Influence of Information About Specific Absorption Rate (SAR) Upon Customers' Purchase Decisions and Safety Evaluation of Mobile Phones

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This study investigated whether the SAR value is a purchase-relevant characteristic of mobile phones for laypersons and what effect the disclosure of a precautionary SAR value has on laypersons' risk perception. The study consisted of two parts: Study part 1 used a conjoint analysis design to explore the relevance of the SAR value and other features of mobile phones for an intended buying decision. Study part 2 used an experimental, repeated measures design to examine the effect of the magnitude of SAR values and the disclosure of a precautionary SAR value on risk perception. In addition, the study included an analysis of prior concerns of the study participants with regard to mobile phone risks. Part 1 indicates that the SAR value has a high relevance for laypersons' purchase intentions. In the experimental purchase setting it ranks even before price and equipment features. The results of study part 2 show that providing information of a precautionary limit value does not influence risk perception. This result suggests that laypersons' underlying subjective ''safety model'' for mobile phones resembles more a ''margin of safety'' concept than a threshold concept. The latter observation holds true no matter how concerned the participants are. Bioelectromagnetics

Key words: specific absorption rate; perception of risk; radio-frequency electromagnetic fields; precaution

INTRODUCTION

Effective and successful risk communication strategies require the recognition that risk perception factors may exert an influence and that these factors must be accounted for. This is particularly true for risk communication efforts with the general public about the safety evaluation of radio-frequency (RF) electromagnetic fields (EMF) associated with mobile phone usage [WHO, 2002]. While recent mobile phone risk communication strategies on the part of industry and regulators have focused on the specific absorption rate (SAR) value of individual phones, little or no research on the public's risk perception of mobile phone SAR values in general has been undertaken. This experimental study performed in Germany provides empirical data to start to address this issue.

Since 2001, when the *Swedish Confederation of Professional Employees* (TCO) issued an ''environmental-safety'' label for low-emission mobile phones on the market, the debate in Germany over an ''eco-seal'' for low-emission mobile phones has been part of the larger discussion about a precautionary approach for health protection [BfS, 2003].

The specific absorption rate (SAR) is the rate at which energy is absorbed in body tissues, in watts per kilogram (W/kg) [ICNIRP, 1998]. In Germany, the allowable absorption of RF EMF in biological tissues is set by regulation at 0.08 W/kg for whole-body exposure (whole-body limit value) and at 2 W/kg for head and torso (partial-body limit). These limit values are based on

Grant sponsor: T-Mobile Deutschland.

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Received for review 9 February 2007; Final revision received 30 August 2007

DOI 10.1002/bem.20371
Published online in Wiley InterScience
(www.interscience.wiley.com).

the recommendations of the *International Commission for Non-Ionizing Radiation Protection* (*ICNIRP*) [1998].

The goal of the limit values is to protect against scientifically proven health risks. On this subject, the WHO International EMF Program states that: ''...below a given threshold, electromagnetic field exposure is safe according to scientific knowledge'' [WHO, 1999].

Following the rationale of ICNIRP and WHO, it can be concluded that exposures to electromagnetic fields from mobile phones whose SAR values are below these limit values should not result in health impairment effects [e.g., Valberg et al., 2007].

The German Radiation Protection Commission (*SSK*) also follows this threshold limit approach in their recommendations for ''Protection of the public from exposures to electromagnetic fields (up to 300 GHz)'' [SSK, 1999]. In this context of a threshold approach, a differentiation of ''safety'' levels on the basis of the SAR values (which are all below the limit value) cannot be justified. Nevertheless, scientific knowledge gaps and uncertainties result in the fact that caveats, reservations, and even calls for caution are also expressed [e.g., IEGMP, 2000; also see BfS, 2002; NRPB, 2004]. Following this point of view, a differentiation of safety levels in relation to the levels of the SAR values—even if they are all below the limit value—is therefore logically consistent.

Case in point: In 2001, German mobile network providers made a voluntary self-commitment to publish data specifications of SAR values for mobile phones in an effort to improve consumer information [BMU, 2001]. Furthermore, they declared that they would urge mobile phone manufacturers to provide this information in consumer-friendly formats.

Since then German mobile network providers have made SAR values for the mobile phones in their assortments publicly available. In June 2002, the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU), created the ''Blue Angel'' environmental seal for mobile phones. It is meant as a ''positive sign for industry and the consumer...as a label for low exposure mobile phones, the Blue Angel serves as a guide for the customer and helps him or her make a decision prior to purchase.''[1] The ''Blue Angel'' designation may be given to all mobile phones whose SAR values are below 0.6 W/kg and that meet additional criteria (e.g., an environmentally and recycling-friendly production).[2]

[1]http://www.bmu.de/english/radiological_protection/pm/3423.php.
[2]http://www.blauer-engel.de/englisch/vergabe/vergabegrundlagen_download/download_ral.php?id=89.

The basis for this precautionary policy for mobile phones is the subject of the study presented here. First, as hypothesized by the BMU, we address the issue of whether the SAR value—when provided and asked for—is considered to be a relevant factor in buying decisions. If this is the case, then a second issue arises: will the SAR value below 0.6. W/kg be perceived as a safety characteristic by the public? Neither of these important questions have to date been scientifically investigated in an experimental setting.

