – as harm assessment is ideal but impossible due to lack of perfect information - one should aim at least at *risk and uncertainty* assessment. In other words, assessments should include not only a probabilistic estimate of a certain outcome, but also an assessment of uncertainty. As the economist Frank Knight pointed out as early as 1921, uncertainty cannot be quantified, and this is its very distinctive character with respect to risk, which instead can be "measured", although in probabilistic terms.

Cranor also recalls the difference between two types of statistical error - which can occur in both hazard identification and dose-response assessment - and shows their implications for regulation. Type 1 error refers to false positives (finding evidence of an effect when it is not there). Type II error refers to false negative (failing to discover an effect when it is there). The constraints and limitations of risk and uncertainty assessment are widely recognised by experts and normally dealt with through the application of mathematical models or other generalisations. Less normal is perhaps the communication of the objective limits of the data outside the scientific community.

The issue of ignorance is substantially different. Ignorance refers to "[T]he impossibility of taking unknown processes and variables into account" (Hoffman-Riem and Wynne 2002). This generates the possibility of Type III errors (as they are now frequently called), i.e. framing issues in inappropriate terms or solving the wrong problems. Such errors derive for example from the lack of understanding of certain biological mechanisms, which prevents not only testing, but the very possibility of conceiving adequate framings and hypotheses and devising appropriate models and measuring tools.

In his article, Renn recognises the existence of ignorance, but he mentions it somewhat hastily, among what he calls "additional components of uncertainty" (page 17). I have devoted some attention to the distinction between risk, uncertainty and ignorance as I consider it a fundamental one. So, in my view, the problem is not that "[T]o communicate complexity, scientific expertise and technical skills are needed" (page 17). I maintain, also based on my own research (e.g. De Marchi

et al. 1996; De Marchi *et al.* 1998; De Marchi 2000; Pellizzoni and De Marchi 2002), that the lay public tends to intuitively grasp complexity as revealed by their curiosity about, e.g., multiple exposure, individual differences, potential long-term consequences, unforeseen interactions among events and phenomena, or even about extrapolation of data from animals to humans, inferences from high doses to low doses or vice versa, relations between laboratory experiments and environmental releases, and so on.

The key issue is rather to recognise, keep in mind, explain, and account for the (inevitable) simplifications operated by scientific risk assessment methods and techniques, in reducing complex contextual situations of risk exposure to a simple figure. Another, closely related, key issue is the consequent need to abandon justifications of risk regimes based on pretension of scientific indisputable truth. As properly expressed by Funtowicz and Ravetz (1992; 1993), in many contemporary problems of risk the traditional distinction between hard facts and soft values has been reversed, and important decisions have to be taken on the basis of very incomplete information and knowledge.

The challenge is not a minor one, especially when philosophical intuition and epistemological discourse are to be translated into practice. Despite the magnitude of the challenge I believe that, at least as far as Europe is concerned, the process of change in the governance of risk is well under way and by now irreversible, after the BSE (Bovine Spongiform Encephalopathy) crisis and many other scares. This is best testified by the current discussion within the European Union on the "democratization of expertise" as a substantial part of the Commission White Paper on the revision of European governance (EC 2001).

To conclude, I will try to summarise the most direct implications of my comments with regard to hormesis. In my view, the problems encountered with the hypothesis do not substantially differ from those normally present in risk assessment and regulation. Despite remarkable evidence of potential beneficial effects of exposure to otherwise dangerous substances at very low levels of concentration (e.g. Calabrese *et al.* 1999), evidence remains - and will remain - limited and controversial. Renn states that "the scientific community *may* never be able to provide sufficient proof for one side or the other" (page 3). On the basis of the above discussion, I argue that, no matter how much new research will be produced (as it is necessary and desirable), it *will* never be able to provide a definitive answer. This is no exception, but normality, as illustrated for example in Gee and Greenberg's essay on asbestos published in a report of the European Environment Agency significantly entitled "Late Lessons from Early Warnings". They write: "Despite huge amount of research, many issues of biological mechanisms and dose-response relationships remain unclear, illustrating the limited relevance of more research to disease" (2001: 58).

The situation is one where scientific data is swamped with uncertainties and there is controversy in interpretation among toxicologists also based on recognition of ignorance of key aspects. As Cranor states, in discussing the shortcomings of animal studies, mathematical models or other generalisations are used to fill gaps which "result from insufficient understanding of the biological mechanisms involved or the relationship between biological effects on one species compared to another" (Cranor 1993: 17). Moreover, key questions may not have been asked, because of unrecognised areas of ignorance. In this context it is required that scientific knowledge is "socially robust" (Gibbons 1999) based on a renewed contract between scientific experts and society (AAAS 1997). Renn warns that the hormesis hypothesis may generate suspicion in the public as "a new strategy of industry to avoid risk reduction and to gain points in court" (p. 20). I have no hesitation arguing that it *will* generate this kind of interpretation.

In an atmosphere of generalised public perplexity (if not open mistrust), it is quite unlikely that regulatory agencies will change current regulatory regimes on the basis of not fully consolidated (can it ever be?) evidence. This is confirmed for example by Berry Lambert in an article on radiation exposure where he states: "There are now substantial lobbies for changes which include both re-introducing the concept of thresholds and considerations of hormesis (small doses which are thought to do some good) – these have been resisted by ICPR [International Commission on Radiological Protection]" (Lambert 2001:33).

We know, with cases such as asbestos and many others, that there have always been delays in changing limits of exposure or banning substances despite clear evidence of harm to human health (EEA 2001). Correspondingly, there has often been resistance by authorities or industry to diffuse information and in some cases actual cover-up. Even when it was a matter of promoting healthy or safe attitudes such as "no smoking", communication campaigns have been conditioned by the pressure of powerful economic interests. Thus what could have been "preventive information" became instead *post-facto* information, addressed to the unlikely outcome of eradicating by then consolidated (and induced) unhealthy/un-safe beliefs and habits.

Is it reasonable to expect modifications in regulatory regimes as a response to (still limited and debated) evidence of good? And, even if this were the case, is it reasonable to expect a positive response from a public who has been deceived many times before and moreover is constantly exposed to contradictory messages? For example, if the public is encouraged to accept hormesis, while as the same time it is warned against homeopathy, whose rationale is ultimately not dissimilar.

