Journal of Risk Research
Vol. 9, No. 4, 361–372, June 2006

ARTICLE

The Impacts of Precautionary Measures and the Disclosure of Scientific Uncertainty on EMF Risk Perception and Trust

PETER M. WIEDEMANN*, ANDREA T. THALMANN**, MARKUS A. GRUTSCH† & HOLGER SCHÜTZ*

**Research Center Juelich, Program Group MUT (Humans, Environment, Technology), D-52425 Juelich, Germany, **Swiss Federal Office of Public Health (SFOPH), CH-3003 Bern, Switzerland, †Gsponer Consulting Group International AG, CH-4015 Basel, Switzerland*

ABSTRACT This study evaluates the impact on risk perception and trust in public health protection resulting from disclosure of information about implementation of precautionary measures and from the disclosure of scientific uncertainty in the area of mobile telephony. Based on an experimental design, the study supports our recent findings (Wiedemann and Schütz, 2005) that precautionary measures may trigger concerns and amplify EMF-related risk perceptions. Furthermore, our present data once again indicates that information about the implementation of precautionary measures has no positive effect on trust in public health protection. These results, contrary to common expectations, should be considered in decisions about precautionary measures. Risk managers who intend to implement precautionary measures merely as a means for reassuring the public will probably fail. Indeed, even if precautionary measures are justified from a public health perspective, it seems prudent to anticipate the possibly countervailing effects of such measures on the public. This leads to two important challenges for risk communication, first to clarify the difference between hazard and risk and, second, to help avoid such unwanted effects by designing better communication about precautionary measures.

KEY WORDS: Precautionary measures, scientific uncertainty, risk management, risk perception, trust

Correspondence Address: P. M. Wiedemann, Research Center Juelich, Program Group MUT (Humans, Environment, Technology), D-52425 Juelich, Germany. Email: p.wiedemann@fz-juelich.de

1366-9877 Print/1466-4461 Online/06/040361–12
DOI: 10.1080/13669870600802111

Introduction

One issue in today's EMF debate is whether precautionary measures ought to be applied when considering possible—but unproven—health risks below the limit values and, if so, which ones. According to widespread opinion, the precautionary principle should be applied to diminish risks by preventing threats before they occur. This is, at least partly, supported by the European Commission's approach and communications on the precautionary principle (European Commission, 2000). A similar thought is embodied in Swiss environmental law (USG): "The precautionary limitation of emissions should be implemented … insofar as this is technically and operationally feasible and also economically viable. In other words: avoidable pollution has to be avoided. Measures for reducing emissions that are possible in practice must actually be carried out[1]" (Röösli and Rapp, 2003, p. 57).

Controversy exists on what sort of precautions need to be taken for the regulation of EMF mobile telecommunication. As a result, greatly differing proposals for limitation and regulation (Wiedemann *et al.*, 2003b) and various methods of implementing the regulation can be observed in a number of countries (Wiedemann *et al.*, 2001). Switzerland, for instance, has imposed more severe restrictions than the International Commission on Non-Ionizing Radiation Protection (ICNIRP) recommended, in order to provide preventive protection for its population. By introducing an installation limit value, the Swiss Agency for the Environment, Forests and Landscape (BUWAL) is placing particular focus on the precautionary principle in Switzerland.

Considerations Concerning the Effects of Applying the Precautionary Principle

A central question is what effect will the introduction of precautionary measures have on the public debate. On the one hand, it is possible to put forward the hypothesis that the introduction of certain precautionary measures (for example, *the protection of sensitive facilities*) could be interpreted by laypersons as a warning signal for a potential danger. It is well known that affectively tinted key signals, in particular, influence risk perception (Lerner and Keltner, 2000, 2001). On the other hand, there is evidence that people's trust in experts and expert measures reduces risk perception (Drottz-Sjöberg and Sjöberg 1991; Figueredo and Drottz-Sjöberg, 2000; Siegrist and Cvetkovich, 2000; Siegrist *et al.*, 2000). Precautionary measures could also be understood as such measures.