RESEARCH QUESTIONS

The purpose of the present study is to examine the significance of the SAR value and the application of the precautionary principle in the context of labeling mobile phones. As outlined above, labeling information about the SAR value is seen as one way of implementing precautionary measures by giving information to consumers which will support their decision making. In particular, providing information about a precautionary SAR value is expected to be especially useful for consumer decision making. This expectation is supported by previous research showing that emission limit values are considered helpful as a standard for comparison of risks, and this tends to increase risk acceptance [Johnson, 2004]. A study by Weinstein et al. [1989] suggests that informing about a limit value or standard ''creates an artificial discontinuity in hazard response as one goes from just below the standard to just above the standard'' [p. 49–50; cited from Johnson, 2003, p. 92].

In this context, the following questions arise:

(1) Is the information about the SAR value—if prompted or asked for—considered to be a relevant attribute for decisions to purchase mobile phones, especially when compared to other features of mobile phones which are usually addressed in marketing, such as price, design, equipment features (camera), or technical specifications (internet access capability)?
(2) Does the introduction of a precautionary SAR value, such as a SAR of 0.6 W/kg which qualifies for the ''Blue Angel'' label in Germany, influence risk perception?

With respect to the second question we posed the following hypothesis: providing information about a precautionary SAR value will ''polarize'' risk perception regarding mobile phones by creating a ''discontinuity'' in the sense of Weinstein et al. [1989]; that is, risk perception for mobile phones with a SAR value below the precautionary value will be distinctly lower than the risk perception for mobile phones with a SAR value above the precautionary value.

In addition, the study investigated whether the relevance and risk perception of the SAR values are influenced by a more general concern about health risks from mobile communication. It is to be expected that people who are concerned should give more weight to the SAR value in a purchasing decision than those who are unconcerned, and that the concerned should assign lower safety evaluations for the SAR values than the unconcerned.

SAMPLING AND STUDY DESIGN

The study was conducted from the end of November 2004 to the beginning of January 2005. 240 subjects participated in the study. Each received for their completed participation a nominal compensation fee of 10 Euro. Recruitment of the subjects was the result of direct contact in adult education center courses (ca. 30%), university lectures (ca. 30%), sports clubs (ca. 12%), second-chance education courses (for secondary school diplomas) (ca. 16%), cafés (ca. 4%), as well as e-mail contact of subjects who had previously participated in survey investigations (of the Institute for Psychology and Labor Science (IPA) of the Technical University Berlin) (ca. 8%). The willingness to participate ranged between approximately 20% (in cafés) and 90% (in second-chance education courses). On average, approximately one half of the approached persons were willing to participate in the survey investigation.

Of the 240 subjects, one had to be excluded from the analysis due to errors in the answers to the provided questions. Of the remaining 239 respondents, 117 (49%) were male and 122 (51%) female. The median age was 29 years (range: 17–57 years). Two hundred twenty four (94%) of the subjects owned a mobile phone.

The test subjects participated in the study individually or in small groups (2–8 persons) where no information exchange between the participants was allowed and each worked on their own. Thus, mutual influences were excluded. The location conditions of the experiment varied (instructional rooms of the adult education centers, lecture halls of the IPA of TU Berlin, workplace, residence). The studies were accompanied and conducted by two experimenters (1 female, 1 male). Table 1 shows the distribution of socio-demographic characteristics among the three experimental conditions. Statistical tests (Kruskal–Wallis for age; chi-square for gender and education) yielded no significant differences between the three experimental groups.

The study consisted of two parts: Part 1 used a conjoint analysis design to explore the relevance of the SAR value and other features of mobile phones for an intended buying decision. Part 2 used an experimental design to investigate whether the risk perception of mobile phones is influenced by the magnitude of their SAR values and whether risk perception is influenced by the disclosure of a precautionary value.

To gain insight as to whether the judgments given in part 1 and part 2 were influenced by prior concerns of the participant with regard to the mobile phone issue, a concern questionnaire was administered to the study participants. It included six challenge statements about their personal views on the subject (see Table 2), each containing a seven-point rating scale. This questionnaire allowed for a differentiation of the participants on the basis of their personal risk perception towards mobile phone technology in general. In this manner, previous investigations [Urbain, 2004; Thalmann, 2005; Wiedemann et al., 2006] have already been able to distinguish groups of people with different levels of concern in relation to mobile phone technology, specifically a *concerned* persons group, a group of *unconcerned* persons, and an *unsure* persons group.

Overall, questions A and B are targeted to the *unconcerned* persons, question C addresses the *unsure* persons, and questions D, E, and F are for the *concerned* persons. The grouping was performed according to the following classification rules:

- *Concerned* persons: those persons who answered at least two of the three questions D, E, and F with a value of >4 and who do not belong to the *unconcerned* group.
- *Unconcerned* persons: those persons who answered questions A and B with a value >4 and do not belong to the *concerned* group.