It is often the case however, that a certain risk issue reaches the communicative arena without regulatory agencies taking the initiative. Nowadays information (and rumours) circulate widely, can leak (or be leaked), trough different media and channels. Therefore, it seems to me that Renn's model of "The Risk Manage-

ment Escalator" is very useful for heuristic purposes, but of limited practical application. Analytical separation is useful for comprehension, but in the real world different sorts of discourses are inextricably intertwined and relevant kinds of expertise (let alone experts) are not so easy to identify and single out. Most important, the different stakeholders are unlikely to enter the scene respecting some kind of "pecking order" established from above. So the very structuring of what Renn defines "a gradually widening process of stakeholder involvement starting with simple risk problems and ending with risk debates centering on complexity, uncertainty and ambiguity" (p. 19) is likely to be interpreted as organised inclusion/exclusion.

As shown by authors such as Fischhoff (1995) and Leiss (1996) - quoted also by Renn (pp. 12) - times have changed and communication strategies have been constantly revised, also as a response to inputs from risk perception research. However, even nowadays, the early involvement of the public is frequently advocated, but rarely practiced. I maintain that, before envisaging or participating in any risk debate (be it a structured program or other) each actor must honestly reply to a question about his/her ultimate goal. This can be derived from the statements contained in Ortwin Renn's last paragraph (page 22), and reframed in an interrogative mode as follows: "Is my ultimate goal to ensure that everyone in the audience readily accepts and believes all the information given? Or is it that all those involved form a well-balanced judgment in accordance with the factual evidence, the arguments of all sides, and their own interests and preferences?" A frank reply to this question will shed light on the interpretation of all what happens next.

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COMMENTARY ON HORMESIS AND PUBLIC RISK COMMUNICATION: IS THERE A BASIS FOR PUBLIC DISCUSSIONS?

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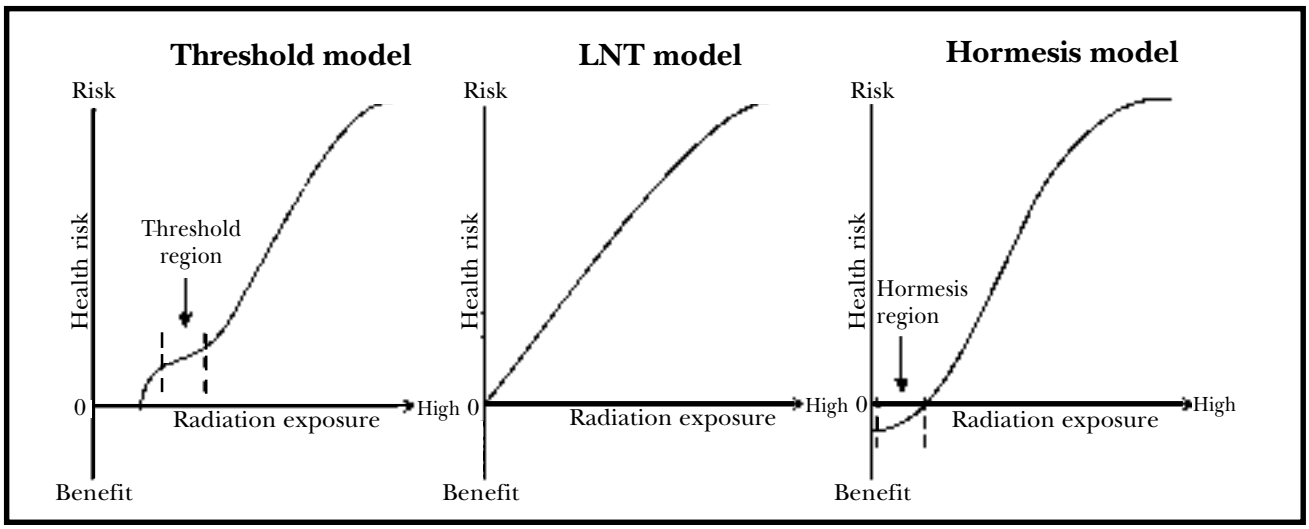
Ortwin Renn has addressed several areas important to the subject of hormesis and risk communication. He does this with the high level of competence and expertise we have come to expect from his work. The point of interest for hormesis and risk communication is with technological risk management, which focuses on policy and program issues arising from industrial sources of risks to human health and the environment. Renn comments on the individual, organizational, and societal responses to a variety of risks and their associated topics. In these comments, he draws numerous lessons that apply in various degrees to the hormesis model as a framework for representing the scientific information that underlies risk assessments. Renn's approach identifies the larger social-psychological context where risk judgments are made. This larger context includes risk perceptions, the characteristics of direct and indirect risk communications, constraints imposed by political and legal administrative processes, the roles of public values and worldviews, trust of managers and advocates of hormesis claims, and the roles of cues, judgment processes, emotion, and cognition. Every item from this list is a legitimate research area in and of itself and in one degree or another Renn identifies within each item serious problems for designing effective risk communications. This overview describes conditions common to many cases involving current science-based risk communications.

It will not be news to those who have worked with risk communications that the issues are difficult and complex. The tensions between expert and public evaluations are well documented and they are reinforced by differences among scientists and other experts. Much of Renn's commentary is devoted to the identification of public-response minefields. To deal with the hazards of public responses, a number of common sense recommendations are put forward in the conclusion section. These include the recommendations to build trust, "convey a basic understanding for the choices and constraints of risk management," consider communications a two-way process, provide useful information, and "meet public demands."

The uses of a hormesis model for chemical and radiation risk management are formidable not only from the perspective of the scientific requirements but because there are established alternative models for risk assessment already in place. Perhaps the case of low dose radiation is the most difficult. Currently the model options include the linear no-threshold model (LNT) and the threshold model with the hormesis model a definitely minority choice. Figure 1 shows a basic graphic of these three models. The linear no-threshold model (LNT) dominates radiation risk assessment and it is well understood by lay people. The LNT model assumes that because we have no direct data about the health effects of low-dose radiation exposures, conclusions have to be made on the basis of information about health effects (particularly cancer) from high exposures. The straight line drawn through the high-exposure data down to zero is assumed to show the cancer risk from different levels of radiation exposure, based on observations of health effects at high levels of exposure. Since precise data are not available for the lower exposure conditions there is considerable uncertainty about the risks at these levels. The justification for the LNT model is that a conservative calculation on behalf of safety is socially more responsible than the potential adverse outcomes especially when large or vulnerable populations are at risk.

The threshold model states that as radiation exposure decreases there is a point where there is no observable effect, which leads to the proposition that there is a point where exposure can be assumed to be safe, in other words a "threshold." Evidence for the threshold models comes from studies that indicate an "adaptive response" by cells when exposed to small amounts of radiation. Similar adaptive responses also appear to occur from exposure to toxic chemicals. In the case of radiation, the adaptive response is thought to arise from the induced repair of DNA damaged by radiation energy or by cell elimination, either of which would prevent potential cancer mutations. However, the evidence from cellular biology to support this conclusion is not yet available and it appears that an adaptive response depends on many factors including age, sex, genetic background, type of cell, and the timing of radiation exposure. While the risk to an individual over long periods of time is uncertain the very low-dose risk to populations appears to be quite small and threshold standards are used in public regulation of substances, living and work conditions. Part of the regulation considers the trade-off of benefits and risks where the

Figure 1



benefits are found to be more important at some level of exposure than the risks, with the caveat that exposures will be reduced to as low as reasonably possible. Certain levels of environmental pollution are included in the acceptance of this model such as levels of air, water, or ground contamination. These societal decisions are most acceptable when people believe they have informed consent and the oversight of public health and safety is maintained by responsible individuals or organizations.

