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When Precaution Creates Misunderstandings: The Unintended Effects of Precautionary Information on Perceived Risks, the EMF Case

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In the past decade, growing public concern about novel technologies with uncertain potential long-term impacts on the environment and human health has moved risk policies toward a more precautionary approach. Focusing on mobile telephony, the effects of precautionary information on risk perception were analyzed. A pooled multinational experimental study based on a 5 × 2 × 2 factorial design was conducted in nine countries. The first factor refers to whether or not information on different types of precautionary measures was present, the second factor to the framing of the precautionary information, and the third factor to the order in which cell phones and base stations were rated by the study participants. The data analysis on the country level indicates different effects. The main hypothesis that informing about precautionary measures results in increased risk perceptions found only partial support in the data. The effects are weaker, both in terms of the effect size and the frequency of significant effects, across the various precautionary information formats used in the experiment. Nevertheless, our findings do not support the assumption that informing people about implemented precautionary measures will decrease public concerns.

KEY WORDS: EMF; precaution; risk perception

1. INTRODUCTION

In the past decade, the risk management debate has moved from "how safe is safe enough?"(1) to "how precautionary is precautionary enough?"(2) One example of this movement toward a precautionary policy is the debate about the safety of mobile communication technologies (MCT), where the most prominent feature has been the controversy about

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the need for and extent of precautionary-based safety measures.[3]

The request for precautionary measures has been amplified by the recent decision of the International Agency for Research on Cancer (IARC) to classify radiofrequency electromagnetic fields (RF EMF), including mobile phones, as "possibly carcinogenic to humans" (Group 2B).[4]

It seems that the precaution policy in the sector of MCT is motivated by two reasons. First, policymakers intend to protect the public, even in a case when the health risk is still uncertain, and second, by using precautionary measures, decision-makers try to calm down RF EMF–related concerns and anxieties. Following the report of the Independent Expert Group on Mobile Phones in the United Kingdom,[5] it is now being widely accepted among both national and international regulatory bodies to implement additional precautionary measures in order to protect public health and to inform the public about these precautionary measures. Interestingly, public health authorities and regulatory bodies assume that informing the public about the applied precautionary measures will reduce public risk perception, mitigate public concerns, and even strengthen trust in the regulatory bodies themselves. For instance, WHO,[6] in its draft on "Precautionary Framework for Public Health Protection," underlines as one import reason for applying precautionary measures: "To address public concerns that a potential or perceived but unproven health problem is taken into account ... " (WHO 2003, p. 3). The question, however, is: Do precautionary measures really cause these expected effects on risk perception?

1.1. The EMF Issue

The RF EMF issue gained momentum with the massive roll out of the networks for wireless communication in the late 1990s of the last century. EU-wide surveys[7,8] indicate that people across Europe are still concerned about the potential adverse health impact of RF EMF exposure from cell phones and base stations. Similar concerns are reported from Australia,[9] Taiwan,[10] and New Zealand.[11] In other parts of the world, for example, the United States, RF EMF is debated too, but is not a core concern.[12] For many countries, especially in Asia, South America, and Africa, no publicly available data on RF EMF risk perceptions seem to exist.

From the available evidence some conclusions can be drawn. First, people are more concerned about base stations than cell phones. Consequently, the siting of base stations is a highly debated and politicized issue resulting in considerable resistance of homeowners and tenants when network providers try to site base stations in their vicinity. Second, on an aggregated level risk perceptions are rather stable, for instance, during 2003–2009 a constant share of about 30% of the German population expressed concerns about RF EMF exposure. However, there is more variation on the individual level.[13] Third, a German survey indicates that about 5–10% of the general population claim that their health problems are caused by RF EMF exposure.[14]

Furthermore, the scientific controversy about the potential health effects of RF EMF as well as the sustaining RF EMF risk perceptions have led to the request for more precaution. As mentioned earlier, this request was initiated by the Stewart Report,[5] published in 2000 in the United Kingdom, which legitimated the need of precautionary measures by pointing at the special need to protect children.

Health authorities in several European countries but also in Australia, Canada, and New Zealand have implemented various precautionary measures such as to recommend a restricted use of cell phones by children, introducing stricter exposure limits for base stations, banning base stations in sensitive areas, that is, in the neighborhood of schools, kindergartens, and hospitals, and the mandatory labeling of cell phones so that consumers can buy low emissions cell phones. As already mentioned, public health authorities expect that such measures not only provide additional protection but also reduce public concerns and anxieties. However, the limited scientific evidence available so far casts doubt on this expectation.[15–17]

1.2. Theoretical Background

There is a vast set of literature on precaution and precautionary measures, but only few studies focus on the effect of informing the public about implementing precautionary measures on risk perception.

From a theoretical perspective two mutually exclusive hypotheses can be stated. On the one hand, based on the trust, confidence, and cooperation (TCC) model[18] one might argue that implementing precautionary measures will improve confidence in the risk management of the health authorities and therefore reduce risk perception. One the other hand, precautionary measures might be seen as a warning signal, that is, as a proxy for a hazard. Theoretically, the utilization theory of Easterbrook[19] supports this view. This theory assumes that messages (for instance, information about precautionary actions) consist of an array of cues. However, a cue that triggers emotions will become dominant and overrule all other cues. Thus, the emotional arousal evoked by interpreting precaution taking as "there is no smoke without fire" might lead to an amplification of risk perception.

