
Final Report

Project Nummer: 20

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Projekttitel: Expert and lay perception of health hazards associated with mobile phone base stations

1. State of Research

1.1 Background of the Research Proposal

1.1.1 Goals, Expected Results

Numerous studies have examined possible health effects of EMF. However, surprisingly few studies examined the question of how lay people perceive risks associated with cell phones or base stations. Furthermore, most of this research was purely quantitative. As a result we do not know what kind of mental models regarding EMF and base stations lay people have. The goal of the present research is to fill this knowledge gap. The applied methodology is able to show how lay mental models differ from those of experts. Therefore, the results will have implications for the practice of risk communication.

1.1.2 Rationale for the Project and State of Research

The number of people who use mobile phones has dramatically increased in Europe and in the US in recent years. This increased demand has led to the construction of more base stations. For the 3G/UMTS-Net that will be introduced in Europe soon, twice the number of base stations will be needed than for today's GSM-net (2nd generation). Therefore, even more base stations will be built in the near future. Faced with a conflict between demand for more transmission facilities and public opposition to them, telecommunication companies and authorities are forced to take into account the risks perceived by lay people.

Few studies dealing with lay people's perceptions of risks associated with cell phones or base stations have been published. Poortinga and Pidgeon (2003) examined factors that influence trust in the authorities responsible for regulating mobile phones. Results of their survey indicated that general trust, skepticism and value similarity affect levels of trust. A study by Sjöberg (2002) showed that people associate "unknown effects" with mobile phones. Similar findings were obtained in a German survey (Zwick & Ruddat, 2002): Respondents viewed risks associated with mobile phones as highly uncertain. The possible effects and the extent of the risks were judged to be uncertain. There are other risks associated with cell phones in addition to those from EMF. White, Eiser, and Harris (2004), for example, examined the perception of risks arising from mobile phone use while driving.

Perceptions of electromagnetic field risks associated with high-voltage transmission lines and other sources of EMF have been examined in several studies (Furby, Slovic, Fischhoff, & Gregory, 1988; Gregory & von Winterfeldt, 1996; Morgan, Slovic, Nair, Geisler, MacGregor, Fischhoff, et al., 1985; Wiedemann, Clauberg, & Schütz, 2003). MacGregor, Slovic, and Morgan (1994) assessed lay people's beliefs about EMF as a cause of health disorders. The highest ratings were obtained for cancer and birth defects. Respondents in this

study also showed strong support for corrective measures such as warning labels, appliance shielding and further research.

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Results of studies utilizing the psychometric paradigm

Psychometric studies have focused on the identification of factors that determine public perception of different hazards (Slovic, 1987). In these studies, participants assessed various characteristics of a broad range of potential hazards, and principal components analysis was used to identify the factors that determined the perception of these hazards. The perceived risks associated with different sources of EMF were examined. Results suggested that fields from large power lines are perceived as little-known risks and as risks with some dread potential (Morgan et al., 1985). The authors concluded that possible negative health effects associated with the EMF of high-voltage transmission lines may have a fairly high "signal potential." In other words, even minor effects would receive considerable media attention, and people might ask for stricter regulations. Morgan et al. (1985) also examined the perception of fields from electric blankets. Results indicated that people perceive electric blankets to be little-known risks with a low dread potential. Since the participants in this study were 116 alumni of Carnegie-Mellon University, generalization of the results is problematic. In a study conducted in Chile, Bronfman and Cifuentes (2003) included the item "cell-phone transmission antennas" in their list of hazards, and respondents perceived base stations as a little-known hazard with medium dread potential.

In these studies utilizing the psychometric paradigm, averages are taken across all participants. Results of recent studies, however, indicate that there are substantial individual differences in risk perception (Marris, Langford, Saunderson, & O'Riordan, 1997; Siegrist, Keller, & Kiers, in press). This suggests that a model based on aggregated data cannot explain lay people's risk perceptions. Clearly, more research that examines factors accounting for individual differences in risk perception is needed.