The hormesis model basically asserts that something toxic or even lethal at one dose can be beneficial at another, smaller dose. Resistance to this idea exists despite the fact that toxicologists have accepted for centuries the idea that "the dose makes the poison" and a great deal of modern medicine, which is widely supported and appreciated, provides daily examples. People are cautioned about overdosing on vitamins that they are simultaneously encouraged to take in proper doses. People are told, and believe, that there are safe and apparently protective doses of alcohol but in excess alcohol can be poisonous. So people can and do recognize and accept hormesis as a valid explanation for certain conditions.

Research has found that small doses of radiation stimulate cells in various organisms such as some plants and insects, as well as chick and salmon embryos. Some scientists argue that cell stimulation is beneficial and may produce positive health effects. However, the meaning and interpretation of potential hormesis effects are often uncertain. Epidemiological studies of human populations are confounded by factors other than radiation exposure that may influence cancer rates, such as life style factors (diet, smoking), genetic predispositions, and other sources of cancer. While suggestive, the lack of a clear cause-effect relationship between very low doses of radiation exposure and health effects cannot be proven.

The cause-effect relationship for low dose exposures is the subject of a basic biological research program now underway at the U.S. Department of Energy.[3] The results of this program may, over the next decade, provide substantial support for either the threshold and/or the hormesis models. To date, however, some of the results are encouraging but not conclusive. The bystander effect, for example, where cells surrounding a target cell show a definite response may indicate either a positive or negative result. That is, the bystander cell responses may prompt cell repair or elimination but these responses may indicate negative effects on the neighboring cells even when they are not directly hit with radiation energy.

If the research from this program and other sources provides clear support for a threshold or hormesis model then a risk communication effort will have solid evidence to proceed. Risk assessment, as a process to protect public health and the environment, must provide for a conservative estimates of harm based upon accepted data and evidence as well as make projections for conditions of uncertainty where the evidence is lacking or ambiguous. A judgment about the probabilities and consequences of outcomes under conditions of uncertainty are guided by a number of social, ethical, legal, and economic criteria. Where does hormesis fit into this established regime of risk analysis and management? The LNT and Threshold models dominate and have established public understanding and legal status. This is a condition of social history and if it is to be modified in favor of a hormesis model scientists will have to provide very persuasive evidence and a new level of cause-effect data. The hormesis model is one that will have to show it is correct in each case where it claims validity and to do so it must provide data in support of its claims that overcome the threshold model and the linear no-threshold model. Only then will the hormesis model gain serious public consideration. Risk communication cannot support that step without a thoroughly convincing case. To present a case that claims hormesis is just as good an explanation of the data as any other simply will not be enough.

Assuming that science provides results supporting hormesis, what risk communication presentations would be necessary? There are many advantages in using the

three existing models as a basis for risk communication since they provide a framework that helps us understand the risk issues and the scientific findings that are common to all and peculiar to one or the other. So this is the place to start if risk communication were to attempt to gain a fair hearing for the hormesis model in the public arenas where risk policy and program decisions are made. We note that these three models serve as operational frameworks for scientists as well as a viable framework for citizen understandings of exposure information. These models are used to construct experiments and research programs as well as to explain scientific results. They provide the guidelines for legislation, regulation, and program design. Our experiments in risk communication suggest that the use of these basic models can orient and clarify public understanding of scientific methods, results and implications.[4] There are many complex details to scientific work. One critical need in risk communication is a viable framework that provides some common ground for discussion between expert and lay interests.

The three models require different levels of scientific evidence. An important question is how much data are required for each model and how each model deals with uncertainty at low doses of exposure. The hormesis model will face the greatest demands to produce directly relevant scientific data and to construct clear, concise, and convincing inferences.

In thinking about these models it may help to recall the distinctive goals each seeks to achieve. The linear no-threshold model is cautious and wants to provide maximum safety through minimum exposure. The Threshold model seeks reasonable safety and tradeoffs that balance risks and benefits. What is the social goal for hormesis? Is it to improve health through exposure? This would make hormesis a public health question. Is it to raise exposure threshold levels and provide economic or other social benefits? Or, is it to do something else, and if so, what? What is the social benefit context for applications of the hormesis model? In medicine radiation trades off risks and benefits, it serves as treatment for cancer, for example, or as a means for diagnosis. But this does not require hormesis. What social good does require it?

[3] This program is the Low Dose Radiation Research Program in the Office of Biological and Environmental Research, Office of Science, U.S. Department of Energy. Decision Research is funded for work on risk communication with this program through a three-year cooperative agreement with the Department of Energy (James Flynn, Principal Investigator).

[4] Space limitations do not allow us to describe the research referred to here but readers interested in the methods and results of our recent work in this area are invited to visit our web site at www.decisionresearch.org. Click on "Low Dose Radiation Research," and access the reports on "Perception of Radiation Exposure," Parts I and Part II. These Reports are currently posted and new material is in preparation.

HORMESIS AND RISK COMMUNICATION: A COMMENT TO ORTWIN RENN

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INTRODUCTION

Professor Ortwin Renn should be congratulated for authoring the definitive piece on risk communication with regard to hormesis (Renn 2002). Most of his conclusions I agree with, specifically the importance of labelling hormesis as a possible natural effect thereby reducing the stigmatization associated with a technical/chemical label. Rather than discussing all the points that Renn raise, in this comment I will focus on the issue of trust, a topic that Renn does examine but which I fell does not get adequate attention and which I do not completely agree with. In so doing, in my conclusions I am more optimistic that Renn is in preparing risk communication strategies regarding hormesis and other new paradigms to target audiences (defined in most instances as the general public and stakeholders).

TRUST AND HORMESIS

Trust is arguably the most important comment of risk communication. Without public trust in authorities/regulators it is very difficult to assemble a successful risk communication strategy be it with regard to hormesis or anything else. As research has shown there is a direct relationship between high public trust in authority and low perceived risk and vice-a-versa (Lofstedt 1996; Slovic 1993). Indeed, research shows that it is possible to communicate issues of high uncertainty in a top-down fashion, when the public trusts authorities/regulators (Lofstedt 1996).