Recent experimental research conducted in Austria and Switzerland[(16,17)] suggests that information about precautionary measures has an amplifying impact on risk perception of MCT. In these studies, subjects who received information about precautionary measures related to base stations expressed a higher perception of risk than subjects who did not receive the information. A U.K. survey on public responses to information about the possible health risks of mobile phones found comparable results.[(15)] However, an additional study from Switzerland found no significant effects of precautionary information on health concerns.[(20)]

However, there are still several open questions. First, it is unclear whether these European findings can be extrapolated to other countries with different cultural backgrounds and levels of technological development. This leads to the need to study the impact of reporting precautionary measures on risk perception in a larger sample across different countries.

Second, differences between various components of MCT have to be taken into account, that is, between base stations and cell phones. Usually, people rate the risks of base stations higher than the risks of cell phones.[(21,22)] A similar difference might occur when reporting precautionary measures.[(23)] Informing people about personal precautionary measures (e.g., using headsets while making phone calls) might strengthen their self-efficacy and thus reduce risk perception. Such reassuring effects might not be expected with respect to bases stations. Here, precautionary actions can only be observed, but not implemented personally and will thus not strengthen self-efficacy. Until now no study has investigated both topics—precaution regarding cell phones and base stations—in a way that allows a comparative analysis of the effects on risk perception.

Third, from a practitioner's point of view, a challenge is to communicate precautionary measures so that they are seen as indicators of increased safety, rather than as a confirmation of the existence and seriousness of an emerging risk. Here, a factor that may play a role in determining the effect of providing information about precautionary measures is the framing of the message. Framing refers to the "description of logically equivalent choice situations in different ways."[(24)] Often, framing is introduced by generating either a gain or a loss perspective.[(25)] According to prospect theory, losses are given more weight than equivalent gains.[(26)] Thus framing a health-related message in terms of losses (e.g., emphasizing the risks of not participating in a breast cancer screening) should produce a stronger motivation to participate in the screening program than using a gain-framed message (e.g., emphasizing the benefits of participating in a cancer screening). One could also argue that putting precautionary measures in a loss frame, as in a study by Wiedemann *et al.*,[(16)] might have different effects on risk perception than using a safety frame. In other words, providing a frame that focuses on safety ("precautionary measures are needed to protect public health") might trigger less concern than using a risk frame ("precautionary measures are needed to avoid health risks from mobile telephony").

1.3. Research Questions

The aim of this study was to examine the effects of providing information about precautionary measures on risk perception and trust for both cell phones and base stations. It also considered the influence of information framing on trust in public health authorities and on the perception of the scientific knowledge base about RF EMF. In this article, however, we will only report the results for risk perception. The main research questions were:

- Does informing about precautionary measures affect risk perception across various countries?
- Does it make a difference whether the precautionary measures refer to cell phones or to base stations?
- Does precautionary information framing in terms of safety have a different effect on risk perception compared to information framing in terms of risk?

1.4. Study Sample

The study was conducted in Australia, Brazil, Germany, India, Japan, the Netherlands, South Africa, the United Kingdom, and the United States.[13]

[13]These countries were selected in accordance with the sponsors of the present study.

Table I. Overview of Sociodemographic Characteristics of Sample

Country	N	Gender		Age	
		Female	Male	Mean	SD
Australia	400	66%	34%	22.5	6.1
Brazil	400	48%	52%	21.4	3.7
Germany	478	59%	41%	22.7	3.7
India	400	50%	50%	19.8	1.3
Japan	499	43%	57%	20.8	1.9
Netherlands	513	52%	48%	21.4	2.5
South Africa	411	80%	20%	21.2	5.1
United Kingdom	400	88%	12%	20.2	4.4
United States	401	54%	46%	22.4	8.4
Total	3,902	59%	41%	21.4	4.6

These countries were selected to include some variety in societal, economic, and cultural background of the study participants. The study design was not intended to investigate such potential background influences systematically. In total, 3,902 subjects participated, 59% of them female, with a mean age of 21.4 years (see Table I). In each country, university social sciences and humanities students were recruited as study participants. While a student population *per se* certainly is not representative for the whole population, we nevertheless think that it is an appropriate study group because (1) students (especially from the social sciences and humanities) are usually familiar with questionnaires, thus minimizing the problem of introducing procedural biases and (2) students (again especially from the social sciences and humanities) may tend to have a skeptical attitude toward technological safety management and consequently should appreciate a precautionary-based safety policy. Thus, if a countervailing impact of precautionary measures on risk perception could be observed with these students, then one could postulate that this effect would hold true and would be likely to be even more pronounced in other segments of the population.

2. METHOD

The experimental study is based on a 5 × 2 × 2 factorial design. The first factor refers to whether or not information on different types of precautionary measures was presented, the second factor refers to the framing of the precautionary information, and the third factor to the order in which the two different exposure sources—cell phones and base stations—were rated by the study participants. In other words, the precautionary measures were related either to bases stations or to cell phones and framed as protecting health or avoiding health risks. Table II provides an overview of the experimental factors and factor levels.

Table II. Design of the Experiment

Factor	Levels
Information on precautionary measures	• no information on precautionary measures (basic text) • minimization of RF EMF emissions (for both cell phones and base stations) • protection of sensitive people (for cell phones) or areas (for base stations) • precautionary limits for both cell phones and base stations) • disclosure of SAR values (for cell phones) or information about the location of base station sites (for base stations)
Framing of the message	• safety ("protect public health") • risk ("avoid health risks from mobile telephony")
Order of presenting the exposure sources	• cell phones → base stations • base stations → cell phones

Based on previous results of Wiedemann and Schütz,[17] a statistical power analysis with $1 - \beta = 0.95$ and $\alpha = 0.05$ was conducted. These authors found a significant main effect of precautionary measures on risk perception ($F_{3,238} = 3.954$; $p = 0.009$) with a partial eta squared of 0.047, corresponding to an effect size $f = 0.222$. This suggests that the experimental design should contain 20 individuals per group to allow country-wise analysis when needed, resulting in a total of 400 individuals per country.

