



# Exposure knowledge and risk perception of RF EMF

Frederik Freudenstein<sup>1</sup>, Peter M. Wiedemann<sup>2\*</sup> and Nadège Varsier<sup>3,4</sup>

<sup>1</sup> Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

<sup>2</sup> University of Wollongong, Wollongong, NSW, Australia

<sup>3</sup> Orange, Issy Les Moulineaux, France

<sup>4</sup> WHIST Lab Common Laboratory of Orange and Institut Mines-Telecom, Paris, France

## Edited by:

Dariusz Leszczynski, University of Helsinki, Finland

## Reviewed by:

Yael Stein, Hebrew University, Israel  
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## \*Correspondence:

Peter M. Wiedemann,  
Wissenschaftsforum EMF,  
Anna-Louisa-Karsch-Straße 2, Berlin  
10178, Germany  
e-mail: peter.wiedemann@wf-emf.org

The presented study is part of the EU-Project Low EMF Exposure Future Networks (LEXNET), which deals among other things with the issue of whether a reduction of the radiofrequency (RF) electro-magnetic fields (EMF) exposure will result in more acceptance of wireless communication networks in the public sphere. We assume that the effects of any reduction of EMF exposure will depend on the subjective link between exposure perception and risk perception (RP). Therefore we evaluated respondents' RP of different RF EMF sources and their subjective knowledge about various exposure characteristics with regard to their impact on potential health risks. The results show that participants are more concerned about base stations than about all other RF EMF sources. Concerning the subjective exposure knowledge the results suggest that people have a quite appropriate impact model. The question how RF EMF RP is actually affected by the knowledge about the various exposure characteristics was tested in a linear regression analysis. The regression indicates that these features – except distance – do influence people's general RF EMF RP. In addition, we analyzed the effect of the quality of exposure knowledge on RF EMF RP of various sources. The results show a tendency that better exposure knowledge leads to higher RP, especially for mobile phones. The study provides empirical support for models of the relationships between exposure perception and RP. It is not the aim to extrapolate these findings to the whole population because the samples are not exactly representative for the general public in the participating countries.

**Keywords:** risk perception, exposure perception, risk communication, exposure reduction, risk assessment

## INTRODUCTION

Risk perception plays a powerful role in public debates about new technologies. It influences media coverage, funding policies, the range of research activities, as well as risk management (1). This is also true of the potential risks of wireless communication, i.e., of base stations and cell phones, which have been controversially debated in Europe for more than 20 years. However, a comprehensive discussion of views on the risk assessment of radiofrequency (RF) electro-magnetic fields (EMF) in the scientific community is out of the range of this paper. A vast amount of literature is available dealing with health risk assessment of EMF (e.g., see FEMU data base)<sup>1</sup> and is reviewed elsewhere (2).

Our interests are shaped by the ongoing EU-project low EMF exposure future networks (LEXNET), in which we participate. LEXNET is a research project that explores technical solutions for RF EMF exposure reduction (3). Exposure reduction might be discussed in two different frames: first, as a precautionary strategy for preventing potential health risks and second, as an approach for gaining more public acceptance of wireless telecommunication networks. From a policy view, the question is what happens when people receive information about exposure reduction. Will it affect public acceptance?

Whether or not communicating exposure reduction is successful in gaining public acceptance of telecommunication networks will depend on individual's risk perceptions (RP) and their judgments about acceptable RF EMF risk potentials. This issue, which concerns our study, will be now outlined in more detail.

Numerous RP surveys are available that document how the public appraises the risk potential of RF EMF emitted by base stations and cell phones. Most of these studies have been conducted on the national level, but a few provide comparative data on the international level. The Eurobarometer survey (4) indicates how different RF EMF RP is across Europe. EMF RP are the highest in Greece and Italy and the lowest in the Northern European countries. Furthermore, and more interesting for our research question, the survey demonstrates that lay-people's knowledge of RF EMF exposure sources is fragmentary. About 41% of the European respondents did not know that base stations and cell phones emit EMF.

Such survey studies provide representative data that depict how people perceive exposure situations and potential EMF risks. They reveal differences between countries, regions, sexes, ages, and education levels. However, there are hardly any studies that analyze how exposure perceptions are related to RP.

For our research – in context of the LEXNET project – this relationship is most important. Several questions are of interest. How do lay-people link exposure and risk? Do people perceive

<sup>1</sup><http://www.emf-portal.de/>

a higher risk if they perceive higher exposure? Another question concerns the exposure itself: What do people know about which exposure characteristics influence the potential health risk of RF EMF. Answers to these questions would provide valuable insights into the cognitive structure of people's RF EMF RP and about how they will respond to exposure reductions as suggested by LEXNET.

### BACKGROUND: STUDIES ON EXPOSURE PERCEPTION

The seminal research of Paul Slovic and colleagues on intuitive toxicology can be used as a starting point (5, 6). They examined how lay-people understand the basic principles of toxicological risk assessment. For instance, they researched how people evaluate dose–response-relationships and whether they are sensitive to exposure strength. Another question referred to the issue of whether lay-people assess natural chemicals more leniently than man-made chemicals. These studies provide some interesting findings. In short, non-experts are less sensitive to exposure dependency of risk magnitude. Furthermore, they evaluate man-made chemicals as more dangerous than natural chemicals.