In an empirical study on the influence of the precautionary principle on risk perception, Wiedemann and Schütz (2005) were able to show that

[1] translated by the authors

precautionary measures increase risk perception. Subjects who were given additional information on the implementation of precautionary measures felt a greater threat from mobile telecommunication than those subjects who were only given a risk assessment statement.

Disclosure of Uncertainty

A second objective of our present study is to examine the effects of disclosure of uncertainties on risk perception. Current discussions of risk communication emphasize the disclosure of uncertainty in risks assessments as an essential component of good risk communication (Thompson, 2002; Neus *et al*., 1998). However, some studies have indicated that this disclosure can amplify risk perception (Johnson and Slovic, 1995, 1998) while others, e.g. Wiedemann and Schütz (2005), found no effects.

Hypotheses

On the basis of the considerations set out above, it is possible to formulate the following alternative pairs of hypotheses:

1a: Information about implementation of a precautionary measure is seen as an indication of a threat and increases risk perception as opposed to information which contains no indications of precautionary measures.
1b: Information about implementation of a precautionary measure increases trust in risk regulation, which, in turn, reduces risk perception.

Hypothesis 1a postulates a path following Easterbrook's cue utilization theory (1959). A suitable "cue" is seen as a warning signal that increases risk perception. In particular, affectively-tinted information is judged to have the quality of a key stimulus. Hypothesis 1b follows a different path: the information reinforces trust because it announces protective measures and thereby reduces risk perception (see Siegrist *et al*., 2000).

When addressing the impact of uncertainty on risk perception, the following pair of alternative hypotheses can be postulated:

2a: The disclosure of uncertainty regarding the scientific status of knowledge leads to an effect (increase or decrease) on risk perception compared to the non-disclosure of the uncertainty.
2b: Disclosing uncertainty has no influence on risk perception.

Until now there have been no universally accepted models about the effect of uncertainty information on risk perception. From the perspective of the classical psychometric model one would expect that disclosure of ignorance and unknown facts will lead to higher risk perception (Slovic *et al*., 1985). However, recent reviews show that the relationship between uncertainty and risk perception are more complex (see Wiedemann *et al*., 2005).

A current issue in risk perception research is the role of cross-cultural differences (e.g. Renn and Rohrmann, 2000). While this is not a central aspect of our study, we had the opportunity to investigate the above mentioned hypotheses with two different samples, one from the German and the other from the French speaking population in Switzerland.

Method

Experimental Design

The hypotheses are examined with a 5×2 experimental design. The factors are: (1) precaution, consisting of five different levels, and (2) uncertainty in knowledge, consisting of two levels. Both factors are varied with the help of various text modules.

The starting point for these texts are risk assessments of EMF mobile telecommunication that can be found in documents of the German Radiation Protection Commission SSK (2001), BUWAL (1999) or ECOLOG (2000). In addition to this, we incorporated existing precautionary proposals and measures. Examples thus include the reduction of ICNIRP values by a factor of 10 (Swiss model), or the German Radiation Protection Commission's recommendation to pay special attention to minimizing exposure (SSK, 2001), as well as its call for citizen participation in decisions concerning possible sites.

The first factor refers to the precaution options that have been discussed in the EMF debate. Module 1 consisted of a basic text, all the other modules included additional information about precautionary measures: ''Demand for minimization of exposure'' (module 2), ''Reduction of the existing limit values by a factor of 10'' (module 3, ''Special protection of sensitive locations'' (module 4), and ''Public participation in deciding on sites'' (module 5) (see Table 1).

The second factor addresses the uncertainty in risk assessment. There are two levels: Level 1—no reference to uncertainty, and Level 2—inclusion of uncertainty. The condition of uncertainty is added to the baseline condition text by the following statement: ''Some scientists argue that substantial uncertainties exist as to whether current protection from electrosmog is sufficient''. The baseline condition text for level 1 does not include this sentence.

The dependent variables are risk perception (''How threatening is electrosmog to you?''), trust in risk regulation (''How much do you trust that the public's health is adequately protected?''), and the assessment of the current state of scientific knowledge (''How do you rate the knowledge about health effects of electrosmog?''). The dependent variables are measured on a seven-point rating scale.