Participants were assigned randomly to one of the experimental groups (within each country). They received a questionnaire that contained the respective stimulus texts as well as the questions addressing the dependent variables. On the first page a brief introduction to the questionnaire was given. The second page presented the stimulus text (see Table III) according to the respective experimental condition as well as the question addressing risk perception. Half of the questionnaires started with base station as the target for evaluation, the other half started with cell phone as target. The full list of stimuli texts is available from the corresponding author.

It should be mentioned that the precautionary measures used in our experiment (see Table II) have been applied by health authorities in

Table III. Examples for Stimulus Text

Framing: Safety Measure: Precautionary limits Focus: Cell phones	In order to protect public health, the International Commission for Non-Ionizing Radiation Protection—an international body collaborating with the World Health Organization—has established exposure guidelines and recommended exposure limits. However, in some countries a debate about the potential health risks of mobile telephony is still ongoing at all levels of the society. As a precaution, to protect public health, some experts (e.g., www.bioinitiative.org) strongly recommend the use of cell phones with substantially reduced emissions.
Framing: Risk Measure: Protecting sensitive areas Focus: Base station	In order to avoid health risks from mobile telephony, the International Commission for Non-Ionizing Radiation Protection—an international body collaborating with the World Health Organization—has established exposure guidelines and recommended exposure limits. However, in some countries a debate about the potential health risks of mobile telephony is still ongoing at all levels of society. As a precaution, to avoid health risks, some experts (e.g., www.bioinitiative.org) strongly recommend that base stations should not be sited near locations of potentially sensitive subpopulations such as kindergartens, schools, or hospitals.

Table IV. Description of the Dependent Variable

Variable	Question Wording
Risk perception	All in all, how threatened do you feel by electromagnetic radiation emissions from <base stations / cell phones>? (1 = I don't feel threatened at all; 7 = I feel very threatened)

various countries (e.g., the United Kingdom, Germany, Austria, France). That is, real measures and not fictional measures are used in the experiment.

The dependent variable "risk perception" was recorded on a seven-point Likert scale with verbal endpoints as listed in Table IV. With respect to this scale, we used the same wording as in our former studies.[16,17] As mentioned earlier, other endpoints were also measured; however, only the "risk perception" results are reported here.

The stimulus material as well as the response scales were originally developed in English. The main researcher met all associate researchers in the various countries and explained the aims as well as the methodology of the planned study. The Dutch, German, Japanese, and Portuguese translations were checked by a second binlingual person.

3. RESULTS

Risk perception was addressed by asking how threatened subjects felt by electromagnetic radiation emissions from base stations or cell phones, respectively. Fig. 1 shows that the mean risk perception for both base station and cell phone varies across countries, with the Netherlands having the lowest ratings and India the highest. It becomes also apparent from Fig. 1 that for five of the nine countries perceived risk differs significantly between base station and cell phone. These are Australia ($p < 0.001$), Brazil ($p < 0.05$), India ($p < 0.05$), South Africa ($p < 0.001$), and the United Kingdom ($p < 0.001$). Except for India and Japan, perceived risk for base station is higher than for cell phone.

The further data analysis is conducted separately for each country. Table V provides an overview of the effects of the independent variables precautionary measures, framing, and order on risk perception of cell phones based on ANOVAs. Means and *SD*s for the experimental conditions are provided in Appendix A.

The ANOVAs presented in Table V indicate mixed results across the nine countries. The factor "Framing" has no statistically significant effect on risk perception. In contrast, the factor "Order of presentation" produces statistically significant effects in all countries except Brazil. Furthermore, the factor "Precautionary measures" is statistically significant only for Australia.

Note, however, that the ANOVA results are not informative for testing our central question regarding the effect of providing information about precautionary measures. Our hypothesis regarding the effects of information about precautionary measures on risk perception is that those who receive such information will on average have a higher risk perception than those who do not receive such information (basic text). Accordingly, the interesting point is whether perceived risk for each of the precautionary measures conditions differs from the

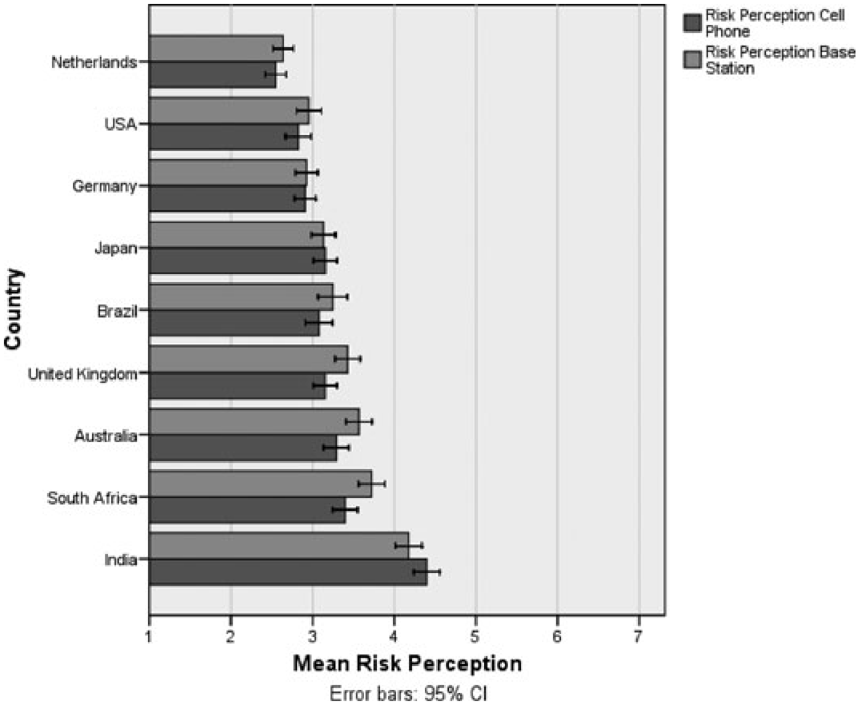

Fig. 1. Mean risk perception for cell phones and base stations.