In Read and Morgan's (7) study, participants completed a pre-test, a brief tutorial about magnetic fields, and a post-test 24 h later. Five different educational treatments and a control group were used. Participants were asked to estimate magnitudes of a magnetic field along a dotted line of a picture of a high-voltage power line. Participants were also given magnitudes and asked to estimate the distance from the power line. The authors could show that lay-people significantly underestimate the rate at which magnetic field strength decrease with distance from a field source<sup>2</sup>. In addition, a MacGregor et al. (8) study on perception of risk from power lines provides some clues that lay-people's appraisal of exposure reduction depends on the perceived costs and benefits. For instance only 40% of their respondents strongly support banning electrical appliances that can result in particularly high exposure to ELF EMF's. However, a similar percentage of the respondents strongly favor removing all existing above ground high-voltage transmission lines and putting them underground at an additional expense to households.

With respect to RF EMF no study is available – to our knowledge – that researches the exposure perception of lay-people. However, anecdotal knowledge indicates the influence of distance of the EMF source to target on EMF RP. For instance, the German RF EMF measurement campaigns in 2003–2006 (9) supports the assumption that people are more willing to accept a base station if the station is located at a higher distance from their home. Similarly, Wiedemann and Claus (10) found a positive correlation between distance and acceptance of high-voltage power lines. The further a power line is located the more people will accept it in the vicinity of their homes.

Distance is only one of various exposure characteristics that affects the magnitude of exposure. Lay-people are not usually well informed about the spectrum of relevant exposure characteristics. It is of interest how lay-people evaluate everyday close exposure characteristics such as duration of exposure, number of exposure

sources, and frequency of exposure. Until now, a systematic analysis is still lacking with respect to which of these factors lay-people consider as relevant in their exposure perception. Furthermore, we do not yet know how RP and exposure perception are related. On the one hand, the hypothesis seems plausible that exposure and RP are correlated: the lower is the perceived exposure the lower is the perceived risk. On the other hand, it could be that people's RP are insensitive to the exposure (11). For example, if RF EMF is perceived as a hazard then it remains a hazard at any distance. Therefore, even a low RF EMF exposure could be perceived as creating a substantial risk.

### RESEARCH AIMS

We are interested in how specific EMF sources are perceived regarding their health risk potentials. In order to analyze people's intuitive RP of RF EMF sources, we used a new approach. By presenting various exposure situations in picture-guided scenarios we improved the standardization of the analysis of RP. All respondents were given the same pictures and evaluated the same situations. This methodology allows more reliable insights into our respondents' RP compared to ordinary surveys like INFAS (12) or the Eurobarometer study (4), which describe exposure situation only by a brief verbal statement. This approach was also tested across the participating countries.

With respect to the analysis of the relationship between EMF exposure perception and EMF RP two approaches are available. First, we can simply ask people how they think that various exposure characteristics may influence the related potential health risk. Second, we can analyze how knowledge about various exposure characteristics actually affects RP. This indicates how the quality of knowledge results in different RP.

The current study examines these three questions in detail:

- (1) How do non-experts evaluate various RF EMF exposure sources with regard to human health risks?
- (2) What do lay-people know about the impact of RF EMF exposure characteristics on health risks?
- (3) Does this knowledge (about the influence of RF EMF exposure characteristics on health risks) influence people's RF EMF RP?

### MATERIALS AND METHODS

The survey was conducted from April 2013 to September 2013 as an online study. Data were gathered in eight European countries, and after quality control, 3097 interviews remained for analysis with most respondents being citizens of the country in which the survey was carried out (Germany  $n = 652$ , France  $n = 200$ , Spain  $n = 298$ , Portugal  $n = 838$ , Romania  $n = 83$ , Serbia  $n = 800$ , Montenegro  $n = 199$ , and Belgium  $n = 27$ ; Romania and Belgium are not considered in the detailed analysis per country due to the small sample sizes).

The mean age of the participants was 33.7 years, with 60% male and 40% female. The majority of the respondents are well educated, with a mean of 16.7 of education years. Most respondents consider themselves as middle class people (mean 5.32 on a 10-point scale from bottom to top of society). Regarding the respondents' working situation in the last 7 days, the largest group (56.9%

<sup>2</sup>Of course, that refers to ideal circumstances. In practice, many conditions can influence this reduction rate.

of the respondents) was in paid work (employees, self-employed, working for family business) and 28.9% were in education.

Although our online sample is not reflective of the entire population of the different countries (our sample has a younger mean age, higher percentage of students, and higher education level compared to the average in the population), it can provide valuable insights into the issues of RP in which we are interested. The sampling was conducted by advertising the survey on websites, by e-mails, and by mouth-to-mouth marketing by project partners. Web surveys are seen as a good alternative to conventional telephone and face-to-face interviews when the target group for the survey can be reached (13). The subjects in this survey are younger, well educated respondents with interest in new technologies, in other words a segment of the society, which plays a crucial role in the public discussion on potential EMF related health risks.