This design brings two types of precautionary measures together that Wiedemann and Schütz (2005) studied in separate experiments: precautionary

Table 1. Text modules, factor "precautionary measures"

Experimental condition	Text modules
Basic text (module 1)	A widespread debate about the potential risks related to electrosmog is ongoing. The International Commission for Non-Ionizing Radiation Protection points out that current exposure limits protect the public adequately.
Demand for minimization of exposure (module 2)	Module 1+ Nevertheless the Commission recommends precautionary measures: exposure to radiation from mobile telecommunication should be kept as low as possible.
Reduction of existing limit values (module 3)	Module 1+ Nevertheless, the Salzburg petition calls for a 10-fold reduction in the limit values by way of a precautionary measure for all places where people are present on a permanent basis.
Special protection of sensitive locations (module 4)	Module 1+ Nevertheless, following a precautionary approach, many local communities demand that base stations should not be sited near sensitive locations such as day care facilities, schools or hospitals.
Public participation (module 5)	Module 1+ However, for precautionary reasons, many local authorities claim that the residents should be involved in the siting process for base stations.

measures related to health and measures related to processes.[2] The latter aim at reducing conflicts as well as improving trust and credibility.

Sample

The experimental study was carried out on an ad hoc sample including 639 subjects from the German- and French-speaking parts of Switzerland (German-speaking sample: $n=396$ (62%); French-speaking sample: $n=244$ (38%)). Of these $n=270$ were women (42%) and $n=369$ men (58%). All participants were between 17 and 43 years of age. The average age was 22;

[2] Wiedemann et al. (2001) differentiate (1) measures related to health protection, (2) measures extending to processes which serve as support for decision making and the reduction of conflict, and (3) measures related to research.

the median 21. All the subjects came from two universities: the University of St. Gallen and the University of Fribourg. The subjects were distributed over the 10 conditions in a balanced and randomized way (between 57 and 74 subjects for each condition). The two samples differ in age and gender distribution (German-speaking sample: average age=21, male 63.6%/ female: 36.4%; French-speaking sample: average age=23.8, male: 48.1%/ female: 51.9%).

Results

Kolmogorov–Smirnov (KS) tests for normality of the dependent variables, carried out separately for each factor level, were statistically significant, indicating that the distributions of these variables were not normal. Therefore, distribution-free tests (Kruskal–Wallis) were calculated for the dependent variables of ''risk perception'', ''trust'' and ''status of scientific knowledge''. To test which factor differs significantly from others, Mann–Whitney U Tests were carried out *post hoc*.

Effects of Precautionary Measures

The ''precautionary measures'' factor has a significant influence on risk perception (Chi^2 (4)=11.644, p=0.020). Figure 1 shows the average rating of risk perception. The average for the condition ''no precautionary measure'' is clearly below the averages for the other conditions.

The analysis carried out with a Mann–Whitney U Test shows that the conditions of ''no precaution'' and ''protection of sensitive locations'' differ significantly (U=5134, p=0.001). This difference also remains significant after a Bonferroni correction for multiple testing. All other factorial differences are statistically insignificant. When looking at the two samples

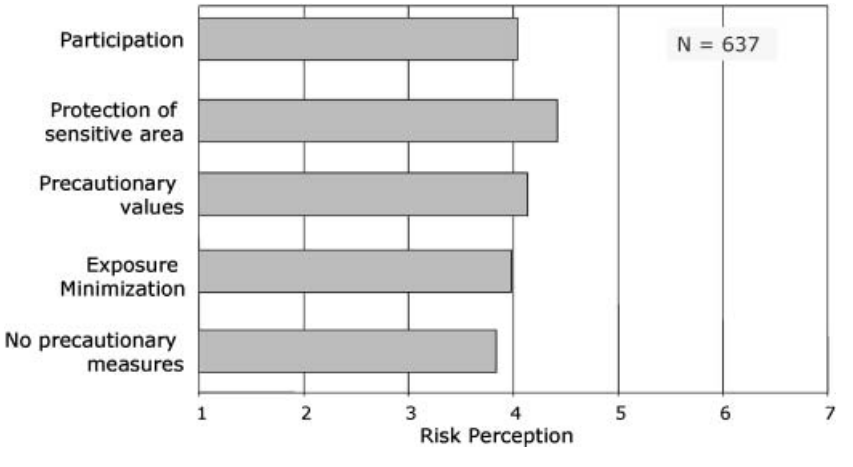

Figure 1. The effect of mentioning precautionary measures on risk perception (mean values)