TABLE 1. Distribution of Socio Demographic Characteristics Among the Experimental Conditions

Experimental condition	N	Male (in % of total sample)	Median age (and 25–75%)	Attained educational level: % Higher education	Pre-college	Modern secondary school	Secondary school
1	78	16.7	29 (23–41)	5.9	9.6	12.6	4.6
2	81	15.5	31 (24–43)	7.5	9.2	12.6	4.6
3	80	16.7	27 (22–41.5)	10.0	9.6	10.5	3.3
Total	239	49.0	29 (23–42)	23.4	28.5	35.6	12.6

TABLE 2. Questionnaire on Personal Risk Perceptions of Mobile Phone Usage

For each of the following six statements, provide an estimate of your agreement with the statement using the scale below.

A: I believe that the fears about risks from mobile phones are exaggerated. I do not believe there is a risk.								
1 = Completely disagree	1	2	3	4	5	6	7	7 = Completely agree
B: Mobile phone usage is just one of the many public issues that are currently hotly debated. As for me, I do not concern myself with it. In my mind, there are more urgent problems.								
1 = Completely disagree	1	2	3	4	5	6	7	7 = Completely agree
C: Even though the media at times certainly exaggerates, I do think that there might be something about risks from mobile phone usage. But I actually do not know enough to be able to make a decision about it.								
1 = Completely disagree	1	2	3	4	5	6	7	7 = Completely agree
D: Somehow I am queasy about it. I have repeatedly heard that there are possible risks from mobile phone usage.								
1 = Completely disagree	1	2	3	4	5	6	7	7 = Completely agree
E: I am convinced that mobile phone usage is health-damaging.								
1 = Completely disagree	1	2	3	4	5	6	7	7 = Completely agree
F: I am convinced that my on-and-off bouts of ill health are triggered by radiation from cell phone towers.								
1 = Completely disagree	1	2	3	4	5	6	7	7 = Completely agree

- *Unsure* persons: those persons who do not belong to the *unconcerned* or *concerned* groups and who answered question C with a value >4.

In the presented experiment, 210 of the 239 study participants can be placed in one of the three groups of *concerned*, *unconcerned*, or *unsure* persons based on the responses to the follow-up questionnaire.

STUDY PART 1: RELEVANCE OF SAR VALUE

The goal of this part of the study was to determine what significance the SAR value has compared to other characteristics relevant to a decision to purchase a mobile phone when the SAR information is provided and whether *concerned*, *unconcerned*, or *unsure* persons differ in their evaluation of the relevance of the SAR value.

Method

The study goal was investigated with the help of a conjoint analysis. This is a frequently applied quantitative procedure for the estimation of individual preferences and utility values for trade and marketing research [Green and Srinivasan, 1978].

The conjoint analysis was employed to determine which mobile phone characteristic influences the purchasing decision. Of particular interest here is the SAR value as well as the price, the equipment features (camera), design, and technical specifications (internet access capability).

In the investigation these five characteristics were combined with their respective, and different, parameter values (see Table 3). Since a comprehensive combination of all parameter values for the characteristics would have required $3 \times 2 \times 4 \times 2 \times 2 = 96$ profiles, an orthogonal design was chosen. This allowed for an estimation of the parameters without having to provide all parameter value combinations.[3] Thus, the number of profiles could be reduced to 16.

Table 4 presents examples of how these profiles were designed. The 16 profiles were written onto index cards and presented to the study participants in random order. Upon request, the participants received an explanation of how the SAR value denotes the emitted radiation value of mobile phones.

Participants were told to rank the 16 profiles with regard to the question of preference for each type of mobile phone as characterized though the profile. To facilitate this ranking task, the task was divided into three steps. The first step was for the participants to assign the cards to one of three groups. Group 1 was for those mobile phones that the participants could imagine purchasing, while Group 3 contained those they would not purchase. Those mobile phones that fell under the heading "would possibly purchase" were placed into Group 2. In the second step, for each group, the participants were to generate ranked lists. Then in the third step, the three separate lists were merged into an overall ranking list by simply placing the ranking of

[3]For this the SPSS procedure "Generate Orthogonal Design" was used.

TABLE 3. Characteristics and Parameter Values for the Conjoint Analysis

Characteristic	Parameter values			
Price	10 Euro	27 Euro	79 Euro	
Feature	With camera	No camera		
SAR-value	0.16 W/kg	0.58 W/kg	1.14 W/kg	1.63 W/kg
Design	Flip-phone	Not a flip-phone		
Technical spec	Web-enabled	Not web-enabled		

group 3 after group 2 after group 1. This way all 16 profiles could be placed into rank order.

Carrying out a conjoint analysis requires specifying a preference model to estimate the utility values for each attribute level. We chose to use a model with no constraints regarding the shape of the preference function for each of the attributes (the 'discrete' model in SPSS). Since we are interested in the relative weight or importance of the five attributes to each other, importance scores for each participant and attribute were computed by taking the utility range for the particular attribute and dividing it by the sum of all the utility ranges. These importance scores reflect the weight a given participant ascribes to each of the attributes, and the sum adds up to 1 for each person. For ease of interpretation the individual scores were multiplied by 100 to provide a zero to 100% importance scale.