The survey consisted of 28 main questions to measure respondents' intuitive risk and exposure perception, starting with a short introduction describing the topic, the general aims, and the background of the study<sup>3</sup>. The respondents were not forced to answer all questions and had the possibility to quit the survey at any time. We used an online survey tool called "Survey Monkey." Some demographic, political, and economic background related items came from the survey platform called "European Social Survey" (14)<sup>4</sup>. The questionnaire was translated into the languages of the participating countries. Each translation was checked by at least two different persons and re-translated into English for consistency with the original English version of the questionnaire.

<sup>3</sup>Online available at: <http://cordis.europa.eu/docs/projects/cnect/3/318273/080/deliverables/001-D22Riskandexposureperceptionv1.pdf>

<sup>4</sup><http://www.europeansocialsurvey.org>

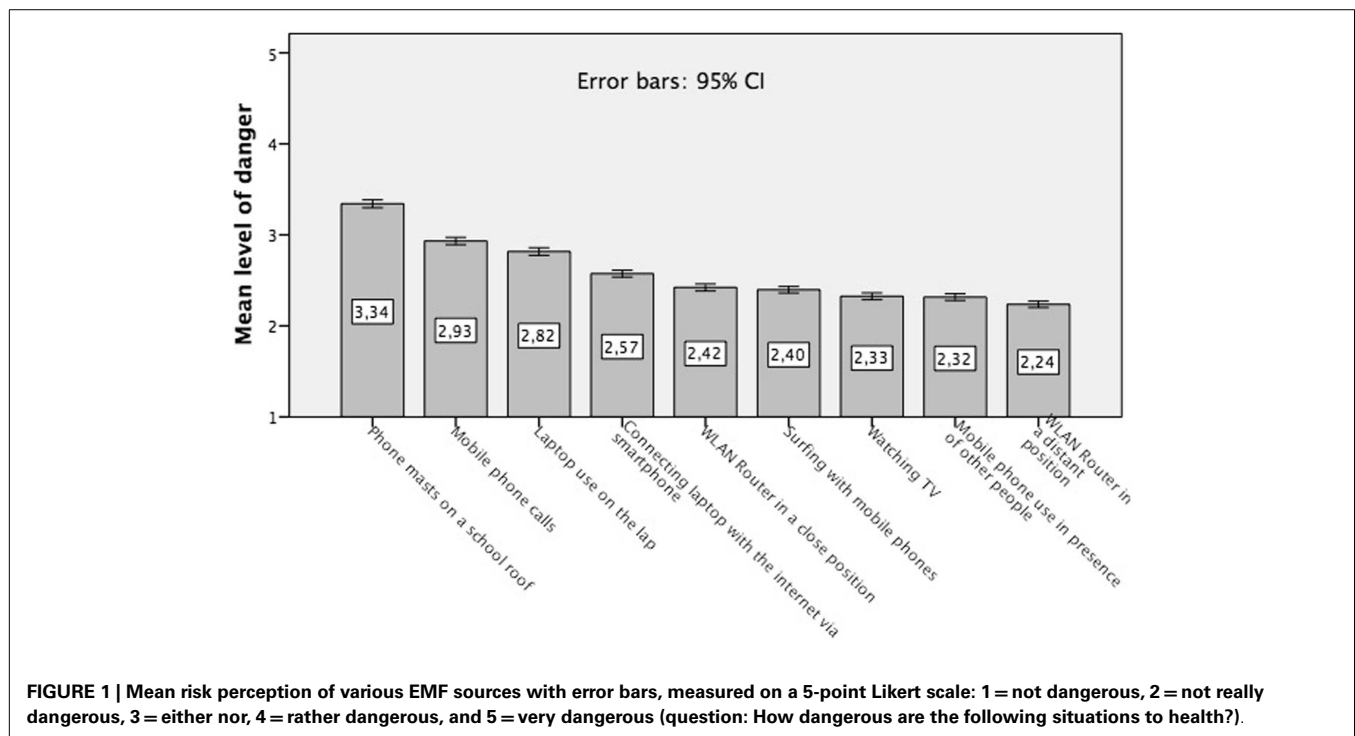
In the survey we asked questions with respect to the perception of health risks of various EMF exposure sources, such as mobile communication mast on school roofs, being exposed by another person's mobile phone use, being exposed by wireless local area networks (WLAN) router in a distant and in a close position, making mobile phone calls, surfing with a mobile phone, using laptop on the lap, connecting a laptop with the internet via smartphone, and watching television. We used picture-guided scenarios, presenting pictures of different exposure situations and the aforementioned various exposure sources, and we asked for how dangerous the respondents consider these situations to health. The perception of health risks was measured on a 5-point Likert scale (1 = Not dangerous to 5 = Very dangerous).

All statistical analyses were performed using IBM® SPSS® Statistics, V20.