(German-speaking and French-speaking Swiss) separately, the same significant effect on risk perception can be observed (French-speaking sample: Chi^2 (4)=9.783, p=0.044/U=904, p=0.031; German-speaking sample: Chi^2 (4)=10.462, p=0.033/U=1722.5, p=0.006).

Information about precautionary measures had no effect on trust in public health protection (Chi^2 (4)=4.836, p=0.305; see Figure 2). Even a separate analysis of the French- and German-speaking samples showed no effect on trust (French-speaking sample: Chi^2 (4)=5.645, p=0.227; German-speaking sample: Chi^2 (4)=2.034, p=0.730).

The inclusion of information on precautionary measures had no statistical effect on the appraisal of the "status of scientific knowledge" (Chi^2 (4)=4.347, p=0.361). A separate analysis of the two samples leads to the same result (French-speaking sample: Chi^2 (4)=1.626, p=0.804; German-speaking sample: Chi^2 (4)=7.031, p=0.134).

Effects of the Disclosure of Uncertainty

There is no significant effect for the factor of uncertainty in respect to risk perception (Chi^2 (1)=0.315, p=0.574) and trust (Chi^2 (1)=0.456, p=0.499). Disclosing the uncertainty of knowledge has no effect on risk perception compared with non-disclosure ($M_{Uncertainty}$=4.1 versus $M_{Certainty}$=4.0). The same applies to the dependent variable of "trust". The subjects trust public health protection to the same extent irrespective of whether uncertainty is disclosed (M=3.6) or not (M=3.7). The results are also the same when a separate analysis is conducted of the two samples (for risk perception: French-speaking sample: Chi^2 (1)=0.057, p=0.811,

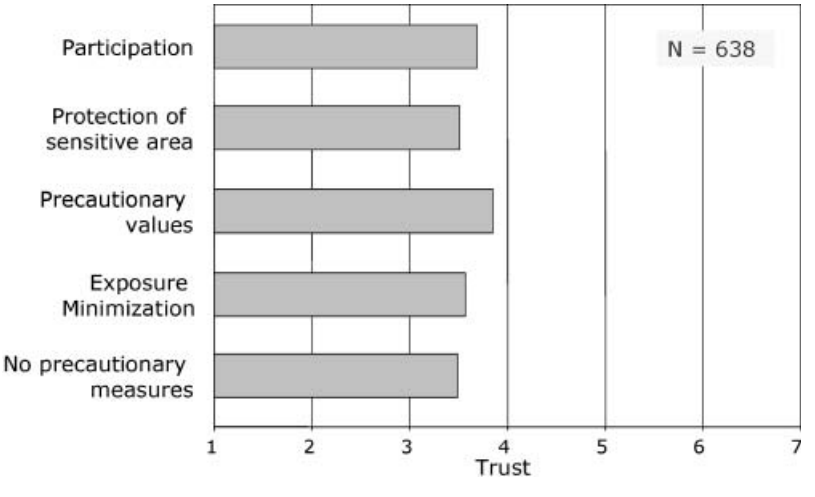

Figure 2. The effect of mentioning precautionary measures on trust (mean values)

German-speaking sample: Chi^2 (1)=0.302, p=0.583; for trust in health protection: French-speaking sample: Chi^2 (1)=2.486, p=0.115, German-speaking sample: Chi^2 (1)=0.345, p=0.557).