What exactly is trust? In a recent literature review Kramer and Tyler (1996), noted that there are no less than 16 definitions of the word. Trust can be an expression of confidence between the parties in an exchange transaction (Axelrod 1984; Bateson 1988; Zucker 1987) and can be both process/system or outcome based. For example, in some cases the public will trust regulators even if they do not agree with a regulatory decision, as long as they see the process as credible, ie. fair, competent and efficient. However, in most cases, the public judges regulators on their past decisions (outcomes). If the public perceives the regulator as competent, fair and efficient, based on previous decisions, the public is highly likely to trust these regulatory bodies in the future. To be more specific I use the term trust in the sense of a complexity reduction thesis, in which the public delegates to authority. That is to say trust means acceptance of decisions by the constituents without questioning the rationale behind it. In such a case constituents are in effect asking to accept a "risk judgement" made by the regulators (Earle and Cvetkovich 1995).

In using this definition, trust becomes something that regulators should strive for. It is always easier to trust than to distrust. By trusting the regulatory process, the public has one less issue to be concerned about.

The three most important components of trust are fairness, competence, and efficiency (Renn and Levine 1991; Viscusi 1998).[1] In order to understand how fairness, competence, and efficiency impact public trust it is useful to look at the criteria in more detail.

Fairness: Impartiality and fairness (also one of the main factors of deliberation) is an important element of any regulatory decision that will have an impact on public trust (Albin 1993; Linnerooth-Bayer and Fitzgerald 1996; Renn and Levine 1991; Renn et al 1995 and 1996; Young 1995). There are two ways to measure fairness in regulation, either via the process itself or through the outcome of the process. Fairness is usually defined by a view of the process or outcome as being impartial. Did the regulators take everybody's interests into account, and not just those of certain powerful industrial bodies? If the regulators are not seen as impartial or fair they are unlikely to gain trust. In such cases deliberative mechanisms including public or interest groups may be needed to build trust.

Competence: Public perceptions of risk managers' competence (one of the underlying variables of technocracy) is viewed by researchers as the most important component of trust (Barber 1983; Lee 1986; Slovic 1993). The easiest way to measure regulators' competence in a specific process is to evaluate it. Did the regulators handle the process as proficiently as possible? Did the risk managers have the necessary scientific and practical background to deal with the range of issues associated with the process? If the regulators are not seen as competent, thereby compromising trust, additional expertise may need to be brought into the process (eg. scientific advisory boards) (Jasanoff 1990).

Efficiency: The third component of trust is efficiency and can be viewed as how taxpayers' money is used in the regulatory process (saving lives or safeguarding the environment) (Hahn 1996; Lofstedt and Rosa 1999).

The efficiency argument is particularly important during periods of economic stress, when levels of government expenditure have significant effects on the public's welfare and state of well-being (Foster and Plowden 1996). The concept of relating efficiency to trust has not been much developed. The reason being that in many cases what the economists and/or technocrats see as inefficient, such as spending public funds on cleaning up contaminated land sites (eg the US super fund project), are seen by the public as very important, for reasons other than efficiency (EPA 1987 and 1990; Graham 1997; Viscusi 1998).

As discussed above, for these three trust components there are different risk management solutions. To deal with fairness, some form of public/stakeholder involvement is necessary, to ensure that the regulators/public authorities have the public's best interest at heart. However, if the lack of public trust is caused by incompetence, greater involvement of experts may be required, and if the process is seen as inefficient then a rational risk analytical approach may be needed. In this regard although I feel that Renn's rule for building trust "listening to public concerns and, if demanded, getting involved in two-way communication" (page 29) does deal with the fairness component, it does not adequately address the issue of competence and efficiency. In other words, by simply making the process more transparent and by encouraging greater stakeholder involvement, not all the issues relating to why the public may distrust the process may be properly addressed.

In sum, in addressing how to best communicate the hormesis effect to the general public I am not convinced that public dialogue is necessarily needed. As trust is by far the most important variable of risk communication, if we address this variable correctly, then the conundrum of communicating hormesis will also be solved. The simplest way to do this is to test for public trust (via open-ended face to face interviews on random populations where the issue has been raised) and based on the results develop a communication programme and act accordingly. In so doing the four following risk communication programmes can be developed:

a) If the interviews show that there is public trust in authorities, top-down risk communication with the general public will suffice. Such a strategy will work even under issues of extreme uncertainty, something that hormesis represents, as long as the message being communicated can be made simple and understandable (for a great review see Renn et al 2002).

b) If the interviews show that the public do not trust authorities because they are not seen as fair, then some form of a dialogue needs to be built up with the public to ensure successful risk communication;

c) If the interviews show that the public do not trust authorities because they are not seen as competent, competent senior civil servants and scientists need to be hired before a top-down risk communication process can commence;

d) If the interviews show that the public do not trust authorities because they are seen as inefficient then competent well respected economists need to be brought on board before a top-down risk communication process can commence.

CONCLUSIONS

Risk communication is never easy particularly not when dealing with complicated issues fraught with uncertainty such as hormesis. However, if we can better establish firstly whether public trust authorities (of course on a case by case basis), and secondly address public concerns if it does not, I take the view that hormesis concept can be successfully communicated. The most obvious place to attempt such a communication is in a region or country where there is both a high public trust in authorities and where the proponents of the hormesis thesis can convince the authorities that this is an important concept that needs to be shared with the general public.

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[1] Renn in his paper identifies six components of which we share two (competence and fairness). To do that I have added efficiency.

HORMESIS: PUBLIC HEALTH POLICY, ORGANIZATIONAL SAFETY, AND RISK COMMUNICATION

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Human beings have long entertained a complex if not paradoxical relationship with substances which can alter their health for good and ill. Myths and legends capture endeavours such as that of King Mithridates who very young had trained his body to assimilate without danger low doses of violent poison. Some twenty centuries later, towards the end of the 19th century, the medical term «mithridatism» was coined to define a form of immunity to toxic substances acquired through the progressive ingestion of these substances. However, throughout the 20th century and in particular during the past 30 years, an additional level of complexity is introduced by studies that have repeatedly identified the hormesis effect, i.e. health benefits associated with exposure to low doses of toxic substances, such as those originating from chemical and nuclear industry. Implications of such an effect upon risk assessment and management are literally revolutionary if we consider the scope and nature of changes that theory and practice should undergo (Calabrese et al., 1999). Notably, the existing risk assessment and management philosophy applied to industry is directly challenged. The necessary scientific consensus on the hormesis effect and its implications for public health has not yet been established. Should it be, several levels of difficulty lay in the task of defining new regulation: these include technical and organizational issues as well as the social acceptability of the implied changes. In other words, it is the whole spectrum covered by the field of risk analysis which is summonsed.