## RESULTS

### DIFFERENTIAL EMF RISK PERCEPTION

Figure 1 indicates that base stations on a school roof are perceived as the highest risk source, followed by making mobile phone calls. The mean RP score for base station is 3.34 (confirmed as also being the highest ranked source in all countries: Germany, mean = 3.03; France, mean = 3.55; Spain, mean = 3.43; Portugal, mean = 3.53; Serbia, mean = 3.31; and Montenegro, mean = 3.50). Using mobile phones for calls is perceived as less dangerous, reaching a mean of 2.93 on the 5-point Likert scale. A somewhat lower score characterizes the laptop usage on the lap. Here, the mean RP is 2.82. The perceived health risks from all other sources are lower (these three sources are highest ranked in all countries, except Germany where Internet usage via smartphone is ranked higher than Laptop use: mean = 2.50 vs. 2.41).



These findings indicate that base stations tend to be perceived as clearly dangerous. With respect to all other EMF sources, our respondents are rather undecided on the matter. Their perceptions vary about the scale midpoint “either nor.”

For the purpose of analyzing the link between risk and exposure perception, we created a new composite indicator for EMF RP across all sources by averaging the perceived potential risks across all presented EMF exposure sources for each respondent. This new variable was labeled general EMF RP [General RP =  $\Sigma$  RP various sources (score mobile communication mast on a school roof + score being exposed by another person’s mobile phone use + score being exposed by WLAN router in distant position + score being exposed by WLAN router in close position + score making mobile phone calls + score surfing with a mobile phone + score using a laptop on the lap + score connecting a laptop with the internet via smartphone + score watching television)/9]. Its mean value is 2.60 and it varies slightly between the country samples: Germany, mean = 2.42 and Spain, mean = 2.44 with lower RP than the other countries: France, mean = 2.71; Portugal, mean = 2.67; Serbia, mean = 2.64; and Montenegro, mean = 2.61.

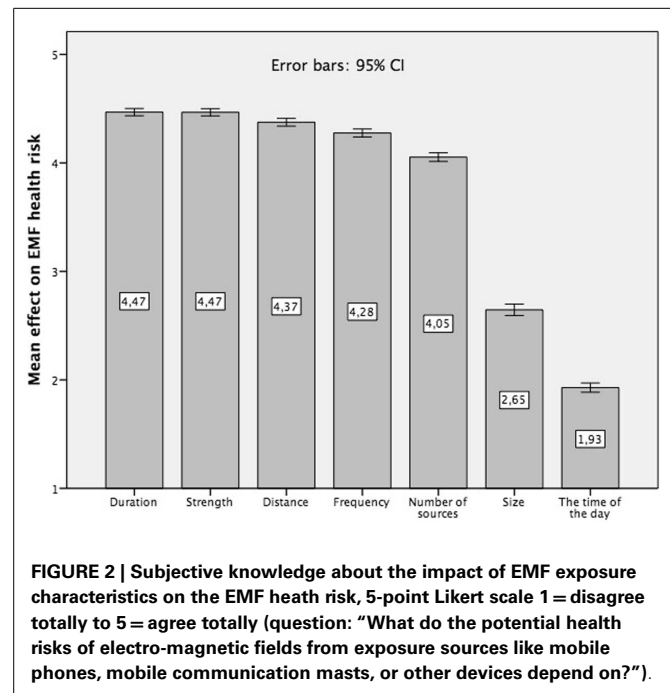
### SUBJECTIVE EXPOSURE IMPACT KNOWLEDGE

Our second research question concerns what non-experts know about the impact of RF EMF exposure characteristics on potential health risks. Respondents were asked to evaluate the impact of the different exposure features on potential health risks (Question: “What do the potential health risks of EMF from exposure sources like mobile phones, mobile communication masts, or other devices depend on?”), on a 5-point Likert scale (with 1 = Disagree totally to 5 = Agree totally). The following exposure features had to be assessed: How long you are exposed, how close the exposure source is, how often you are exposed, how strong the field is, how many sources are present, the time of the day during the exposure and the size of the source.

In the average, our respondents revealed a rather appropriate subjective knowledge about the impact of exposure characteristics on potential EMF health risks. As displayed in **Figure 2**, the following characteristics are seen as essential for health risks: (1) the strength of exposure (mean = 4.47), (2) duration of exposure (mean = 4.47), (3) the distance (mean = 4.37), (4) the frequency of exposure (mean = 4.28), and (5) the number of exposure sources (mean = 4.05). The physical size of the exposure source as well as the time of the day of exposure, are less relevant (mean = 2.65 and mean = 1.93).

These findings indicate that in average our subjects’ subjective exposure impact knowledge model about EMF exposure is fairly adequate. Moreover, it is remarkable that the same pattern of exposure characteristics (as depicted in **Figure 2**) can be found across all countries: size and time of the day are always evaluated as less relevant exposure characteristics, see **Figure 3**.

However, what people know or believe to know about exposure characteristics and RF EMF health risk is one thing, but whether this knowledge is actually influencing their RF EMF health risk judgments might be a different thing. In other words, we assume that people’s knowledge can but does not necessarily have to influence their RP.