Disclosing uncertainty has a statistical impact on the subjects' appraisal of the current state of scientific knowledge (Chi^2 (1)=10.060, p=0.002). The subjects rated the status of knowledge higher when uncertainty is disclosed (M=3.1), whereas when uncertainty is not mentioned the mean value is lower (M=2.8). Figure 3 visualizes these results and also the impact of the factor "disclosure of uncertainty" on risk perception and trust. A separate analysis of the two samples indicates differences in means under the uncertainty condition (German-speaking subjects: $M_{Certain}$=2.85 versus $M_{Uncertain}$=2.95/French-speaking subjects: $M_{Certain}$=2.75 versus $M_{Uncertain}$=3.38). The tests, however, yield that the disclosure of uncertainty has only a significant effect among the French-speaking subjects' appraisal of the status of knowledge (Chi^2 (1)=13.243, p<0.001), but not among the German-speaking subjects' appraisal (Chi^2 (1)=0.886, p=0.347).

Discussion

The present study replicates the findings of Wiedemann and Schütz (2005) on the relationship between information about precautionary measures on the one hand and risk perception and trust in health protection on the other hand.

First of all, providing information about the implementation of precautionary measures does not result in lower risk perception. On the contrary, our study indicates that people feel more threatened by the

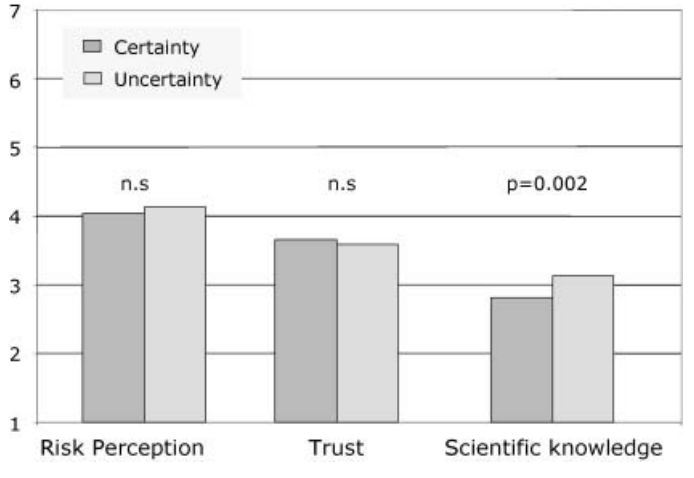

Figure 3. Effects of the disclosure of uncertainty in knowledge on risk perception, trust and assessment of current knowledge (mean values)

so-called "electrosmog" when precautionary measures mention the need for increased protection of sensitive locations. One can assume that the mentioned key stimuli—day care facilities, schools, and hospitals—are understood as warning signals and thereby trigger risk perception.

The small absolute (though statistically significant) size of effects as well as the missing effects on risk perception may point to criticism questioning the practical relevance of the findings. But even minor effects are of practical significance if they point in the opposite direction. In this case, the findings contradict the standard expectations and convictions that public concerns about potential threats from mobile phones can be reduced through precautionary measures.

Our results additionally show that precautionary measures do not increase trust in public health protection. This is consistent with the previous results of Wiedemann and Schütz (2005). They found a negative effect (i.e. mentioning precautionary measures reduced trust in public health protection), whereas the present study showed no influence. In particular, both sets of findings support the conclusion that reference to participation does not create additional trust. Furthermore, even precautionary measures addressing probable health improvements, like the lowering of limit values, do not strengthen people's trust in health protection. This latter conclusion is new, as Wiedemann and Schütz (2005) did not previously study this aspect. Thus, it appears fair to state that we have no scientific evidence that the implementation of precautionary measures will result in increasing trust in risk management.

Regarding the disclosure of uncertainty and its impact on risk perception and trust in health protection our results found no effects. This confirms the results of Wiedemann and Schütz (2005). The findings in respect to the influence of the disclosure of uncertainty on risk perception prompt critical reflection. Although they confirm Wiedemann and Schütz' (2005) findings, it would have only been plausible for the explicit mentioning of uncertainty (text module used: "Some scientists argue that substantial uncertainties exist as to whether current protection from electrosmog is sufficient") to increase risk perception. Further studies would have to change the operationalization of the uncertainty in order to find out whether there are any effects and, if so, when they appear.

In contrast to Wiedemann and Schütz (2005), the present study shows significant effects of a disclosure of uncertainty on the appraisal of the current state of scientific knowledge. Our subjects assessed scientific knowledge concerning consequences of EMF as being better when there was a disclosure of uncertainty and as being less good when there was no disclosure. A future study would have to analyze whether this result is of a durable nature.