Table V. Effect Sizes (Partial Eta Squared) of Main and Interaction Effects for Risk Perception of Cell Phones from ANOVAs; Statistically Significant Effects ($p < 0.05$) Are in Bold

Country	Measures	Framing	Order	Measures × Framing	Measures × Order	Framing × Order	Measures × Framing × Order
Australia	**0.027**	0.002	**0.035**	0.005	0.003	0.000	0.009
Brazil	0.007	0.000	0.006	0.008	**0.027**	0.000	**0.028**
Germany	0.007	0.000	**0.037**	0.018	0.011	0.008	**0.035**
India	0.013	0.008	**0.036**	0.014	0.015	0.000	0.014
Japan	0.008	0.000	**0.019**	0.015	0.017	0.000	**0.031**
Netherlands	0.009	0.000	**0.051**	**0.021**	**0.035**	0.007	0.003
South Africa	0.013	0.001	**0.028**	0.011	0.007	0.009	0.013
United Kingdom	0.020	0.000	**0.047**	0.010	0.000	0.000	0.009
United States	0.010	0.009	**0.016**	0.001	0.004	0.000	0.018

baseline condition (no information about precautionary measures). To answer this question, planned contrasts were computed between the noprecautionary information condition on the one hand and each of the four precautionary information conditions on the other hand. These contrasts provide difference scores between the no information condition (NI) and each of the precautionary information conditions (PI), that is, mean (PI) minus mean (NI). A positive difference score would indicate that the mean risk perception score is higher in the respective precautionary information condition than in the no information condition. Conversely, a negative difference score would indicate that the mean risk perception score is lower in the respective precautionary information condition than in the no information condition. A difference score of zero indicates that the two conditions do not differ.

Fig. 2 shows that in accordance with our hypothesis the difference scores for the four precautionary information conditions are, with one exception (South Africa), all positive (the numerical values are presented in Tables B1 and B2, see Appendix B). More important, the figure also shows the 95% confidence