Results of the research group

Perceptions of risks associated with mobile phones, base stations, and other sources of electromagnetic fields (EMF) were examined (Siegrist, Earle, Gutscher & Keller, 2004). Data were derived from a telephone survey conducted in the German and French speaking parts of Switzerland (N=1015). Results of this study indicate that, for a majority of Swiss people, base stations for mobile phones evoke negative associations. Most respondents mentioned abstract associations like electromagnetic radiation pollution, irradiation, or illnesses. However, free associations evoked by the term "base station" were less negative and much more abstract than the ones obtained for gene technology (Siegrist, 2003) or for a nuclear waste repository (Slovic et al., 1991). Participants evaluated risks of different sources of EMF. Lay people's risk assessments

for high-voltage transmission lines were higher than for mobile phone base stations. Interestingly, there are public discussions about base stations and their possible health effects, but there are almost no discussions about high-voltage transmission lines in Switzerland anymore. One explanation for this result is the fact that there are currently many more cases of base station construction than transmission line construction. Utilizing multiple regression analysis, the impacts of a variety of factors on the perception of EMF risks were examined. Reaction to the item "Most chemical substances cause cancer" was the best predictor. People who are afraid of chemical substances are also afraid of EMF. This suggests that, for some people, technology is associated with harm, and, for other people, technology is not primarily associated with harm. Belief in paranormal phenomena was also a significant predictor. Results observed by Sjöberg and af Wahlberg (2002) were successfully replicated. The influence of these two predictors suggests that beliefs not supported by most scientists can influence lay perceptions of risk.

Based on a comprehensive review of the trust literature we proposed a "dual-mode model of cooperation based on social trust and confidence" (Siegrist, Earle, & Gutscher, 2003). Trust and confidence are separate, but, under some circumstances, interacting sources of cooperation. Trust is based on value similarity, and confidence is based on past performance (or on restrictions placed on future performance). According to our model, the judged similarity between one's currently salient values and the values attributed to others determines social trust (Earle & Cvetkovich, 1995; Siegrist, Cvetkovich, & Roth, 2000). Thus, the basis for trust is the belief that the person to be trusted would act as the trusting person would in that situation. One's interpretation of the other's past performance influences one's confidence in future performance. Confidence can be based on formal record keeping, contracts, control systems or other indicators of past performance or systems to control future performance. This division of information, although central in studies of impression formation, has been overlooked in most studies of trust and confidence in risk management contexts. We hypothesized that trust-related information with values implications, which we call morality information, tends to dominate performance information. By "dominate" we mean that, to an observer, morality information is more important and that it conditions the interpretation of performance information. For example, given positive morality information, negative performance is judged much less harshly than it would be if the morality information were negative. According to our model, both social trust and confidence have an impact on people's willingness to cooperate (e.g., accept antennas emitting electromagnetic fields in the neighbourhood). Our model was tested in the applied context EMF risks. Data from a random sample of 1313 Swiss citizens were collected. The telephone survey yielded a response rate of 42%. Structural equation modelling procedures were used to test the plausibility of the postulated dual-mode model of cooperation based on social trust and confidence. Results indicated that the proposed model fit the data very well.

Rationale for the proposed project

Most studies examining risk perception related to EMF have utilized a quantitative survey approach. Consequently, the question of why some people think that cell phones or power lines are risky cannot be fully answered. It remains unclear how, according to the thinking of some lay people, EMF may influence health. The mental model approach (Atman, Bostrom, Fischhoff, & Morgan, 1994; Bostrom, Atman, Fischhoff, & Morgan, 1994; Bostrom, Fischhoff, & Morgan, 1992; Bostrom, Morgan, Fischhoff, & Read,

1994; Cox, Niewöhner, Pidgeon, Gerrard, Fischhoff, & Riley, 2003; Morgan, Fischhoff, Boström, & Atman, 2002; Niewöhner, Cox, Gerrard, & Pidgeon, 2004), combined with the think aloud method (Earle, 2004), should be used to get a better understanding of the underlying cognitive processes. Such research could provide the basis for a better understanding of the risk perception of lay people in the domain of electromagnetic fields.

1.2 Detailed Research Plan

The project included three parts. The following explanations give an overview on the different steps undertaken.

Part 1: Literature Research and Open Interviews with Experts – The Construction of an Expert Model

Literature from different relevant fields was reviewed and analysed. The first goal was to gain technical knowledge about functional aspects of mobile phone communication. In addition, the current scientific knowledge base about health risks associated to high frequency electromagnetic field was studied. The literature review showed that there is a disagreement between experts whether EMF affects human's health. There is also disagreement how EMF might affect human's health. Therefore, we focused our ongoing work mainly on the technical knowledge about EMF. On this basis, a first expert model was developed.

To understand the current situation and the dynamics of the social process in Switzerland, an actor analysis based on the World Wide Web was accomplished. This analysis was used to identify relevant persons for the expert interviews. Attention was paid to selected persons with different backgrounds and opinions about the health effects of EMF.

The interviews were guided by a manual, which covered different fields of interest. Most experts were asked to create their own model and explain their construction. After this part, our own basic model was presented to the experts and they were asked to comment on it. The interviews lasted between one and two hours, were recorded and transcribed. In total, sixteen interviews were completed and evaluated. With the new insights, the basic expert model was modified and accomplished.