Results

Figure 1 presents the importance scores across all the participants for each of the five different characteristics of a purchasing decision in a box plot. It can be seen that the SAR value has the highest significance before price, equipment feature (camera), technical specifications (internet access capability) and design. The presentation also points out that for each of the characteristics a wide range in weighting is clearly evident.

If you consider all three "concern" groups (*concerned*, *unconcerned*, and *unsure* persons) separately, the SAR value has the highest relevance for all three groups (see Table 5). The groups differ, however, with respect to the magnitude of the weighting. The *concerned* group assigned the SAR value the highest weight, while the *unconcerned* group offered the lowest weight. The *unsure* group lies in between. These differences are statistically significant (Kruskal–Wallis-test; $\chi^2 = 9.916$; $df = 2$; $P = 0.007$). No other characteristic demonstrated a significant weighting difference across the three groups.

The differences between the three groups are also evident in another respect. The *unconcerned* group differentiated the SAR value characteristic from the second most important characteristic—price—by approximately 1% point only. This makes the two characteristics, SAR value and price, nearly equally important for the *unconcerned* group. The gap between the two most important characteristics increases to 12.8% for the *unsure* persons group and to an even greater, 14.9%, for the *concerned* group. Thus the higher the level of concern, the more important the SAR value becomes.

STUDY PART 2: SAR VALUE AND RISK PERCEPTION

This part of the study investigated whether the risk perception of mobile phones is influenced by the magnitude of the SAR values and whether risk perception is influenced by the disclosure of a precautionary value.

Method

To properly address the problem under investigation, a two-factorial experimental design with repeated measures was used. The first experimental (between-subjects) factor was defined by three different types of information about the SAR value. In the simplest case (see Condition 1 in Table 6), the study participants or test subjects[4] received only the basic text information module about the SAR value. In two further versions, the test subjects received additional information about the precautionary limit value, which was either attributed to the German Federal Office for Radiation Protection (BfS) or to consumer protection advocacy groups (see Conditions 2 and 3 in Table 6). The wording of the basic information about the SAR value closely followed the presentation of the BfS's website indicating the SAR values of different mobile phones.[5]

The subjects were assigned alternately to one of the three experimental conditions in the order of their recruitment (Condition 1: $N = 78$, Condition 2: $N = 81$;

[4]For this type of experiment a bioethics or oversight committee review process is not an applicable requirement in Germany, but relevant safeguards and regulations for dealing with human subjects were acknowledged and complied with, as applicable.

[5]see http://www.bfs.de/elektro/oekolabel.html.

TABLE 4. Example Profiles

Profile A	Profile B
Price: 79 Euro Feature: no camera SAR-value: 1.14 W/kg Design: flip-phone Technical specification: not web-enabled	Price: 10 Euro Feature: with camera SAR-value: 0.58 W/kg Design: not a flip-phone Technical specification: web-enabled

Condition 3: $N = 80$). Since the recruitment itself is independent of the current experimental condition to be assigned at any one time, the procedure led to a random placement of the study participants in each of the three experimental conditions.

In this study, we wanted to avoid introducing any kind of bias towards a risk perspective; therefore, risk perception was operationalized by asking for a judgment regarding the safety that SAR values provide rather than asking for a risk judgment. Thus, the study participants were asked to evaluate the safety to health that selected SAR values offer. The respondents were to provide their judgments of the safety to health in percent values ranging from 0% to 100%, with 100% reflecting complete health safety. For this safety evaluation, four predetermined SAR values were given: 0.16, 0.58, 1.14, and 1.63 W/kg. The evaluation of the four SAR values constitutes the second experimental (within-subjects) factor.

The four SAR values were selected from the publicly accessible database of the Nova Institute [www.handywerte.de; accessed: 30.09.2004] which provides SAR values for a substantial number of mobile phones. The database contained 558 mobile phones with SAR values ranging from 0.04 to 1.94 W/kg. The SAR values were ranked in numerical order and the mean values of the top and bottom 5% of the numeric range were chosen (1.63 and 0.16 W/kg, respectively). The remaining 90% of the SAR value range was equally split and the mean value of the top and bottom half determined (1.14 and 0.58 W/kg, respectively).

Results

The safety evaluations by the participants are shown in a boxplot in Figure 2. The highest SAR value (1.63 W/kg) is evaluated the worst in respect to safety, while the lowest SAR value (0.16 W/kg) is judged by the respondents to be best. However, based on the aggregate across all subjects, no SAR value offers a 100% safety evaluation judgment. On average, the lowest SAR value offers an 80% protection level. In contrast, the highest SAR value only offers a remaining 32% protection. A relatively large spread for the estimated safety levels is noticeable.