In that perspective, Renn (this issue) provides a comprehensive and important effort of placing hormesis as a risk object into correspondence with the existing knowledge of risk communication research. Hormesis through Renn's effort gains a thoroughly profiled identity as a risk object in our societies where it stands largely ignored outside a small circle of experts. In

addition, the confrontation between this new and complex object and existing theories of risk communication allows Renn to test those theories and to renew the formulation of some fundamental findings. The profile constructed will remain hypothetical until hormesis becomes the object of applied social research. By the end of Renn's exercise, it appears that major problems regarding hormesis remain unsolved and very separate courses of action appear open.

Risk assessment in the chemical field rests upon toxicological and epidemiological research and has differentiated two sorts of chemicals, leading to two distinct modes of regulation and risk management, which Renn outlines. The hormesis effect concerns the group of toxic substances for which no threshold of dose-response effect has been identified. Should hormesis be borne out, the usual philosophy of continually minimizing exposure, which is costly for industry (and, it can be argued, for society as a whole) is reversed: hormesis implies that some exposure and intake of low-doses of toxic substance is not only acceptable but ought to be sought after given its potentially positive impact upon public health.

Considering the scientific uncertainties, the equity problems and the policy dilemmas raised by the hormesis effect, Renn suggests seeking insights from risk perception and communication research to try to predict how people will respond to hormesis and what risk communication actions should be considered. At the outset, Renn rightly reminds us that the public is generally concerned by the health risks associated with chemical and physical hazards. The role thus imparted to risk communication is manifold, from explaining assessment rationales and techniques to improving trust and credibility in regard to managing institutions. The effort to predict societal response is justified, according to Renn, by the facts that "society has no other choice but to live with ambiguities" and that "major scientific controversies will find their way into the public debate before the issues are resolved in the scientific community".

Renn reaches several conclusions in terms of risk communication, and formulates recommendations:

- three discourses (epistemological, reflective and participative) must be connected in the risk debate; this need could be addressed by a major risk management agency;

- information must integrate risk perception effects which tend to limit the "good" news of hormesis considering the pre-existing public associations between chemicals, toxins, pollutants and poison;

- the existing culture of risk management agencies must be revised.

This work provides knowledge and opens perspectives for all those who may become engaged in communicating about hormesis as a new paradigm. In that framework, some issues in our view must be urgently highlighted.

The hormesis effect must be recognized and treated primarily as a public health policy issue—not as a an industrial issue. The hormesis concept suggests that potential public health benefits from small doses of substances may rest untapped at this time. This hypothesis seems to attract interest at this time particularly from the industrial sector, as it implies that ongoing industrial activity may be viewed as readily providing those low doses. Practices which in the past have been viewed essentially as polluting, under this new paradigm could become justified as therapeutic.

Should the hormesis effect gain scientific consensus, authorities will be faced with new decisions in formulating and implementing appropriate policy to improve public health. The usual, and significant, issues of levels and standards of exposure, and the equity issues raised by the fact that some individuals may suffer negative effect even while collective health improves, will need to be addressed through assessment and deliberation. The question may one day be raised of whether public health authorities and the state are to be accused of not doing all that it is realistically possible to do to protect lives and improve public health, should they omit to monitor public exposure and intake and eventually decide to generalize the emission of some toxic substances at low doses.

In view of such potential questions and issues, hormesis should be regarded primarily as posing a challenge to the public health policy sphere; second, and only second, should one consider the fact that some of the substances in question are readily available from industrial activity. Only when the public health challenge has been taken up by the appropriate range of actors can it be possible to envision killing two birds with one stone: improve public health, and save money in industry, through reconsidering risk assessment philosophy.

Hormesis implies that organizational safety culture must be revised—this must be managed. In addition to the problems mentioned by Calabrese et al. (1999) and Renn regarding the revolutionary changes that risk assessment and management should undergo to integrate the hormesis effect, attention should also be given to the management of safety within organizations of high hazard potential (nuclear and chemical plants, notably). The overall trend during the past century has led to establishing organizational safety culture (IAEA, 1991) to make most of these organizations highly reliable. This trends rests upon the active involvement of the groups and individuals working in installations to minimize accidental occurrences; the continual limitation of toxic substance emission, as expressed in the ALARA principle, is part of that culture. Safety culture, even in the best-performing enterprises, is not established once and for all; safety consciousness and practices must be continuously reinforced and transmitted. The hormesis effect raises a contradiction with ALARA which functions today as a

cornerstone of safety culture. The integration of the hormesis effect thus in effect introduces a new risk in the organizational environment. The contradiction therefore must be laid out clearly, and addressing it must itself become a part of safety culture. Safety managers must not ignore this issue.

In our culture the bad news of toxic exposure may outweigh any good effects—this potential should be studied. Although it can be difficult to assess, evidence has been produced that human health may respond not only to effective exposure to toxic substance, but to the "bad news" of emission, even when no toxic substance reaches a given population. Baum (1987) points out such an effect regarding public response to T.M.I. and Love Canal, and Poumadère (1991) analyses the policy effects of the Chernobyl accident in this light. Poumadère and Mays (1990) consider the integration of potential negative health impact of "bad news" in risk communication programs. Among the public health assessments that may be performed one day, we would suggest giving careful attention to how this "bad news" effect might counterbalance the hormesis effect. Research on the psycho-social impact of bad news so far has dealt with emissions of large, potentially toxic, doses of substances, and not with small doses potentially beneficial. However, Slovic (2000), in surveys performed in Sweden and the U.K., points to the high sensitivity of the public in regard to the negative impact of therapeutic drugs. Depending on how the question is framed, persons may judge that a toxic drug effect on even a small number of individuals is sufficient to reject the therapeutic value for the greater number. This is one of many examples in which the risk-benefit rationality does not pertain when citizens consider questions of human mortality; it may take on special significance in the context of hormesis.

Renn succeeds in producing social knowledge and risk communication proposals about hormesis, even while it remains a highly hypothetical effect. Hormesis is not a public issue at this point and it might never become one. We have highlighted, however, that hormesis should first be considered in the realm of public health policy, before looking at possible impacts in terms of industrial risk regulation. Organizational aspects of safety would be deeply affected; this impact would require management. Finally, the societal response to the hormesis concept would require research and attention, as human health relies not only upon biology but also upon mental and social variables.