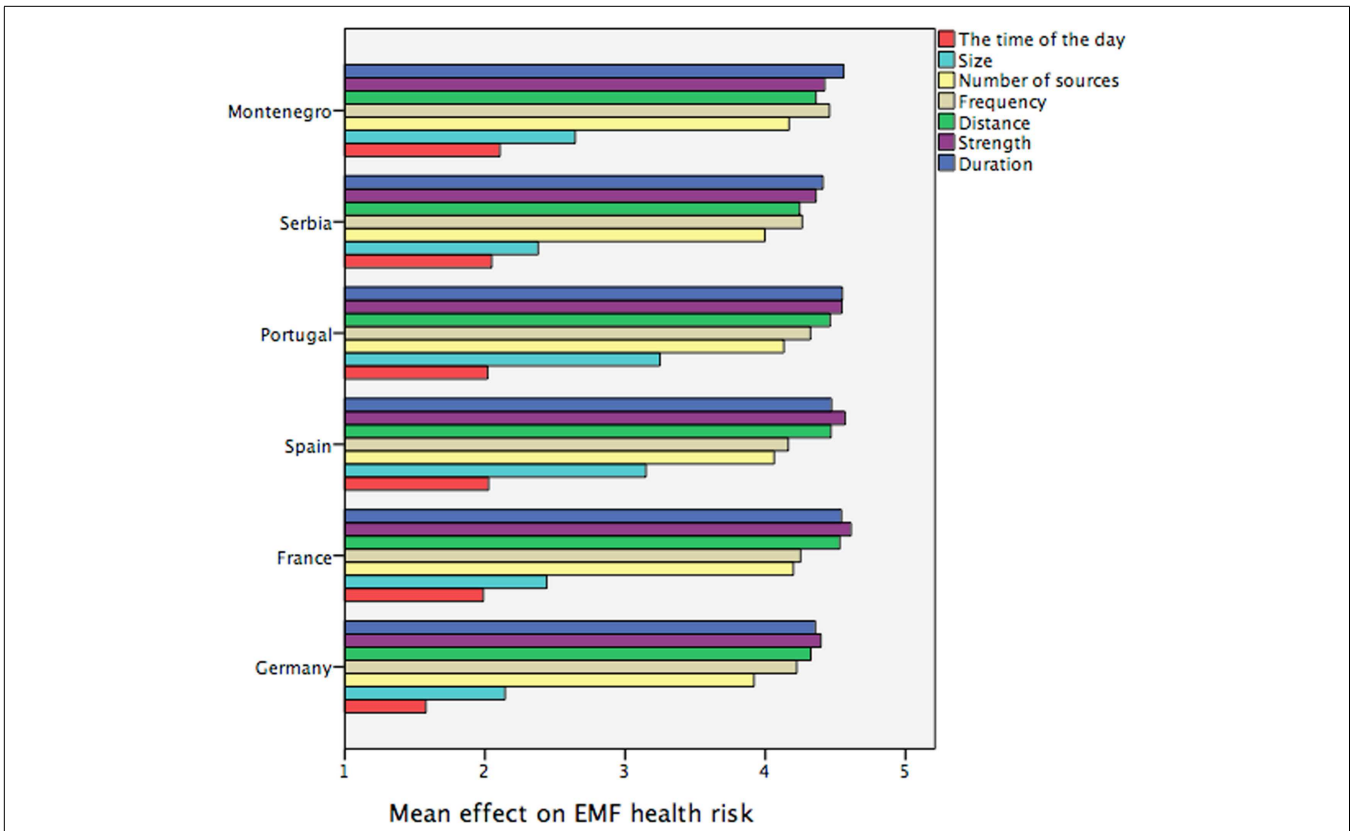
**FIGURE 2 | Subjective knowledge about the impact of EMF exposure characteristics on the EMF health risk, 5-point Likert scale 1 = disagree totally to 5 = agree totally (question: “What do the potential health risks of electro-magnetic fields from exposure sources like mobile phones, mobile communication masts, or other devices depend on?”).**

### SUBJECTIVE EXPOSURE IMPACT KNOWLEDGE AND EMF RISK PERCEPTION

The third research question refers to the issue how general EMF RP is actually affected by the knowledge about the various exposure characteristics. Therefore, a regression analysis was conducted using the exposure characteristics as independent variables and general EMF RP as dependent variable. We computed all calculations with the linear regression model (enter method) as specified in SPSS®, V20. The analysis demonstrates that the distance to the exposure source is not a significant predictor of general EMF RP ( $\beta = 0.014$ ,  $p = 0.613$ ). Significant predictors are the number of the exposure sources ( $\beta = 0.148$ ,  $p = 0.000$ ), the frequency of exposure ( $\beta = 0.129$ ,  $p = 0.000$ ) as well as the time of the day of exposure ( $\beta = 0.136$ ,  $p = 0.000$ ), the duration ( $\beta = 0.066$ ,  $p = 0.028$ ), the strength ( $\beta = -0.063$ ,  $p = 0.022$ ), and the physical size of the device ( $\beta = 0.099$ ,  $p = 0.000$ ), see **Figure 4**.