Precautionary limit value and risk perception. An analysis of variance (ANOVA) for the SAR values and

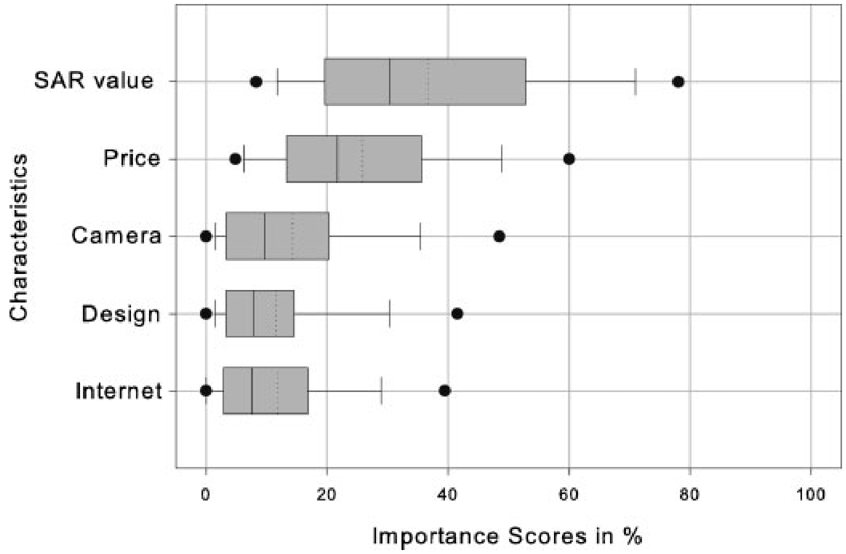

Fig. 1. Boxplot of the importance scores across all participants for each of the five different characteristics for a purchasing decision.

TABLE 5. Weights of the Attributes for the Groups "Unconcerned," "Unsure," and "Concerned"

	Unconcerned ($N = 52$)			Unsure ($N = 78$)			Concerned ($N = 80$)		
Characteristic	$\bar{X}$ (%)	Min. (%)	Max. (%)	$\bar{X}$ (%)	Min. (%)	Max. (%)	$\bar{X}$ (%)	Min. (%)	Max. (%)
SAR-value	29.9	5.6	76.5	36.8	2.7	81.4	40.5	3.3	87.3
Price	28.7	2.6	66.7	23.9	3.2	65.6	25.5	2.9	66.7
Feature	15.6	0.0	51.6	15.2	0.0	57.1	11.1	0.0	48.1
Design	13.5	0.0	49.6	12.0	0.0	50.0	11.0	0.0	57.7
Technical specs	12.3	0.0	47.1	12.2	0.0	50.4	11.9	0.0	53.3

the information conditions was performed. In this analysis, the SAR values were treated as repeated measurements, and the three information conditions (no statement as to precautionary values, precautionary value attributed to BfS, or precautionary value attributed to consumer protection advocacy groups) treated as levels of the independent variable. This allowed for testing whether the information conditions influence the safety evaluations. Figure 3 shows that with decreasing SAR values, the safety evaluations increase. Since data deviated from normality and the Mauchly test indicated that sphericity assumption was violated we tried logit, probit and cauchit transformations (after rescaling the original 0–100% range to a 0–1 range) to enhance sphericity.[6] The cauchit worked best: the Mauchly-W value for sphericity improved from 0.177 for the original data to 0.493 after cauchit transformation. Nevertheless, the Mauchly-W value for sphericity remained significant, therefore a Greenhouse-Geisser correction for the degrees of freedom was used in the ANOVA. The repeated measurement ANOVA indicates a statistically highly significant effect of the repeated measurement factor ($F(1.996, 471.011) = 60.037$, $P < 0.001$). However, Figure 3 also suggests that the different information conditions do not influence the safety evaluations, as they are very close to each other for a given SAR value. This is confirmed by the ANOVA which yields a non-significant effect for the "between-subjects-factor" ($F(2{,}236) = 0.192$; n.s.). Neither the disclosure of a precautionary limit value of 0.6 W/kg on the part of the BfS, nor the analogous reference to consumer protection advocacy groups changed the safety evaluation significantly.

In toto, it can therefore be concluded that the evaluation of the SAR values follows the expected direction—the lower the SAR value the higher the safety judgment—but that on the whole the evaluation showed the subjects were rather skeptical of the associated health protection. Even reference to the precautionary value did not change that.

Concern and risk perception of SAR values. As can be expected, differences in concern about mobile phones play a role in the safety evaluation of SAR values (see Fig. 4). The higher the anticipated risk of mobile communication technology, the lower the safety is evaluated. For the *unconcerned* group, the mean value of all safety evaluations over the four SAR values is 70%, in contrast to 55% for the *unsure* and 49% for the *concerned* groups. The repeated measurement ANOVA again indicates a highly significant effect of the repeated measurement factor ($F(1.970, 407.863) = 54.590$; $P < 0.001$; again using a cauchit transformation for the data and a Greenhouse–Geisser correction). In addition, the difference between the three groups is statistically highly significant ($F(2{,}207) = 15.227$; $P < 0.001$).

Figure 4 also shows that for the *unconcerned* group, in comparison with the *concerned* and the *unsure* groups, the safety evaluation (51%) is much higher for the worst SAR value (1.63 W/kg), and rises almost linearly to 88%. In contrast, the *unsure* and the *concerned* group give much lower safety evaluations (29% and 23%) for the worst SAR value. For the lowest SAR value, however, their safety evaluations are much closer to the *unconcerned* group (81% and 76%). However, the crucial point is that when considering the mean values of the safety evaluations, there is no "harmless" SAR value—not even for the *unconcerned* group.