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HORMESIS: IMPLICATIONS FOR POLICY MAKING AND RISK COMMUNICATION A REPLY

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INTRODUCTION

The four comments on my paper on hormesis and risk communication add valuable insights to the understanding of the issues and address a couple of issues that were raised in my paper and that, in the view of the reviewers, need further refinement and specification. I am very grateful to Bruna de Marchi, Ragnar Löfstedt, James Flynn and Donald MacGregor as well as Mark Poumadere for their thoughtful and constructive comments. Most of what they have expressed in their statements do not challenge or even contradict any of the major points that I made in my paper. They expand on several issues such as the role of science in the hormesis debate (De Marchi; Flynn and MacGregor), the role of trust in the respective regulatory regime (Löfstedt), the implications for policy making (Poumadere; Flynn and MacGregor) and the framing of the issue as a public health or industrial policy problem (Poumadere). With most of what the reviewers have raised and added to my analysis, I have no objections. On the contrary, I welcome these comments since they give me more intellectual food to digest. Their remarks fuel my motivation to invest more time and effort investigating the context and the mechanisms that govern the risk communication process when it comes to a new scientific challenge such as hormesis. I would like, however, to select a few aspects that were raised in the comments and take them as an opportunity to clarify some of my own propositions in this field.

THE ROLE OF SCIENCE

All reviewers stressed the importance of the deliberations within the scientific community as one major factor that will impact regulatory policies as well as public perception. Flynn and MacGregor are convinced that hormesis will only enter the regulatory regime and the risk communication arenas if the evidence is so overwhelming that regulators and the social multipliers cannot ignore this phenomenon. They state: *"Risk communication cannot support that step without a thoroughly convincing case. To present a case that claims hormesis is just as good an explanation of the data as any other simply will not be enough"*. So they advocate a serious attempt to reach a consensus among the respective scientists as to which of the three models (no threshold linear dose-response relationship; threshold at low doses; hormesis) be used as the main reference for risk policies.

In my original paper, I was more sceptical about the likelihood that scientists would actually come to a consensus on this issue, but did not rule out the possibility that they would. Bruna de Marchi is even more sceptical in this question:

"Renn states that 'the scientific community may never be able to provide sufficient proof for one side or the other' (page 3). On the basis of the above discussion, I argue that, no matter how much new research will be produced (as it is necessary and desirable), it will never be able to provide a definitive answer."

In her view, science will never be able to provide sufficient prove for one side or the other. In my terminology, this problem refers to the concept of ambiguity. Ambiguity can be extended to the factual as well as the normative indecisiveness with respect to competing cognitive or moral claims. In contrast to Bruna de Marchi, I am not so pessimistic about the possibility to reduce ambiguity either through an epistemological or through a moral discourse (or both). Bruna de Marchi's comments touch upon some crucial aspects with respect to the role of scientific analysis and judgement for risk management. She writes:

In his article, Renn recognises the existence of ignorance, but he mentions it somewhat hastily, among what he calls "additional components of uncertainty" (page 17). I have devoted some attention to the distinction between risk, uncertainty and ignorance as I consider it a fundamental one. So, in my view, the problem is not that "[T]o communicate complexity, scientific expertise and technical skills are needed" (page 17). I maintain, also based on my own research (e.g. De Marci et al. 1996; De Marchi et al. 1998; De Marchi 2000; Pellizzoni and De Marchi 2002) that the lay public tends to intuitively grasp complexity as revealed by their curiosity about, e.g., multiple exposure, individual differences, potential long-term consequences, unforeseen interactions among events and phenomena, or even about extrapolation of data from animals to humans, inferences from high doses to low doses or vice versa, relations between laboratory experiments and environmental releases, and so on. …- that it is precisely the complexity of the new problems of risk and the environment which require a shift in paradigm towards Post-Normal Science. The very concept of complexity implies the coexistence of plurality of legitimate perspectives.

Indeed, Bruna de Marchi is right in criticizing my use of the word complexity. I have used it in the paper and elsewhere to mean a complicated web of causal strains that cannot be grasped by intuition or common sense (Renn and Klinke 2001). All kind of counter-intuitive insights fall under this category. If intuition,

common sense and anecdotal evidence were sufficient to understand the world, we would neither need to spend so many resources on science and education nor would any methodological rigor in delineating causal truth claims make sense. In postmodern thinking a juxtaposition of knowledge sources without distinguishing different qualities of knowledge with respect to some notion of truth (understanding causal structures) or effectiveness (changing structures in a desired direction) has been advocated, yet such a position inevitably leads to vicious cycles and contradictions (Rosa 1998; Shrader-Frechette 1991: 53ff.). Having said this, the reliance on science as a neutral and comprehensive guide to truth and desired change is also laden with problems: Scientific knowledge has its limitations and biases, too, (as any other from of knowledge) and it is important to shed light on issues such as framing the questions, unintended effects of different methodologies, implicit assumptions and conventions within a specific science community, the treatment of uncertainty and ambiguity, and many other "fallacies" that Bruna de Marchi mentioned in her comment.

As it is not possible to identify all possible effects of chemicals or other risk agents and many theoretical possibilities for extrapolation of values are limited to the low-dose range due to a lack of significant cause-effect relationships (as Flynn and MacGregor point out), experts rely on plausible models, theories and assumptions (Peters 1996: 63). In reality, the need for interpretation has contributed to a pluralization of expert opinions and assessments within the science system. There are consequences for the treatment of risk assessment both inside and outside the scientific community. Firstly, the case of scientific treatment, often referred to as an expert's dilemma of the first degree: experts conduct risk assessments in a variety of ways. Four categories can be identified in the plural sphere of expert opinion (Streffer et al. 2000: 309ff.):

- Expert assessments that focus on the experimental results of risk studies and conventions drawn up by experts, and which deal with remaining uncertainties by simply ignoring rather than assessing them. They enlarge the existing knowledge within the frames provided by mainstream conventions. This is the case that Bruna de Marchi had probably in mind.

- Expert assessments that focus on the empirical results of risk studies but which hover on the border of the range of conventions drawn up by experts and, in doing so, interpret uncertainties within the meaning of those agreed conventions. These experts create diversity in assessments without violating any scientific rules or major conventions.

- Expert assessments that focus on the empirical results of risk studies, but which reject conventions agreed to by experts or replace them with their own interpretation models. These experts are the innovators in the classic (Kuhn's and Merton's) sense; they try to develop new paradigms.

- Expert assessments that question both conventions and empirical results, and see their purpose in fundamental critique of the methods and interpretations of the relevant scientific community. These experts are the rebels who like to see themselves as a radical alternative to the existing science camps.

Without a doubt, the vast majority of experts in the risk field are to be found in the first two categories, so that the conflicts that arise in reality are less strongly manifest than one would expect from all four. At the same time, the various scientific communities use methods such as consensus conferences, meta-analyses or Delphi surveys in their attempts to resolve conflicts between the four types of expert opinions (Pinkau and Renn 1998: 267ff.). The multi-layered nature of risk analysis makes it difficult, however, to find a clear-cut solution for conflicting expert assessments. In addition, we have a situation where statements on risk are difficult or impossible to falsify. The lack of opportunity to falsify statements using empirical evidence (at least in the short-term) limits the effectiveness of knowledge as a tool to evaluate risk assessment studies. Different bodies of knowledge compete with each other and the competing demands for truth cannot be met to the exclusion of all possible doubt.