Part 2: The Construction of a Lay Mental Model

The final expert model was used to design the manual for the lay interviews. Apart from 42 half-standardised questions grouped into 13 fields of interest, some experimental tasks were conceived. As an example, six maps of the same village with different antenna placements were presented to the participants. They were asked to indicate their preferences and explain why some placements were better in their opinion than others.

The lay interview was mainly designed to disclose gaps in one's knowledge and understanding. Some questions address the dynamics around the ongoing mobile phone discussion in Switzerland. Also, frequently used images, metaphors, and sets of beliefs about risks were collected.

The manual for the interviews was pre-tested and modified. The interview lasted about an hour and took place during May and June 2006. In sum, sixteen laypeople and fifteen base station opponents were interviewed. Demographic characteristics (e. g., age, education level, sex) were counterbalanced as far as possible. The comparison of experts and lay models showed what kind of misconceptions exist and which misconceptions most seriously hamper achieving a better understanding of the hazard.

Part 3: Construction of a Mail Survey – Quantitative Aspects

The mental model interviews provided a rich set of beliefs about risk as well as different gaps of knowledge and understanding. To obtain insight into the prevalence of these beliefs in the general population, a mail survey based on lay people's mental models was constructed. The used questionnaire covered different areas of interest. First, 'affect', 'perceived benefit' and 'perceived risk' of cell phones and base stations were measured. Afterwards, subjective knowledge, trust in different actors, cell phone use and personal concerns in regard to base stations were assessed. In a second part, respondents were asked to answer 28 knowledge questions including two visual supported tasks. The first 26 items were written true / false questions with the answer possibilities 'true', 'wrong' and 'don't know'. In addition, participants had to indicate their preferences about base station siting in a forced-choice task. In a third part, health concerns, attitudes, presumed health effects and related causal models were explored. Demographic characteristics were recorded at the end of the questionnaire. The questionnaire was carefully worded to minimize technical and academic language and it was pre-tested in detail.

The mail survey was conducted between December 2006 and February 2007 in the German-speaking part of Switzerland. A random sample of addresses was selected from the electronic directory. Finally, 765 questionnaires were included for data analysis. This was equal to a response rate of 41 %. Forty-two percent ($N = 311$) of the respondents were female, and fifty-eight percent ($N = 435$) were male. Reported age ranged between 19 and 105 years, with a mean age of 51.62 ($SD = 16.60$). Respondents were better educated than the general Swiss population.

1.2 Selected Findings and Discussion of the Results

The results of these three steps can be summarized as follows:

Part 1: The Construction of an Expert Model

The final expert model depicts a broad variety of aspects and influence factors in regard to risk perception of mobile communication. The model reflects the beliefs of a group of Swiss experts. It can be

stated that experts overwhelmingly agree on technical as well as on social and individual aspects. Yet, beliefs about scientific uncertainties and probabilities of possible health effects differ to some degree. The lack of causal models explaining bodily changes, missing long-term studies, and the difficulties in appropriately measuring radiation results in uncertainty and offers space for personal opinions and speculations. The expert model allows important insights into the structure of the complex problem field.

Part 2: The Construction of a Lay Mental Model

The evaluation of the lay interviews generates a broad set of beliefs. For this report, we focus only on the insights about the technical aspects. The comparison between laypeople and base station opponents shows a lot of similarities but also some differences. Various levels of knowledge concerning the technical aspects of mobile communication were found in both groups. Most opponents, however, knew more than average laypeople. They were better informed about laws, exposure standards, and network construction processes than laypeople. The most striking discrepancy between experts and laypeople was the degree of certainty about health effects of radiation. All opponents and all but two laypeople were certain that high-frequency electromagnetic fields could harm human beings.

Part 3: Construction of a Mail Survey – Quantitative Aspects

Lay interviews and survey results indicate that the general public is familiar with diverse aspects of mobile communication but shows specific knowledge gaps and misconceptions. In other words, people's objective knowledge depended on the topic. Correct answers to the knowledge questions ranged between 10.6 % and 74.1% (answer possibilities: correct, wrong, don't know). Respondents had reasonable knowledge about cell phones (mean of 49% correct answers based on 9 items) and even base stations (mean of 33.8% correct answers based on 5 items), but most of them ignored the interaction patterns between cell phones and base stations (mean of 21.2% correct answers based on 6 items). Knowledge about radiation in general (mean of 19.3% correct answers based on 2 items) and about regulation was also low (mean of 21.7% correct answers based on 2 items). Only 26% of the respondents reported that they had actively searched for information about mobile communication. Self-reported knowledge (6-point-scale: 1=no knowledge, 6=good knowledge) fluctuated across various knowledge topics. Respondents reported knowing more about risk ($M = 3.42$, $SD = 1.3$) than technical aspects ($M = 3.03$, $SD = 1.32$) or legal aspects ($M = 2.27$, $SD = 1.24$). Perception measurement (affect, risk, benefit) of cell phones and base stations revealed

findings along the expected lines. Base stations were perceived as significantly more negative, riskier, and less beneficial than cell phones.