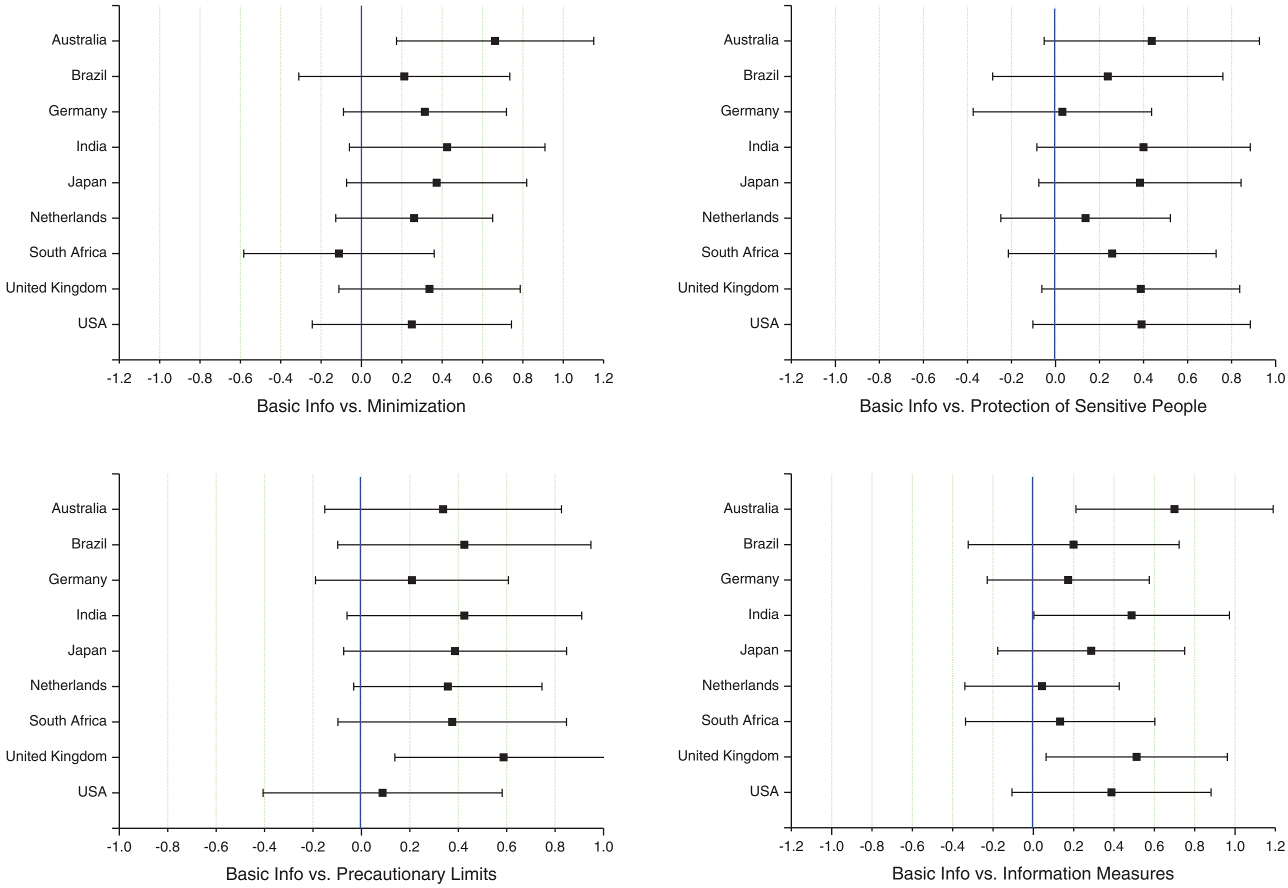

Fig. 2. Effects of information on precautionary measures on risk perception of cell phones with no information as base line (with 95% confidence intervals).

intervals for the difference scores. If a 95% confidence interval does not include zero this indicates that difference between the no information condition and the respective information condition is statistically significant (with $p < 0.05$).[27] Regarding cell phones, it is the case for only five out of the 36 difference scores. Furthermore, the average effect sizes are rather small, the maximum difference score is about 0.7 on a seven-point Likert scale. Nevertheless, taken together, our data do not support the taken-for-granted assumption of many health authorities that informing about precautionary measures reduces public concerns.

Next, the results with respect to base stations are presented. Table VIII summarizes the effects of the independent variables "Precautionary measures," "Framing," and "Order" on risk perception of base stations for the nine countries.

The factor "Precautionary measures" provides a statistically significant main effect only for the United States. The factor "Framing" has a significant effect on risk perception for the Netherlands and India. Furthermore, the factor "Order of presentation" produces significant effects in five out of nine countries. Again, with respect to the factor "Precautionary measure," we are not interested in its overall effect on risk perception, but in differences in risk perception between those who receive no precautionary information and those who do receive one of the four different types of precautionary information. The differences scores are depicted in Fig. 3, the numerical values (Table B2) are given in Appendix B.

Regarding base stations, the data show that for 10 out of 36 difference scores the 95% confidence intervals do not include zero, thus indicating a significant increase of risk perception when people are informed about precautionary measures. However, the effect sizes are rather moderate. Only one differences score reaches one scale unit on the seven-point Likert scale. Nevertheless, compared with cell

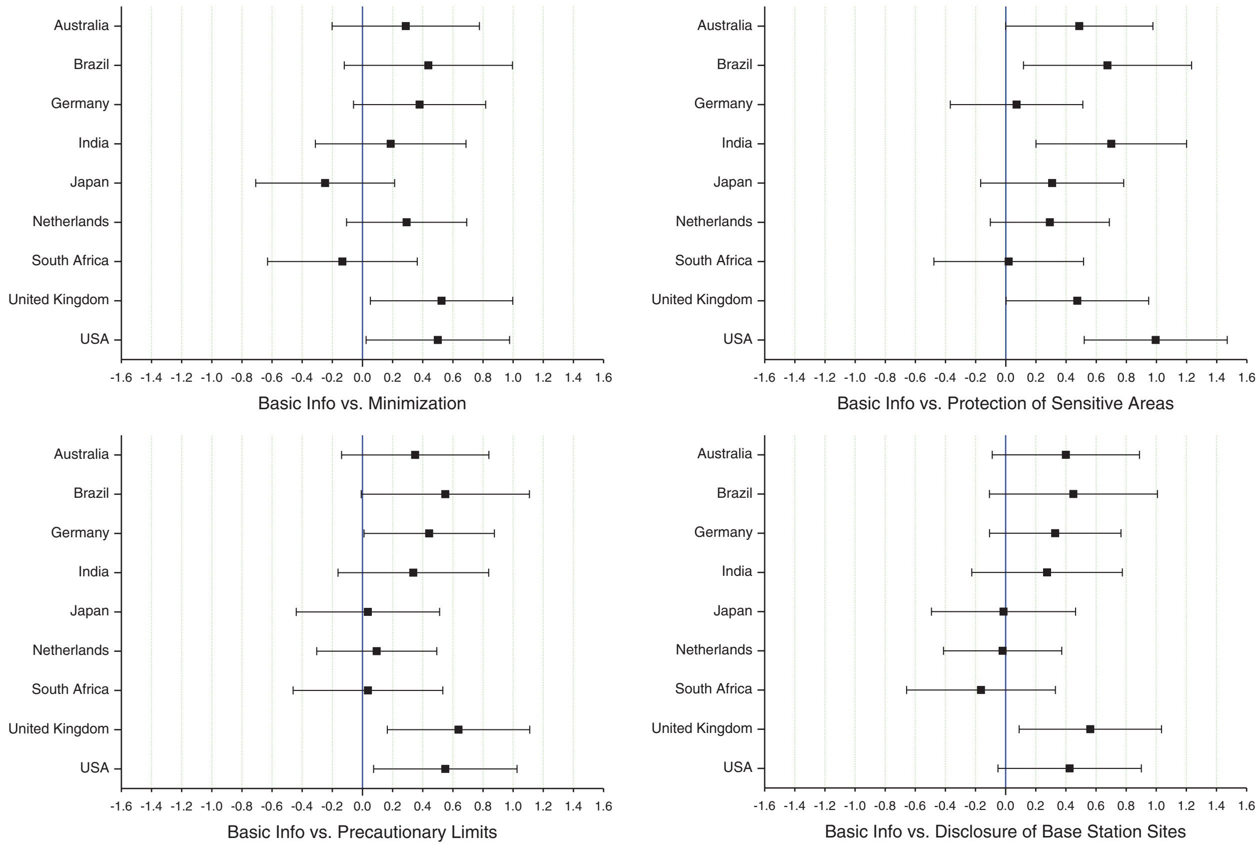

Fig. 3. Effects of information on precautionary measures on risk perception of base stations with no information as base line (with 95% confidence intervals).

phones as target of the precautionary measures, it seems that informing about precaution taking has a stronger effect when targeting base stations, albeit in the direction of increasing perceived risk. Taken together, the data suggest that informing people about precautionary measures aiming at base stations does not decrease concerns. Rather, our results point in the opposite direction.