Secondly, we need to consider the non-scientific consequences: the existence of discretionary freedom in the assessment of effects on different endpoints, the need to implement conventions that cannot be justified by science alone, the constant uncertainty in effects analyses and the fact that numerous scientific controversies are debated in public all have a sustained effect on people's perceptions and experience. In many ways, this involves the importance that outsiders ascribe to conflicts between experts: firstly, most people believe that, in principle, science can come up with clear and precise definitions of environmental pollution. Confronted with a large number of conflicting assessments by experts, people are thus forced to conclude that in the course of such conflict at least one or other of the parties involved is not revealing the truth, be it intentionally or unintentionally. It is not without reason that in the public eye, what experts put out is seen as a reflection of what their financial backers, their ideological preconceptions or their blinkered specialized world put in.

As most people are unable either to confirm or to reject the statements put out by experts by applying their own knowledge or experience, they must depend on external criteria if they want to assess the trustworthiness of those experts. Such external criteria range from assumed vested interest in the subject (an area in which industrial experts have particular difficulty) to the perceived likeableness or expertise of those involved (how they handle themselves on TV, how they dress, their debating style). Laypeople often follow an intuitive

better safe than sorry principle. The assumption that the most pessimistic expert embodies the epitomy of trustworthiness is reinforced by the fact that in the past environmental pollution has often been reported as less harmful than it actually turned out to be. Conversely, some experts often feel pressured by public expectations to place greater emphasis on negative outcomes in order to improve their public standing (Renn 2001).

This situation describes the circumstances that will govern the hormesis debate once it has fully entered the scientific communities. Since there are and will be scientists representing any one of the four expert categories above, interpretations as well as recommended policy implications will differ widely among those who are respected as "experts" in the field. One possibility to deal with this expert dissent is to delegate the decision to a wider audience: first the policy makers, then the stakeholders and then the general public (whoever that may be). Ragnar Löftstedt points out in his comment that such a delegation to a larger audience is often counterproductive. He writes:

"If the interviews (to investigate public attitudes towards regulatory authorities, O:R.) show that the public do not trust authorities because they are not seen as competent, competent senior civil servants and scientists need to be hired before a top-down risk communication process can commence".

Löfstedt advocates broader discourse only if distrust is based on perceived lack of fairness, but not in the cases of perceived lack of competence or efficiency. Bruna de Marchi obviously disagrees with this advise and advocates a broader inclusion of all relevant viewpoints without too much orchestration from top-down. She writes:

"Renn's model of "The Risk Management Escalator" is very useful for heuristic purposes, but of limited practical application. Analytical separation is useful for comprehension, but in the real world different sorts of discourses are inextricably intertwined and relevant kinds of expertise (let alone experts) are not so easy to identify and single out. Most important, the different stakeholders are unlikely to enter the scene respecting some kind of "peaking order" established from above. So the very structuring of what Renn defines "a gradually widening process of stakeholder involvement starting with simple risk problems and ending with risk debates centering on complexity, uncertainty and ambiguity" (p. 19 is likely be interpreted as organised inclusion/exclusion."

The papers by Flynn and MacGregor as well as the paper by Poumadere echo this concern about the procedure to structure the debate as it was indicated in my paper. Their main point in this issue is, however, in opposition to Bruna de Marchi's position. Poumadere supports the idea of structuring the debate but along different lines. He emphasizes three framing conditions:

We have highlighted, however, that hormesis should first be considered in the realm of public health policy, before looking at possible impacts in terms of industrial risk regulation. Organizational aspects of safety would be deeply affected; this impact would require management. Finally, the societal response to the hormesis concept would require research and attention, as human health relies not only upon biology but also upon mental and social variables.

Flynn and MacGregor advocate structuring the debate along the question of defining the social gaols and normative policy implications of hormesis. In my view the distinction (that I introduced in may paper) between three different but intertwined discourse types does not contradict the reviewers' comments and critical remarks. The rationale behind my structuring proposal refers to the type of knowledge that is most suited for resolving or dealing with different types of conflicts: epistemological, reflective and evaluative. Each of these conflicts are present in the hormesis debate and thus three parallel discourses are needed: One clarifying what we really know and what we can clearly reject (epistemological); one where we specify the remaining uncertainties, the range of ignorance and the boundaries of our theoretical frame (reflective) and one where we identify the values and preferences that help us to evaluate decision options and to come to some kind of closure in the respective issue (evaluative). Naturally these three discourses rely on each other, but their specific function requires different types of procedures for discourse management as well as a different composition of the participants involved. We may never be able to resolve all the ambiguity around a risk issue (such as hormesis) but we may limit the degree of arbitrariness in framing and interpreting this ambiguity – factually as well as normatively. This is the major opportunity in selecting a discursive path to conflict resolution and policy making, which goes beyond the objective of assuring fairness as Löfstedt proposes in his paper.

In essence, my suggestions for public discourse pursue a middle path between the traditional model of having the experts come to a consensus first before moving the topic to a larger audience, and the postmodern model of having a comprehensive debate among all relevant actors from the beginning hoping that somehow a reasonable consensus will evolve. The issues are much too serious in my view to rely solely on the "hidden rationality" of public discourse; the issues are also much to complex in my view to expect acceptable solutions by delegating the facts to the scientists and the values to the politicians. We need a structured protocol for a combination of different discourse types each of which addresses key characteristics of the complex issue. In my eyes, a distinction in epistemological, reflective and evaluative discourse would provide a reasonable basis for such a required superstructure.

TRUST

Ragnar Löfstedt emphasizes in his paper the crucial role of trust in the debate on hormesis. He defines trust as acceptance of decisions by the constituents without questioning the rationale behind it. In his view, trust consists of three components: fairness; competence; efficiency. Depending on which trust component is missing or lacking, he advocates different strategies:

- *If the interviews show that the public do not trust authorities because they are not seen as fair, then some form of a dialogue needs to be built up with the public to ensure successful risk communication;*

- *If the interviews show that the public do not trust authorities because they are not seen as competent, competent senior civil servants and scientists need to be hired before a top-down risk communication process can commence;*

- *If the interviews show that the public do not trust authorities because they are seen as inefficient then competent well respected economists need to be brought on board before a top-down risk communication process can commence*

I totally agree with Löfstedt's analysis of the three components and the need for different types of responses for each component. In particular, his argument that more deliberation may be counter-productive has not been voiced in the social science community on risk issues in the past. His own work shows many examples where deliberation in the form of stakeholder participation did not enhance but destroyed trust (Löfstedt 1999; 2001). One should notice, however, that participation of stakeholders and deliberation as a tool for orientation and decision making is not the same. As pointed out before, deliberation among knowledge carriers may be an essential elements to confirm "competence" and a stakeholder deliberation among industry and regulators may enhance "efficiency". It depends therefore on the nature and the structure of the deliberation that determine which of the components of trust it may address.