An objective of the presented study was to achieve a better understanding of laypeople's information requirements in regard to mobile communication. Results suggest that laypeople's objective knowledge varies considerably across the different topics. Knowledge about cell phones and base stations is widespread, but 'knowledge about interaction patterns', 'regulation', and 'radiation in general' is lacking. The knowledge about interaction pattern is considered particularly and highly relevant for the full understanding of EMF exposure. Qualitative and quantitative results stress that people misperceive the exposure contributions of cell phones and base stations. They underestimate the contribution of cell phones and are not aware that the amount of radiation emitted depends on factors like distance to the base station or shielding by walls. In fact, most people ignore that their cell phone is also an antenna and has the same functionality as a base station. They perceive distance to the base station as a protecting factor, yet all the while the fact that they themselves hold an antenna close to their heads goes unheeded.

In spite of these findings, the role of knowledge for risk perception cannot be fully assessed. It is difficult to evaluate the interaction between risk perception and knowledge because most respondents had a low level of knowledge. Therefore, more research is needed. The effect of specific knowledge provision could be tested in experimental settings. The approach also allows for information provision not just focused on an aggregated public but for specific groups and individuals within their specific social and institutional contexts. For instance, information for a general public and for citizens concerned by a new base station could be adapted accordingly.

Risk communication addressed to laypeople should consider the unveiled misconceptions or knowledge gaps. Worried cell phone users can be shown simple and effective ways of how to reduce their daily exposure dose. The knowledge about interaction patterns between base stations and cell phones is also useful in regard to base station placement. Base station opponents often wish to remove base stations from residential areas in order to reduce their daily radiation exposure. Again, the 'homemade' radiation by their own cell phone and its dependence on factors like distance to base station and shielding are ignored. Perhaps knowledge about these interaction patterns could help people to accept the necessary proximity of base stations. However, even adequate knowledge about technical aspects is probably worthless if there is

a lack of trust in the involved actors. Therefore, it is important to invest in accurately timed and open communication.

As long as it cannot be satisfactorily documented that EMFs of mobile communications are innocuous, people have to deal with uncertainty. Information about technical aspects cannot compensate the uncertainty and the health concerns, but they can help people, establish accurate beliefs about exposure and give them helpful behavioral guidelines. This can help to qualify their fears and anticipated health consequences.

1.4 Literature

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2. Annex

2.1 Publication and Conference Contributions

Selected Results were presented at the following conferences:

- Cousin, M-E., & Siegrist, M. (2007). What do laypeople know about Mobile Communication? A Mental Model Approach. 2nd Workshop on EMF risk communication: "Effective Risk Communication in the context of uncertainty". Stresa (Italy), May 2-4, 2007.
- Siegrist, M., & Cousin, M-E. (2007). Wahrnehmung der Gesundheitsrisiken von Basisstationen durch Experten und Laien. 6. Science Brunch der Forschungstiftung Mobilkommunikation. Zürich, 1. Juni, 2007.
- Cousin, M-E., & Siegrist, M. (2007). Why do people fear mobile phone base stations? A Mental Model Approach. The 16th SRA Europe Conference, Building Bridges: Issues for future risk research. Den Haag, June 17-19, 2007,
- Siegrist, M., & Cousin, M-E. (2007). Laypeople's Knowledge about Mobile Communication. EMC Zurich 2007, 18th International Zurich Symposium on Electromagnetic Compatibility. Munich (Germany), September 24-28, 2007.
- Cousin, M-E., & Siegrist, M. (2007). Laypeople's and experts' risk perception of mobile communication in Switzerland 10th Congress of the Swiss Society of Psychology. Differences, Diversity, and Change. Zurich, September 13-14, 2007.

Two manuscripts are submitted to peer-reviewed journals and two manuscripts are in preparation.

- Risk Perception of Mobile Communication: A Mental Model Approach (submitted to *Risk Analysis*)
- Not in my Backyard but in my Pocket! Why Do People Fear Mobile Phone Base Stations but not Their Cell Phones? (submitted to *Public Understanding of Science*)

Date and Signature

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