The separate analysis of the French- and German-speaking sample did reveal substantial similarities. The only difference we found referred to the disclosure of uncertainty. The impact of disclosure of uncertainty on the

appraisal of the state of scientific knowledge was only statistically significant for the French-speaking but not for the German-speaking subjects.

A final word on the limitations of our study. In our experiment the average age of the participants was 22. We do not know whether the experimental treatment effects would be the same for other age groups. A second point pertains to the missing effects of our experimental treatments on the dependent variables. Such "non-effects" are often due to sample sizes which are too small to detect actually existing effects. However, in our study the sample size was large enough at least for an average effect size—as confirmed by a *post hoc* power analysis: in a sample with 640 subjects, the factor "precautionary measures" attains a power of 0.9998 and the factor "disclosure of uncertainty" a power of 1.0 (average effect size, Alpha=0.05; N=640). If there were only very small effects, the factor "precautionary measures" would have a power of 0.5 and "disclosure of uncertainty" would attain 0.7 (small effect size, Alpha=0.05; N=640).

Conclusion

The results raise questions about the communication of precautionary measures concerning mobile telecommunication. Contrary to what is believed by regulatory and political common sense, which assumes that the introduction of precautionary measures increases trust and reduces fear and doubts, we found no such effects.

Furthermore, it seems that precautionary measures that are associated with affectively-tinted key signals might be able to increase risk perception. This result was already found in a previous, comparable study (Wiedemann and Schütz, 2005).

The results of the present study should not lead to the conclusion that precautionary health protection should be abandoned. However, they may serve to warn risk managers that using precautionary measures merely as a means for reassuring the public will probably fail. Indeed, even if precautionary measures are well justified from a public health perspective, it seems prudent to take into consideration possible disturbance effects of such measures on the public's perception.

This leads to two important challenges for risk communication, first to clarify the difference between hazard and risk and, second, to help avoid such unwanted effects by designing better communication about precautionary measures.

Instead of hoping that implementation of precautionary measures will help to lower public concerns, risk communication should focus on clarifying the difference between hazard and risk, as well as between proven and unproven hazards. First, a hazard does not necessarily result in a risk. Second, and more importantly, simply talking about hazards without informing about the underlying scientific evidence remains insufficient to appraise the potential health risk from mobile telecommunications. One

needs to know the strength of evidence (e.g. whether the hazard is proven, only possible, or whether the evidence is inadequate).

Unfortunately, to date there is only little knowledge about how risk communication has to be designed in order to highlight such distinctions. In general, the empirical research on communicating ambiguous hazards and knowledge gaps in risk assessment is rather poor and the few available studies show mixed results. Thus, further research is urgently needed.

Acknowledgements

This research was funded by a grant from the Swiss Research Foundation on Mobile Communication. The authors want to express their gratitude to Prof. Dr. Meinrad Perrez from the University of Fribourg and PD Dr. Annette Kluge from the University of St. Gallen (HSG) for supporting the data gathering. The authors also wish to thank Dr. Martin Clauberg and two anonymous reviewers for their helpful comments.

References

BUWAL (1999) Verordnung über den Schutz vor nichtionisierender Strahlung (NISV) Erläuternder Bericht. 23. Dec. 1999.

EC (2000) *Communication on the Precautionary Principle* (Brussels: Commission of the European Communities).

ECOLOG (2000) *Mobilfunk und Gesundheit. Bewertung des wissenschaftlichen Erkenntnisstands unter dem Gesichtspunkt des vorsorgenden Gesundheitsschutzes* (Hannover: ECOLOG).

Easterbrook, J. A. (1959) The effect of emotion on cue utilization and the organization of behavior, *Psychological Review*, 66, pp. 183–201.

Drottz-Sjöberg, B. M. and Sjöberg, L. (1991) Adolescents' attitudes to nuclear power and radioactive wastes, *Journal of Applied Social Psychology*, 21, pp. 2007–2036.