DISCUSSION AND CONCLUSIONS

The research presented here addresses the relevance of SAR values for mobile phone purchasing decisions of consumers and their influence on risk perception of mobile phones.

In the first study part, which used a conjoint analysis design, participants had to rank in order

[6]We thank an anonymous reviewer for suggesting the data transformation procedure to us.

TABLE 6. Text Used in the Experiment for the Three Conditions

Condition 1: Basic text module	When using mobile phones, high-frequency electromagnetic fields are absorbed in the head. This absorption can be quantified by the so-called specific absorption rate (SAR), a measure of the tissue mass related absorbed power (W/kg). The limit-setting for this absorption rate is a generally accepted, international radiation protection criterion in the area of high-frequency electromagnetic fields. The basis for the establishment of the limit value in Germany is a recommendation of the Radiation Protection Commission, which calls for an upper limit value of 2 W/kg, averaged over 10 g. This recommendation is based on a guideline from the International Commission on Non-Ionizing Radiation Protection (ICNIRP), which the Council of the European Union has also endorsed.
Condition 2	Basic text module + The German Federal Office for Radiation Protection recommends, however, that for precautionary reasons a minimization of the exposure is desirable and that a SAR value of 0.6 W/kg should not be exceeded.
Condition 3	Basic text module + Consumer protection advocacy groups recommend, however, that for precautionary reasons a minimization of the exposure is desirable and that a SAR value of 0.6 W/kg should not be exceeded.

16 mobile phones for a (hypothetical) purchasing decision. The mobile phones were characterized by their SAR value and four other features: price, design, equipment features (camera), or technical specifications (internet access capability). The SAR value turned out to be by far the most important attribute, with price coming next. The other features received much lower attribute weights. This is also true if one distinguishes between the three groups of *concerned*, *unsure* and *unconcerned* persons. The groups differ significantly, however, with regard to their weighting of the SAR value. These are highest for the *concerned* group and lowest for the *unconcerned* group. No statistically significant differences were found between the groups with regard to the other four attributes.

Of course, these results from a hypothetical purchasing decision do not imply that they will be actually relevant for consumers in a real purchasing situation. It shows, however, that at least consumers will pay more attention to the SAR value if this information is made more prominent, as has been suggested by several organizations, as for instance the German Federal Office for Radiation Protection (BfS) is proposing.

In its annual survey from 2004 the BfS [2004] has asked for the respondents' evaluation of the SAR value: ''Did you know that each mobile phone possesses a so-called SAR value? Yes/No.'' Only 28% of the respondents answer in the affirmative. Of those who answered ''yes'' only 11% claim that they have already

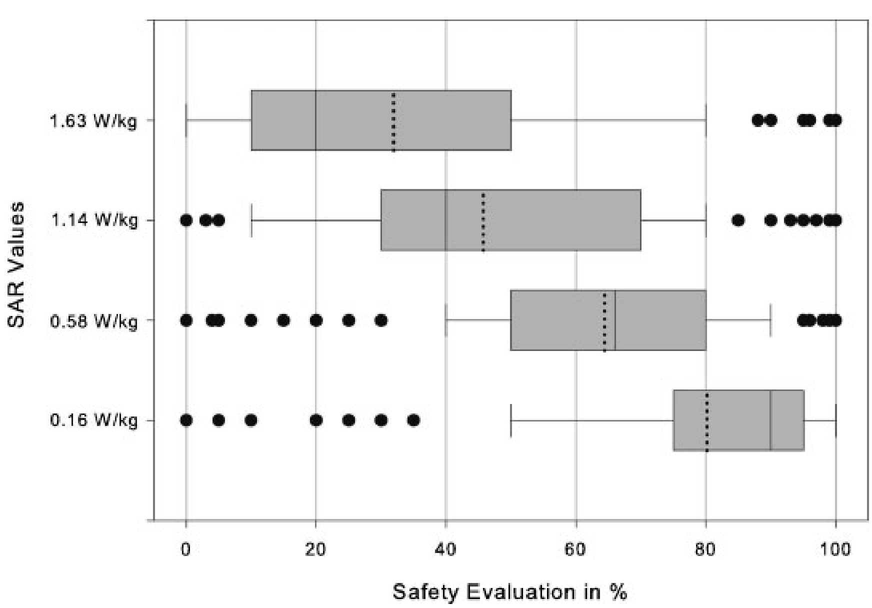

Fig. 2. Boxplot of the safety evaluations for the four different SAR values.