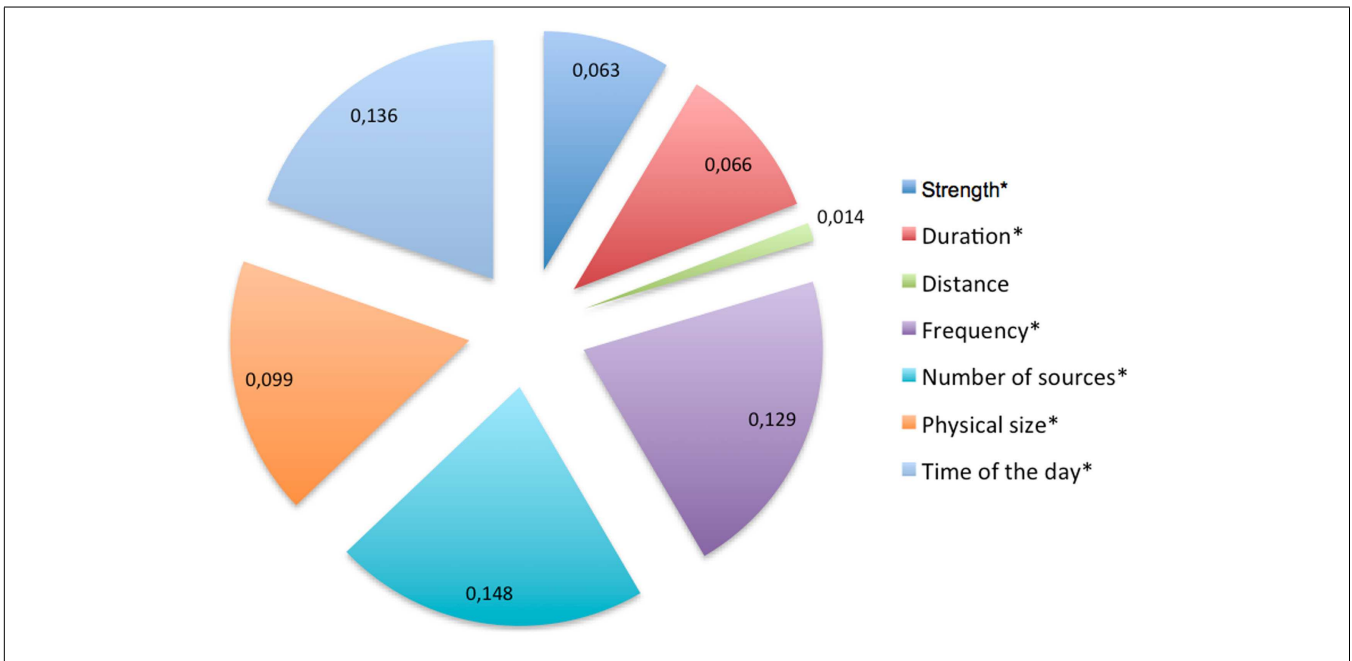
All in all, these results indicate that knowledge about the influence of exposure characteristics on potential health risks do influence peoples RP, at least at the aggregated level. Note, however, which the share of the unexplained variance in the linear regression model amounts to nearly 90% ( $R^2 = 0.115$ ;  $R^2$  is the coefficient of determination, maximum  $R^2$  is 1). Furthermore, it cannot be excluded that these findings are an artifact, due to the composite measurement of general EMF RP. For this reason, it might be useful to change the approach and analyze the impact of exposure knowledge with respect to RP regarding separate EMF sources. In addition, it would be interesting to take into account how the quality of exposure impact knowledge influences RF EMF RP. Does more accurate knowledge correlate with a higher or a lower RP?

Therefore, we divided our subjects into two knowledge groups. First, people with adequate knowledge about the impact of exposure characteristics on risk potentials ( $n = 708$ ), which score high



**FIGURE 3 | Subjective knowledge about the impact of EMF exposure characteristics on the EMF health risk by country, 5-point Likert scale 1 = disagree totally to 5 = agree totally (question: “What do the**

**potential health risks of electro-magnetic fields from exposure sources like mobile phones, mobile communication masts, or other devices depend on?”).**



**FIGURE 4 | Linear regression of various perceived exposure characteristics on general EMF risk perception.** Beta values (β) are indicated. β represents the relative importance of the independent variable (various exposure characteristics) in predicting the dependent variable (general EMF risk perception), the maximum β is 1, \*statistically significant (level 0.05); significance levels:  $p \leq 0.05 = \text{sign.}$ ,  $p \leq 0.01 = \text{high sign.}$ ,  $p \leq 0.001 = \text{highly sign.}$

**Table 1 | Results of the ANOVA.**

Independent variable	Mean group with adequate knowledge	Mean group with inadequate knowledge	F	p	$\eta^2$
General risk perception	2.57	2.48	1.05	0.304	0.0033
Risk perception regarding phone masts on a school roof (base station)	3.24	3.16	0.30	0.579	0.0010
Risk perception regarding mobile phone for calls	2.98	2.61	8.83	0.003*	0.0273
Risk perception regarding WLAN router in a close position	2.47	2.34	1.26	0.261	0.0040
Risk perception regarding WLAN router in a distant position	2.21	2.16	0.18	0.664	0.0006

With knowledge groups as independent variable and EMF risk perception as dependent variable; indicated: means of knowledge groups; F-values ( $F > 1$  indicates significant differences between the groups); p represents the significance level, in the table \*statistically significant; eta squared ( $\eta^2$ ) represents the effect size.