In addition to these main findings about the impact of informing on precautionary measures, we looked into how other factors such as gender, MCT benefit perception, or technology-related attitudes might affect risk perception (see Table VII). Although a number of correlations are statistically significant, the effect sizes are small or at best medium. The only variable that in all countries except Japan consistently shows statistically significant correlations with perceived risk is perceived personal benefit. These correlations are all negative, indicating that the higher the perceived personal benefit of cell phones, the lower the perceived risk. Interestingly, the amount of daily use of cell phones for talking to others is not associated with perceived risk. Gender also shows no statistically significant correlation with perceived risk except for Japan, where women tend to have higher perceived risk than men. Attitude toward science and technology are also not consistently related to perceived risk of cell phones, but when they are, a more favorable attitude toward science and technology is associated with lower perceived risk.

With regard to the association of perceived risk of base stations and the selected variables even fewer correlations are statistically significant and the effect sizes are again small (see Table VIII). The direction of the associations is the same as for cell phone risk perception. Where gender is statistically significant, risk perception for females tends to be higher on average than for males. Higher perceived personal benefit is associated with lower perceived risk, and positive attitudes toward science and technology are associated with lower perceived risk.

Table VI. Effect Sizes (Partial Eta Squared) of Main and Interaction Effects for Risk Perception of Base Stations from ANOVAs; Statistically Significant Effects ($p < 0.05$) Are in Bold

Country	Measures	Framing	Order	Measures × Framing	Measures × Order	Framing × Order	Measures × Framing × Order
Australia	0.012	0.001	**0.034**	**0.028**	0.006	0.001	0.018
Brazil	0.017	0.001	**0.027**	0.013	0.004	0.004	0.012
Germany	0.014	0.002	0.005	0.008	0.004	**0.010**	0.016
India	0.021	**0.015**	0.002	0.011	0.010	0.008	0.024
Japan	0.012	0.001	0.004	0.009	0.003	0.000	0.018
Netherlands	0.009	**0.010**	0.000	0.010	**0.019**	0.000	0.002
South Africa	0.003	0.000	**0.060**	**0.027**	0.005	0.000	0.012
United Kingdom	0.023	0.001	**0.052**	0.005	0.004	0.001	0.014
United States	**0.043**	0.001	**0.018**	0.019	0.003	0.000	0.012

4. DISCUSSION

Previous findings[15,16] suggested that information about precautionary measures aimed at dealing with potential risks of RF EMF does amplify risk perception. The present results point in the same direction, but the effects are weaker, both in terms of the effect size and the number of significant effects across the various precautionary information formats used in the experiment. Furthermore, our analysis indicated remarkable differences between countries. It seems that respondents from countries with Anglo-Saxon backgrounds tend to be more sensitive to interpret information about precautionary measures as a risk indicator than other study respondents. However, the evidence for this conclusion is not consistent and rather weak. Further cross-cultural studies could make use of three competing approaches: the cultural cognition model of Kahan,[28] the approach of Hofstede,[29] and the moral foundation theory of Haidt.[30] While there are some data about the usefulness of Kohan's model, the two other approaches have not yet been applied in explaining cultural differences in interpreting risk communication. It would be interesting to see which one is the most beneficial.

It is interesting to compare the effect sizes of the experimental manipulation with regard to information about precautionary measures on risk perception with the association of the sociodemographic, behavioral, and attitudinal variables presented in Tables VII and VIII. The squared correlations can be computed from Tables VII and VIII. Furthermore, they can be directly compared to the partial eta squared from the ANOVAs (see Tables V and VI), as both indicate the variance in risk perception explained by the respective explanatory variable. For cell phones the partial eta squared values regarding the effect of the precautionary measures on risk perception range from 0.007 to 0.027 across the countries (see Table V), while r^2 for gender ranges from 0.000 to 0.013, personal benefit from 0.007 to 0.038, frequency of daily use of cell phone from 0.000 to 0.006, "environmental problems" from 0.000 to 0.048, and "cure illnesses" from 0.000 to 0.009 (compare Table VII). For base stations, the respective effects are: precautionary measures (0.003–0.043) (see Table VI), gender (0.000–0.013), personal benefit (0.000–0.037), frequency of daily use of cell phone (0.000–0.006), "environmental problems" (0.001–0.033), and "cure illnesses" (0.000–0.009) (compare Table VIII). None of these sociodemographic, behavioral, and attitudinal variables has a substantially stronger explanatory power for perceived risk than the different types of precautionary information, not even variables that have been extensively discussed to influence perceived risk, such as gender[31,32] and personal benefit.[33]

Furthermore, the findings do not support the expected framing effect. Framing the information on precautionary measure as "protecting public health" versus "avoiding health risks" did not result in different risk perceptions. The significant order effect might be attributed to the circumstance that our respondents became sensitized to risks due to the repeated measurement design.[34] This issue seems to be above all a methodological challenge.