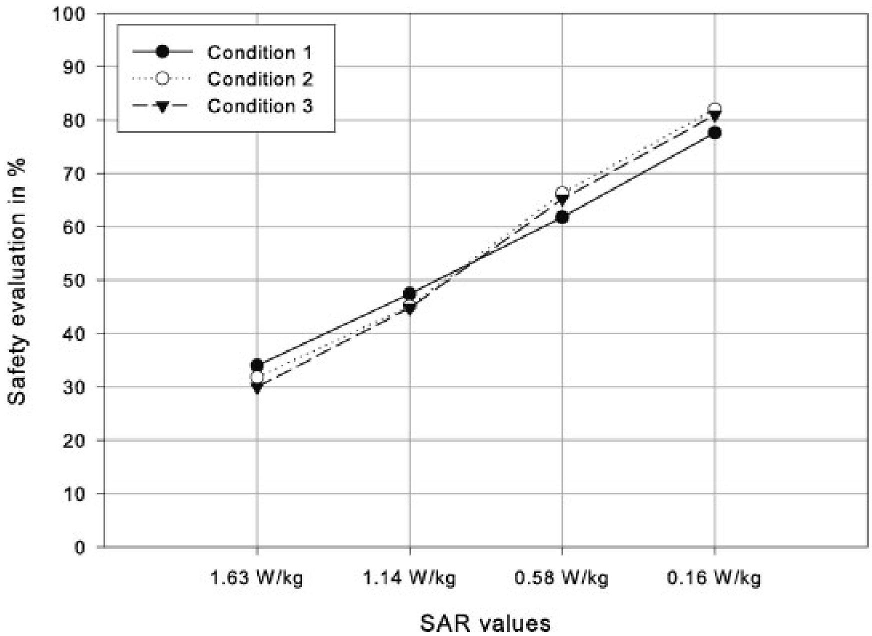

Fig. 3. Mean values of safety evaluations for the four SAR values under the three experimental conditions (untransformed data).

drawn upon this information in their purchase decision for a new mobile phone. Our results suggest that this proportion will rise if the information on the SAR value is highlighted. However, while we were interested in the risk or rather safety perceptions of the respondents, supplementary research is necessary to make a reliable assessment of the extent to which consumers will consider the SAR value as critical information.

The second study part focused on the question of whether risk perception of mobile phones is influenced by the magnitude of the SAR value. Using a repeated measures ANOVA design, the participants were assigned randomly to one of three experimental conditions, each yielding a different type of information about the SAR value. In the simplest case the study participants received only basic information about the

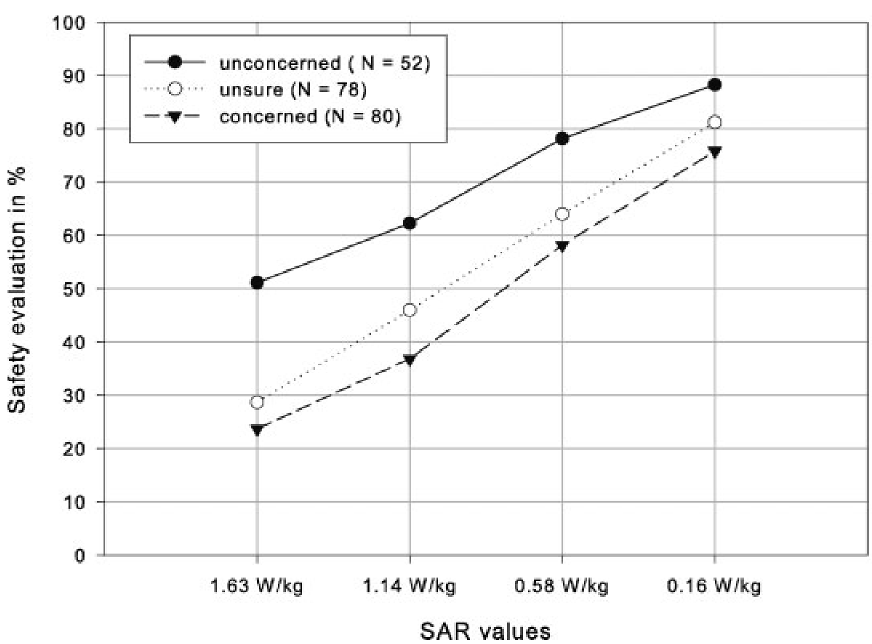

Fig. 4. Mean values of safety evaluations for the four SAR values of the three concern groups (untransformed data).

SAR value, namely an explanation of what the SAR value is, and that there is a limit value of 2 W/kg in Germany which is based on recommendations of the German Radiation Protection Commission and on an ICNIRP guideline. In the two other experimental conditions, the study participants received additional information about the precautionary limit value of 0.6 W/kg, which was either attributed to the German Federal Office for Radiation Protection (BfS) or to consumer protection advocacy groups. Then each participant was asked to assess four SAR values (0.16, 0.58, 1.14, and 1.63 W/kg) with regard to how much health safety they think the SAR value provides. The respondents were to provide their judgments of the safety to health in percent values ranging from 0% to 100%, with 100% reflecting complete health safety. Thus, since we wanted to avoid introducing any kind of bias towards a risk perspective in this study, risk perception was operationalized by asking for a judgment regarding the safety that SAR values provide rather than asking for a risk judgment.

First of all, the results support the assumption that the study participants clearly differentiate among various degrees of safety as a function of the SAR value. The data also indicate a relatively large spread: lay people vary in their safety appraisals of the SAR values. Nevertheless, there seems to be an overall inverse relationship: The lower the SAR value—the greater the magnitude of perceived safety (see Fig. 2).