**Table 2 | Multiple linear regression analysis (method enter) of beliefs and personality factors on risk perception (RP) of various EMF exposure sources.**

Regression personality factors and beliefs	Beta values				
	General RP	Base station	Mobile phones	Router close	Router distant
Age	-0.050*	0.082*	-0.059*	-0.042	-0.023
Gender	0.062*	0.078*	0.026	0.033	0.033
Pioneer role	-0.078*	-0.023	-0.033*	-0.072*	-0.074*
Political orientation	0.019	-0.007	0.000	-0.008	0.023
Societal position	0.054*	0.072*	0.024	0.029	0.019
R <sup>2</sup>	0.015	0.021	0.007	0.008	0.008

Beta values indicated, \*statistically significant (level 0.05).

(4 or 5 on 5-point Likert scale) for the following exposure characteristics: duration, strength, distance, frequency and number of sources, and score low for the characteristics “size” and “time of the day” (1 or 2 on the 5-point Likert scale). The second group, people with inadequate knowledge of exposure characteristics, was operationalized by low scores ( $\leq 3$  on the 5-point Likert scale) for duration, strength, distance, frequency and number of sources and high scores ( $\geq 3$  on the 5-point Likert scale) for size, and time of the day ( $n = 89$ ). A comparison of these two knowledge groups allows us – in a first approximation – to assess whether the quality knowledge about the impact of exposure characteristics on potential health risks will affect RP (see **Table 1**).

The results show a consistent tendency toward higher RP across various exposure situations (base stations, mobile phones, router in a close, and distant position) for people with adequate knowledge about the impact of exposure characteristics. **Table 1** reveals only one statistically significant result with respect to mobile phone use ( $F = 8.83$ ,  $p = 0.003$ ).

The evaluation of these findings requires taking into account the amount of explained variance. The knowledge difference explains only a few percent of variance of RF EMF RP (e.g.,  $\eta^2$  for mobile phones = 0.0273). This leads to the conclusion that other factors beside knowledge about the influence of exposure characteristic on potential health risks determine people’s RF EMF RP.

The high amount of unexplained variance leads to the question of which other factors, especially personality factors, might influence EMF RP. In order to explore this question, we conducted a further multiple linear regression analysis with the following

regression variables: age, gender, as well as three belief scales. The first belief item referred to one’s openness to new technologies (labeled as pioneer role). Here, our respondents were asked to compare themselves to two fictitious characters – Hans and Clara who “are open to using new technical innovations at home, at work, and in their spare time. They have to try everything new.” The second belief item refers to one’s political orientation (left–right), and the third belief item to one’s position in the societal hierarchy (top–bottom).

As indicated in **Table 2**, the openness to new technologies seems to be a significant factor across all telecommunication devices. The more open to new technologies the respondents are the lower are their EMF RP (general RP:  $\beta = -0.078$ ,  $p = 0.001$ ; mobile phones:  $\beta = -0.033$ ,  $p = 0.023$ ; router close:  $\beta = 0.072$ ,  $p = 0.002$ ; and router distant:  $\beta = 0.074$ ,  $p = 0.002$ ). This relationship was not found for the RP regarding base stations. The political orientation has no impact on various RF EMF RP. Age, gender, and societal position show varying impacts, see **Table 2**. However, the low explained variances ( $R^2$ ) signify that the tested beliefs and personality factors have only a minor impact on RF EMF RP.

#### LIMITATIONS OF THE STUDY

Some limitations of the present study should be clarified. First, our sample is not representative for the general public in the different countries, but it describes a societal group of younger and well educated people who influence the discourse about new technologies and hence public opinion in western societies. Especially, we do not refer to persons who perceive EMF exposure as a

cause of their health issues. Additionally, we conducted an online survey that excludes – per definition – all subjects without Internet access. This approach could result in a selection bias toward more technology-accepting people. Moreover, we used a purposive sampling strategy. Therefore, it cannot be the aim of the present study to extrapolate the findings to the populations of the participating countries as a whole. The purposive sampling strategy can only serve one aim: to provide empirical support for models that describe the relationships between exposure perception and RP, and examine the results for internally consistent relationships. Further studies based on a probability sampling are required, to explore the generalizability of our findings to populations.

Second, the country specific data presented here should not be understood as a cross-cultural analysis, which we have observed to be a much more complex issue in previous multi-national investigations (15). Instead, as already mentioned above, the comparisons were used to check consistency of the main findings.

Third, we followed a cross sectional study design that does only allow the analysis of associations. A strict causal interpretation of the associations is not possible. This has to be taken into account when interpreting the regression analyses presented above.

## DISCUSSION

A vast amount of studies in RP research have demonstrated that lay-people's RP do not reflect experts' risk judgments. This difference is partially due to knowledge deficits on the side of the public, but it is also shaped by idiosyncrasies of intuitive RP (16). Therefore, a simple "deficit perspective" on how the public perceives risks is inadequate.