In summary, it remains to be noted that our findings do not support the assumption that informing people about implemented precautionary measures will decrease public concerns. Such an effect seems to be unlikely. In addition, the expectation to overcome

Table VII. Product-Moment Correlations Between Perceived Risk of Cell Phones and Selected Variables for Each Country

Country	Gender[a]	Personal Benefit[b]	Daily Use[c]	Environmental Problems[d]	Cure Illnesses[e]
Australia	0.029	– 0.144**	0.000	– 0.089	0.027
Brazil	0.024	– 0.166**	0.015	– 0.021	– 0.071
Germany	0.001	– 0.138**	– 0.028	– 0.064	– 0.052
India	– 0.024	– 0.117*	– 0.008	– 0.014	– 0.012
Japan	0.114*	– 0.084	0.023	– 0.092*	– 0.094*
Netherlands	– 0.055	– 0.098*	– 0.051	– 0.070	– 0.015
South Africa	0.063	– 0.146**	0.056	– 0.152**	0.049
United Kingdom	0.014	– 0.194**	0.016	– 0.218**	– 0.004
United States	0.093	– 0.183**	– 0.010	– 0.165**	– 0.033

[a]Gender coded as male = 0 and female = 1.
[b]"The benefits associated with the use of cell phones to me personally are . . . " (1 = very low to 7 = very high).
[c]"On an average workday, how often do you use your cell phone for talking to somebody on the phone?"
[d]"Science and technology are responsible for most of the environmental problems we have today" (5 = strongly disagree; 1 = strongly agree); taken from European Commission (2005).
[e]"Scientific and technological progress will help to cure illnesses such as AIDS, cancer, etc." (1 = strongly disagree; 5 = strongly agree); taken from European Commission (2005).
*$p < 0.05$.
**$p < 0.01$.

Table VIII. Product-Moment Correlations Between Perceived Risk of Base Stations and Selected Variables for Each Country

Country	Gender[a]	Personal Benefit[b]	Daily Use[c]	Environmental Problems[d]	Cure Illnesses[e]
Australia	0.075	– 0.098	– 0.071	– 0.083	0.011
Brazil	0.083	– 0.191**	0.000	– 0.078	– 0.042
Germany	0.020	– 0.064	– 0.058	– 0.026	– 0.096*
India	0.019	– 0.132**	– 0.076	0.063	0.073
Japan	0.082	– 0.015	0.043	– 0.132**	– 0.074
Netherlands	– 0.075	– 0.088*	– 0.017	– 0.073	0.003
South Africa	0.113*	– 0.027	0.046	– 0.079	0.051
United Kingdom	0.079	– 0.069	0.027	– 0.139**	– 0.017
USA	0.106*	– 0.039	– 0.008	– 0.182**	– 0.001

[a]Gender coded as male = 0 and female = 1.
[b]"The benefits associated with the use of cell phones to me personally are . . . " (1 = very low to 7 = very high).
[c]"On an average workday, how often do you use your cell phone for talking to somebody on the phone?"
[d]"Science and technology are responsible for most of the environmental problems we have today" (5 = strongly disagree; 1 = strongly agree); taken from European Commission (2005).
[e]"Scientific and technological progress will help to cure illnesses such as AIDS, cancer, etc." (1 = strongly disagree; 5 = strongly agree); taken from European Commission (2005).
*$p < 0.05$.
**$p < 0.01$.

this effect by framing the precautionary messages in terms of safety did not occur. Framing does not provide a solution for this risk communication challenge.

However, one could argue—at least after the classification of RF EMF as "possibly carcinogen to humans" by IARC[(4)]—that some caution and, accordingly, an elevated risk perception might be appropriate. Therefore, it can be claimed that risk perceptions as found in this study represent a reasonable response to a potential hazard and do not pose any serious risk communication challenge. Others might nonetheless stress that our findings still imply a risk communication problem because the precautionary measures are meant to prevent the potentially adverse health effects and, therefore, should contribute to a decrease in risk perceptions.

Further studies might look into this issue in more detail. Two different starting points are recommended. First, the effects of informing about precautionary measures might be different for different audience groups. In terms of dual processing theories,[(35)] it seems reasonable to assume, that analytic versus intuitive processing strategies of information about precaution taking will lead to different effects. Analytic strategies, which are cognitively more elaborated, might result in a comprehensive processing of a precautionary message. Thus, the cue utilization could be more balanced and not only based on a dominant affective signal. Second, an approach focusing on personality traits such as trait anxiety,[36] sensitization and repression,[37] and personal need for structure[38] might also be a useful research strategy. Unpublished research conducted in Australia and Singapore supports this assumption.[39]

A further issue is the extrapolation of our findings to other technologies.[40] Until now, there is only sparse evidence available that would offer a conclusive answer. Therefore, it is an open question whether in the field of biotechnology or nanotechnology—to name only two other areas where precautionary measures are discussed or even applied—our results can be generalized. In addition, this study used student samples. Therefore, we have to be cautious about extrapolating the findings to the general public without additional evidence from nonstudent samples.

Finally, the issue of ecological validity of the findings has to be dealt with. This is especially important for precautionary actions that can be implemented personally by cell phone users. Risk perception might decrease if cell phone users directly adopt such measures. However, this effect might not happen in case of governmental precautionary actions concerning base stations that can only be observed but not personally implemented by individuals.