Figueredo, C. J. and Drottz-Sjöberg, B. M. (2000) Perceived control, voluntariness and emotional reactions in relocated areas of Russia, Ukraine and Belarus, *Risk: Health, Safety & Environment*, 11, pp. 233–242.

Johnson, B. B. and Slovic, P. (1995) Presenting uncertainty in health risk assessment: Initial studies of its effects on risk perception and trust, *Risk Analysis*, 15, pp. 485–494.

Johnson, B. B. and Slovic, P. (1998) Lay views on uncertainty in environmental health risk assessment, *Journal of Risk Research*, 1, pp. 261–279.

Lerner, J. S. and Keltner, D. (2000) Beyond valence: Toward a model of emotion-specific influences on judgment and choice, *Cognition and Emotion*, 14, pp. 473–493.

Lerner, J. S. and Keltner, D. (2001) Fear, anger, and risk, *Journal of Personality and Social Psychology*, 81, pp. 146–159.

Neus, H., Ollroge, I., Schmidt-Höpfner, S., Kappos, A. (1998) Zur Harmonisierung gesundheitsbezogener Umweltstandards – Probleme und Lösungsansätze, in: Umweltbundesamt (Ed.) *Aktionsprogramm Umwelt und Gesundheit: Forschungsbericht* (Teil 1) (Berlin: Erich Schmidt).

Renn, O. and Rohrmann, B. (2000) *Cross-cultural Risk Perception* (Dordrecht: Kluwer).

Röösli, M. and Rapp, R. (2003) Hochfrequente Strahlung und Gesundheit. BUWAL Umwelt-Materialien Nr. 162 (Bern: BUWAL).

Siegrist, M. and Cvetkovich, G. (2000) Perception of hazards: The role of social trust and knowledge, *Risk Analysis*, 20, pp. 713–719.

Siegrist, M., Cvetkovich, G. and Roth, C. (2000) Salient value similarity, social trust, and risk/benefit perception, *Risk Analysis*, 20, pp. 353–362.

Slovic, P., Fischhoff, B. and Lichtenstein, S. (1985) Characterizing perceived risk, in: R. W. Kates, C. Hohenemser & J. X. Kasperson (Eds) *Perilous Progress: Managing the Hazards of Technology*, pp. 91–125 (Boulder, CO: Westview).

SSK (2001) Empfehlungen und Stellungnahmen der Strahlenschutzkommission 2001, Bundesministerium für Umwelt, Natur und Strahlenschutz (Ed.) *Veröffentlichungen der Strahlenschutzkommission*, Vol. 48 (München, Jena: Urban & Fischer).

Thompson, K. M. (2002) Variability and uncertainty meet risk management and risk communication, *Risk Analysis*, 22, pp. 647–654.

Wiedemann, P. M., Clauberg, M. and Schütz, H. (2003a) Understanding amplification of complex risk issues: The risk story model applied to the EMF-case, in: N. Pidgeon, R. E. Kasperson & P. Slovic (Eds) *The Social Amplification of Risk*, pp. 286–305 (Cambridge, UK: Cambridge University Press).

Wiedemann, P. M., Mertens, J., Schütz, H., Hennings, W. and Kallfass, M. (2001) *Risikopotenziale elektromagnetischer Felder: Endbericht für das Bayerische Staatsministerium für Landesentwicklung und Umweltfragen* (Vol. 1) (Juelich: Research Center Juelich).

Wiedemann, P. M. and Schütz, H. (2005) The precautionary principle and risk perception: Experimental studies in the EMF area, *Environmental Health Perspectives*, 113, pp. 402–405.

Wiedemann, P. M., Schütz, H., Mertens, J. (2005) Kommunikation undeutlicher Risiken, in: Bundesumweltministerium (Ed.) *Veröffentlichungen der Strahlenschutzkommission*, Band 54, pp. 175–194 (München: Urban & Fischer).

Wiedemann, P. M., Schütz, H. and Thalmann, A. T. (2003b) Mobilfunk und Gesundheit. Risikobewertung im wissenschaftlichen Dialog. Schriften des Forschungszentrums Juelich, Reihe Umwelt 42, Juelich, Research Center Juelich.