Our RP data provide a complex picture. On the one side, it seems that the study participants, in the average, focus especially on the riskiness of base stations, a tendency that was also found in other surveys (15, 17). However, the cross-cultural study of Wiedemann et al. (15) demonstrated some variability.

The focus on base stations as the dominant risk source is inconsistent with experts' evaluation. For instance, the International Agency for Research on Cancer (IARC), which evaluated the RF EMF exposure as possibly carcinogen to humans, explains that this categorization refers only to personal exposure, i.e., cell phones. The evidence from environmental exposure (base stations) was evaluated as inadequate (18, 19). Moreover, the typical exposure levels from base stations are generally several orders of magnitude lower than from cell phones (3, 20, 21). In Lauer et al. (21), combining exposure from far-field and near-field sources into a metric evaluating the whole-body personal dose averaged over 24 h of exposure to EMF they found that 80% of the dose is caused by the person's own mobile phone for the user of a 2G cell phone.

However, one could argue from a psychological perspective that RP reflects always a certain view to its object. In this sense, perceptions are neither false nor true, but unique. It is shaped by the characteristics of the perceiver. This is the very reason for recognizing that the deviations of public perceptions from experts' viewpoints should be explored in detail. The perception of familiarity (22) and benefits plays an important role in shaping RP (23). Furthermore, some dimensions of Slovic's psychometric paradigm can be used to explain the above finding – specifically, controllability and voluntariness (24, 25) could be relevant factors. Base

stations are not under control of the people living in vicinity of them and residents are usually not involved in the siting of base stations. In contrast, people can decide whether or not to buy a cell phone, and they can switch off their phones at any time. Moreover, there are no noticeable advantages for people who have a base station close to their homes. In contrast, mobile phones and laptops have obvious benefits for their owners (17). The perceived lack of control and the involuntariness attributed to base stations as well as lower benefit perception lead to amplified RP.

The analysis of the subjective exposure impact knowledge model reveals further interesting results. The strength and the duration of exposure, the distance to the exposure source, the frequency of exposure and the number of exposure sources are crucial factors in the eyes of non-experts that determine the potential EMF health risks (time of the day and size being less relevant, see **Figure 2**). It suggests that peoples' subjective exposure impact model is quite appropriate (which is confirmed by the country specific analysis). Nonetheless, it would be too early to celebrate this as a result of successful EMF risk communication efforts, due to the fact that our sample consists of subjects with education levels above the average.

Moreover, what people believe impacts their judgments and what actually impacts their judgments is often different (26). We looked into how the knowledge about exposure characteristics influences RP. As known from the relevant research, the relationship between RP and knowledge is complicated. Various studies analyzing the link between knowledge and RP found mixed results. For ELF EMF, MacGregor et al. (8) found that higher knowledge is associated with amplified RP.

In the present study, we examined how knowledge about the impact of various RF EMF exposure characteristics on health risks influences RF EMF RP. A linear regression analysis indicates that the knowledge about the influence of exposure characteristics on potential health risks – except distance – does indeed influence people's general RF EMF RP. This finding might be explained through the fact that the influence of the distance on health risks is intuitively not as evident as frequency, number of sources, and size of the exposure source. The statistical significance of the predictor "time of the day" points, in all probability, at the widespread belief that people are more vulnerable in the night when they sleep.

Another potential explanation for this result might be the difficulty to evaluate in general how the distance as an exposure characteristic contributes to the potential health risk. Sometimes, distance is only a poor predictor for exposure [see (27), p. 113]. Therefore, it might be more appropriate to analyze the link between knowledge and RP separately for various exposure sources. In addition, the quality of knowledge about the influence of exposure characteristics on EMF health risks matters. An analysis that takes both issues into account indicates a tendency to higher RP for the higher knowledge group across all considered exposure sources (see **Table 1**). Statistical significance is reached only with respect to cell phones. Here, we can clearly say that better exposure knowledge leads to higher RP. However, the effect strength is rather small and knowledge differences explain only 3% of variance for mobile phone RP ( $\eta^2 = 0.0273$ ).

Radiation protection agencies, which are primarily interested in supporting informed judgment about RF EMF risk potentials,



might learn from our findings that risk communication should address exposure issues in detail and with regard to specific exposure situations. A “one size fits all” – approach will certainly fail. EMF exposure communication should be communicated for base stations and cell phones as well for other EMF exposure sources as WLAN and tablet computers. The real challenge is to explain the interactions of exposure characteristics in a simple and sound way.

More efforts are needed for understanding how other factors beside knowledge of exposure characteristics influence public perception of potential EMF health risks. Here, we must break new ground, given that the beliefs and personality factors can only be described as having minor influence due to the low amount of explained variance ( $R^2$  indicated in **Table 2**).

For the LEXNET project and others who share interest in the question of whether lower RF EMF exposure will improve the acceptability of wireless technologies, we do not have a simple answer. The question of how exposure reduction may influence the acceptability of new telecommunication technologies seems to be more complex as previously assumed. Our results indicate that knowledge about exposure characteristics is influencing RP. In principle, increased knowledge seems to amplify RF EMF RP. This effect will be analyzed in depth in an upcoming study. The key question is: How much reduction is enough for gaining more acceptance of new telecommunication technologies?

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