In our view, the practical implications of the present findings are not to abandon the implementation of precautionary measures, which are important for the mitigation of potential risks from exposure to RF EMF. However, what becomes clear is that public health authorities should not expect that the implementation of precautionary measures alone will strengthen trust in risk management and thus reduce risk perception. If the intention is to reassure the general public, simple reliance upon providing information about precautionary policies is likely to fail. Even if one argues that alerting the general public is justified and necessary due to the "possibly carcinogenic" classification of RF EMF by IARC,[4] it remains a challenge not to undermine the trust in established risk management efforts—that is, the exposure limits—by inducing additional precautionary measures.

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APPENDIX A

Table A1 and A2. Means and SDs for Risk Perception Regarding Cell Phones and Base Stations by Country

Risk Perception Cell Phone	Risk Perception Cell Phone by Precautionary Measures									
	Basic Text		Minimization		Sensitive Areas		Precaution		Information	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Australia	2.86	1.46	3.53	1.61	3.30	1.55	3.20	1.58	3.56	1.71
Brazil	2.86	1.90	3.08	1.83	3.10	1.67	3.29	1.47	3.06	1.63
Germany	2.76	1.36	3.08	1.40	2.80	1.41	2.96	1.50	2.92	1.53
United Kingdom	2.79	1.47	3.13	1.47	3.18	1.40	3.38	1.43	3.30	1.55
Netherlands	2.41	1.47	2.64	1.47	2.53	1.32	2.75	1.61	2.43	1.50
India	4.05	1.58	4.48	1.70	4.45	1.48	4.48	1.63	4.54	1.57
Japan	2.88	1.49	3.26	1.72	3.22	1.68	3.25	1.79	3.14	1.60
South Africa	3.27	1.54	3.16	1.37	3.52	1.73	3.65	1.59	3.39	1.52
USA	2.60	1.64	2.85	1.48	3.00	1.68	2.69	1.50	2.99	1.67

	Risk Perception Base Station by Precautionary Measures									
	Basic Text		Minimization		Sensitive Areas		Precaution		Information	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Australia	3.26	1.54	3.55	1.53	3.75	1.54	3.61	1.70	3.66	1.73
Brazil	2.83	1.64	3.26	1.89	3.50	2.04	3.38	1.65	3.28	1.83
Germany	2.67	1.27	3.05	1.56	2.74	1.50	3.12	1.63	3.01	1.57
United Kingdom	2.99	1.48	3.51	1.59	3.46	1.54	3.63	1.46	3.55	1.67
Netherlands	2.50	1.53	2.80	1.39	2.82	1.58	2.62	1.40	2.49	1.39
India	3.88	1.38	4.06	1.81	4.58	1.31	4.21	1.81	4.15	1.78
Japan	3.13	1.75	2.88	1.54	3.42	1.82	3.16	1.62	3.10	1.64
South Africa	3.75	1.72	3.65	1.46	3.79	1.82	3.80	1.62	3.62	1.69
USA	2.46	1.55	2.96	1.44	3.46	1.64	3.01	1.55	2.89	1.52

APPENDIX B

Table B1. Difference Scores (DS) and Lower Bounds of 95% Confidence Intervals for Cell Phones by Country

	Exposure Minimization		Protecting Sensitive People		Precautionary Limits		Information Measures	
Country	DS	95% CI[a]	DS	95% CI[a]	DS	95% CI[a]	DS	95% CI[a]
Australia	0.662	0.174	0.437	– 0.051	0.337	– 0.151	0.700	0.211
Brazil	0.212	– 0.310	0.237	– 0.285	0.425	– 0.098	0.200	– 0.323
Germany	0.315	– 0.089	0.031	– 0.374	0.209	– 0.190	0.173	– 0.229
India	0.425	– 0.060	0.400	– 0.085	0.425	– 0.060	0.488	0.003
Japan	0.373	– 0.073	0.384	– 0.075	0.387	– 0.073	0.287	– 0.176
Netherlands	0.262	– 0.127	0.137	– 0.248	0.357	– 0.031	0.043	– 0.339
South Africa	– 0.111	– 0.583	0.258	– 0.214	0.375	– 0.097	0.133	– 0.336
United Kingdom	0.338	– 0.112	0.388	– 0.062	0.588	0.138	0.513	0.063
USA	0.250	– 0.244	0.391	– 0.103	0.087	– 0.406	0.388	– 0.106

[a]Lower bound of 95% confidence interval.

Table B2. Difference Scores (DS) and Lower Bounds of 95% Confidence Intervals for Base Stations by Country

	Exposure Minimization		Protecting Sensitive People		Precautionary Limits		Information Measures	
Country	DS	95% CI[a]	DS	95% CI[a]	DS	95% CI[a]	DS	95% CI[a]
Australia	0.287	– 0.201	0.487	– 0.001	0.350	– 0.139	0.400	– 0.089
Brazil	0.437	– 0.121	0.675	0.117	0.550	– 0.008	0.450	– 0.108
Germany	0.379	– 0.059	0.072	– 0.368	0.443	0.011	0.329	– 0.107
India	0.187	– 0.312	0.700	0.200	0.338	– 0.162	0.275	– 0.225
Japan	– 0.248	– 0.708	0.308	– 0.167	0.036	– 0.439	– 0.014	– 0.493
Netherlands	0.293	– 0.105	0.292	– 0.102	0.095	– 0.304	– 0.020	– 0.412
South Africa	– 0.133	– 0.630	0.019	– 0.478	0.036	– 0.460	– 0.164	– 0.658
United Kingdom	0.525	0.052	0.475	0.002	0.638	0.165	0.563	0.090
USA	0.500	0.024	0.995	0.520	0.550	0.074	0.425	– 0.051

[a]Lower bound of 95% confidence interval.

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