With respect to hormesis, I would agree with Flynn and MacGregor that we enter an arena in which a dominant frame (dose-response without a threshold) has been the engine for understanding and regulating risks in the past. Any change in this paradigm necessarily challenges existing trust relationship. In my view, all three components of trust will be under severe scrutiny once hormesis enters the field of deliberation. In order to cope with such a situation, all three types of discourse are required.

POLICY IMPLICATIONS

Poumadere as well as Flynn and MacGregor address the issues of policy implications if hormesis became a guiding principle for regulation. Flynn and MacGregor ask critical questions about the reference level for public policy making:

What is the social goal for hormesis? Is it to improve health through exposure? This would make hormesis a public health question. Is it to raise exposure threshold levels and provide economic or other social benefits? Or, is it to do something else, and if so, what? What is the social benefit context for applications of the hormesis model? In medicine radiation trades off risks and benefits, it serves as treatment for cancer, for example, or as a means for diagnosis. But this does not require hormesis. What social good does require it?

It is interesting to note that Poumadere raises exactly the same questions but also provides constructive suggestions of how to deal with the issues raised in these questions. He writes:

- *The hormesis effect must be recognized and treated primarily as a public health policy issue—not as a an industrial issue.…The usual, and significant, issues of levels and standards of exposure, and the equity issues raised by the fact that some individuals may suffer negative effect even while collective health improves, will need to be addressed through assessment and deliberation.*

- *Hormesis implies that organizational safety culture must be revised—this must be managed. … The hormesis effect raises a contradiction with ALARA which functions today as a cornerstone of safety culture. The integration of the hormesis effect thus in effect introduces a new risk in the organizational environment. The contradiction therefore must be laid out clearly, and addressing it must itself become a part of safety culture.*

- *In our culture the bad news of toxic exposure may outweigh any good effects—this potential should be studied… Depending on how the question is framed, persons may judge that a toxic drug effect on even a small number of individuals is sufficient to reject the therapeutic value for the greater number. This is one of many examples in which the risk-benefit rationality does not pertain when citizens consider questions of human mortality; it may take on special significance in the context of hormesis.*

I am in full agreement with this analysis. It provides the three major content issues that need to be addressed in two of the three discourse types that I proposed. The reflective discourse is the right place to deal with issues of framing and safety culture. The evaluative discourse is the appropriate platform for dealing with principles and values regarding equity and utilitarian arguments. In addition, I believe, we need epistemological discourses as a means to understand the validity and the limits of our knowledge on hormesis and competing models of dose-response-relationships.

CONCLUSIONS

At the end of this exchange on hormesis, public perception and risk regulation & communication, the main issue addressed in all papers in this series has been the role of science and representatives of the public(s) in providing frames for understanding the "world" and providing guidelines for making policy decisions. Hormesis has been a powerful example for a case study of what to expect when a policy arena faces a severe paradigm shift in both understanding the issue and regulating the implications. Although the current

situation in hormesis does not allow to draw empirically confirmed conclusions, the analysis of risk perception and communication in similar fields still provides a number of lessons for policymakers, especially if one accepts a pragmatic approach to this interaction.

- Science-based risk assessment is a beneficial and necessary instrument of pragmatic risk policy. It is the only means by which relative risks can be compared and options with the lowest statistical expectations selected. However, it cannot and should not be used as a general guide for public action. The price for its universality is abstraction from context and the overshadowing of other rational and meaningful perception characteristics. Without taking context and situation-specific supporting circumstances into account, decisions will not, in a given situation, meet the requirement of achieving collective objectives in a rational, purposeful and value-optimising manner. This is true regardless which model of does-response-relationships is selected.

- Context and supporting circumstances are significant characteristics of risk perception. These perception patterns are not just individual perceptions cobbled together: they stem from cultural evolution, are tried and trusted concepts in everyday life and, in many cases, control our actions in much the same way as a universal reaction to the perception of danger. Their universal nature across all cultures allows collective focus on risk and provides a basis for communication (Renn and Rohrmann 2000). While the effectiveness of these intuitive perception processes depends on ingrained values and external circumstances, they remain ever-present and measurable despite cultural reshaping. Intuitive mechanisms of risk perception and assessment have practically universal characteristics that can be shaped by sociocultural influences but not overruled by them.

- From a rational standpoint, it would appear useful to systematically identify the various dimensions of intuitive risk perception and to measure those dimensions against prevailing, empirically derived characteristics. In principle, the extent to which different technical options distribute risk across the various groups of society, the extent to which institutional control options exist and to what extent risk can be accepted by way of voluntary agreement can all be measured using appropriate research tools. Risk perception supplies lessons in the need to incorporate these factors into policymaking. This is based on the view that the dimensions (concerns) of intuitive risk perception are legitimate elements of rational policy, but assessment of the various risk sources must follow rational, scientific procedures in every dimension. This applies in particular to the hormesis hypothesis: It makes little sense to allocate societal resources into measures that prevent people from a positive health impact. Society needs an epistemological discourse that specifies the evidence and the limitations of hormesis and point out to the needs for regulatory reform based on sound scientific analysis and the risk characteristics that people are concerned about.

- Risk perception is no substitute for rational policy. Just as technical risk assessment should not be made the sole basis for decision-making, factual assessment of risk should not be made the political measure of its acceptability. If we know that low levels of a potential toxin enhances rather than endangers public health, then policies to reduce these levels are inappropriate even if there is a lack of awareness of the effects among the general public. To allow oneself to be guided by ignorance or obviously false perceptions hardly meets the prescription of pragmatic risk policy. Knowledge of existing perception patterns can, however, be used to structure and implement informational and educational measures in a beneficial manner. The inability of many people to understand probabilistic statements or hormesis is surely one problem area in which targeted education and information can be of benefit. What is really needed is mutual enhancement between technical risk assessment and intuitive risk perception.

Social scientists have no instruments or methods available to predict the fate of the hormesis debate in the different public arenas. What they can do, however, is to provide orientation and enlightenment to those who will enter this arena and deal with a plurality of opinions and evaluations. I am confident that the exchange of arguments in this series of papers, comments and rebuttals will contribute to this goal.

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