The ANOVA results demonstrate that the safety evaluations increase almost linearly when the SAR values decrease. Thus, rather than considering the four SAR values, which all are below the official limit value of 2 W/kg, to be equally safe, SAR values are perceived to be safer the lower they are. This shows that in this experiment the study participants do not follow the threshold approach which underlies the regulations about limit values.[7] The linear increase of safety evaluations with decreasing SAR values in all three experimental conditions also implies that the precautionary value of 0.6 W/kg is not seen as providing a particular safety threshold. If this were the case, one would expect a different shape of the gradient of the safety evaluations for conditions 2 and 3, in which the information about the precautionary SAR value was added to the basic information given in condition 1. The gradient should have the shape of a step function where the two SAR values above the precautionary value of 0.6 W/kg would be considered as (almost) equally unsafe, and the two SAR values below the precautionary limit value would be evaluated as being (almost) equally safe. Thus, our hypothesis that the disclosure[8] of a precautionary SAR value has an impact on risk perception is clearly not supported by the data.

The ANOVA results also show that it does not matter whether the source of the information about the precautionary SAR value is the German Federal Office for Radiation Protection or consumer protection advocacy groups. One might argue that both the German Federal Office for Radiation Protection (BfS) and the consumer protection advocacy groups are not seen as trustworthy information sources.

Although we cannot rule out this possibility—because we did not ask for an evaluation of the credibility of the information—we do not think that this is a valid or self-contained explanation, since a recent representative survey has shown that both organizations are considered as highly trustworthy: 92% of the respondents state that for them consumer protection advocacy groups are credible or very credible, and 88% state this for the BfS [Büllingen and Hillebrand, 2005].

These results are applicable to all three groups of *concerned*, *unsure*, and *unconcerned* persons. Nevertheless, while not surprising, those persons who are *concerned* about risks from mobile phone usage provide lower safety evaluations than the *unconcerned* group, while the *unsure* group is situated in between these estimates.

The more interesting point, however, is that when considering the mean values of the safety evaluations, there is no ‘‘harmless’’ SAR value. Based on the averaged data across all subjects, no SAR value is perceived to be 100% safe (see Fig. 2). Even the *unconcerned* people—those who do not consider mobile communication technology as risky—are not convinced that SAR based exposure limits guarantee safety. Basically they follow the same evaluative heuristic as the other two groups, namely: There is no safe level of exposure, therefore ‘‘the less the better.’’

Of course these results need further corroboration. It would be interesting to test whether the type of introductory information on SAR values used by the manufacturers which might be less alarming than the text we used will make a difference in the conjoint study. It could be that the relevance of the SAR value as

[7]This opinion, that safety is present below the limit value, is—in general—held by the WHO: ‘‘Guidelines indicate that, below a given threshold, electromagnetic field exposure is safe according to scientific knowledge.’’ [WHO, 1999].

[8]We chose the word ‘‘disclosure’’ to signify the *act of providing information about* the precautionary SAR value, in part because the additional information in the second and third experimental conditions reveals something not previously given in the limit value discussion of the basic text module. Our wording choice does not intend to imply that information about precautionary SAR values is or should in any way be concealed.

a purchase criterion will be correlated with the degree of alarm signaled by the text. Another worthwhile point to address is the distinction between hot and cold decisions [Loewenstein, 2005]. Purchase decisions are often ‘‘hot’’—that is, in a mobile phone shop customers might be tempted by special offers or by aggressive marketing activities that overrule their safety concerns.

In our view, these results have a number of implications for informing the public about SAR values of mobile phones. First, information about SAR values is relevant for a purchasing decision if lay people are actually presented with and asked about this information. This strongly suggests the importance of providing SAR value information to support informed consumer decision-making. However, some limitations of the conjoint study should be taken into account. As mentioned above, the impact of the SAR value on the purchase decision might be reduced in a hot-decision context, especially when stronger affective stimuli are introduced [Loewenstein, 2005]. Thus, further studies should be conducted to obtain a reliable quantitative assessment of the magnitude of the impact of the SAR value on mobile phone purchasing decisions under varying settings.

Our results also suggest that people do not simply follow a threshold approach, which differentiates between safe and unsafe mobile phones following the idea suggested by Weinstein et al. [1989]. Rather, perceived safety is a matter of degree. Neither the official limit value of 2 W/kg nor the precautionary SAR value of 0.6 W/kg seem to signal a specific safety quality for those mobile phones which are below these values. Rather, study participants appeared to use a simple heuristic in their evaluation of safety: The smaller the SAR value the better for health. This holds not only for the group of *concerned* people but also for the *unconcerned*. The drawback of this heuristic is that there might not be any SAR value at all which will be considered to be 100% safe. Since mobile phones will always emit some RF EMF, they may always be perceived as entailing some risk.

It is important to stress the point that our results do not undermine the precautionary Blue Angel concept of the German Ministry of the Environment or similar proposals for precautionary policies in other countries, for example, the TCO labeling in Sweden.[9] Informing people that a phone complies with such a label is certainly valuable. However, our data indicate that additional information may be required, for example, the range of the SAR values of the available phones and the position of the SAR value of the selected phone within this range. Thus, the goal is to learn how to better communicate information about precautionary measures through careful design of the message and diligent evaluation of non-intended effects, but not to capitulate nor impetuously abandon the application of the precautionary principle in light of this challenge.

[9] http://www.tcodevelopment.com/.

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