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Low EMF Exposure Future Networks

LEXNET
Low EMF Exposure Future Networks

D2.7 – Risk and exposure perception of RF EMF and acceptance of exposure reduction

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Abstract	The report D2.7 summarizes the final outcome of the social science section of WP2, by introducing the main results from LEXNET surveys “Risk and Exposure perception 1&2” and lessons from stakeholders’ workshops organized at the beginning and at the end of the project in Berlin and Brussels.
Key words	risk perception, exposure perception, risk communication, exposure knowledge, acceptance of RF EMF

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Executive Summary

The following report provides answers to the main research questions of LEXNET's social science section:

- What do non-experts believe about exposure and risks from various RF EMF exposure situations?
- What is most important for RF EMF risk perception: Exposure perception, affective evaluation or moral evaluation of RF EMF exposure situations?
- What do lay people know about the impact of RF EMF exposure characteristics on potential health risks?
- How does exposure reduction affect the acceptance of base stations?
- Do people agree with the basic principles of the exposure index?

Main results:

- Base stations are considered as the most dangerous RF EMF source.
- Risk perception is mainly based on exposure perception and to some degree on moral judgments. Affective evaluations play only a minor role.
- Risk perception is only slightly affected by relevant exposure characteristics
- Exposure reduction leads to acceptance of base stations in closer distance.
- The majority of the respondents support LEXNET project aims.

Lessons from stakeholders' workshops in Berlin and Brussels about EMF exposure and risk perception are also discussed to finally propose one possible way to handle risk communication by using exposure communication.

1 BACKGROUND

The usage of wireless telecommunication technologies in our day-to-day life has dramatically increased over the years. This tendency is still ongoing along with the continuous development of new technologies and related applications. The World Health Organization estimates that there are 6.9 billion mobile phone subscriptions worldwide (WHO, 2014).

Therefore, the safe use of wireless technology is a priority of regulatory agencies, which oversee the radio-frequency electromagnetic fields (RF EMF) that are emitted by all wireless technologies. Until now, no adverse health effects have been established (WHO, 2014). However, RF EMF is evaluated as "possibly carcinogenic" by the Internal Agency for Research on Cancer (IARC, press release 2011) and there are still some open questions regarding health protection (WHO, 2010 and SCENIHR, 2015). No wonder, that the policies applied to protect public health differ across the world. However, the problem is wicked. First, "possibly carcinogenic" sounds dramatic but it is only a weak indication. In the evaluation scheme of the IARC "possibly carcinogenic" is the weakest category that still points towards a carcinogenic effect (IARC Monographs, 2015) asking for extra protection and precautionary measures. Paradoxically, such measures, e.g., the prohibition of siting cell phone base stations in the vicinity of kindergartens and schools, may amplify public concerns (Wiedemann et al., 2013, Barnett et al., 2007) and lead to less acceptance of wireless technologies in the society.

However, because wireless technologies are an indispensable part of the ongoing digital revolution that will shape the success of national economies, politics is interested in the broad public acceptance of wireless technologies.

This raises the question about the way of reaching both the goal of public health protection and improved acceptance of wireless technologies. One answer refers to the minimization of exposure, as taken by LEXNET.

Nevertheless, even a technical approach to the acceptance of wireless technologies is based on some assumptions about how people perceive and evaluate EMF issues. At the core is the question of whether people will appreciate exposure reduction. More precisely, it is a matter of how people's RF EMF risk perceptions are linked to their RF EMF exposure perceptions.

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 (Slovic, 1993). 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 twenty years.

Currently, numerous risk perception 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, and a few provide comparative data on the international level (Eurobarometer, 2010).

These studies provide representative data that depict how citizens perceive the potential risks of base stations, cell phones and other RF EMF emitting devices. They indicate differences between countries, regions, sexes, ages and education levels. This approach, usually labelled design-based, provides valuable data for understanding how risk perceptions are distributed in a population. However, these surveys do not usually inform us how risk perceptions are constructed in lay people's mind. In this respect, several questions are of interest.

Of interest is whether the crucial factors predicting the RF EMF risk perception depend on the frame from which people evaluate exposure situations. Three frames can be used: A cognitive frame, a moral frame, and an affective frame. In a cognitive frame, exposure is assessed regarding its intensity ("How intense is the exposure to the exposed person?"). In a moral frame, the moral rightness of the exposure is judged ("Is being exposed fair?"); and in the affective frame, the feelings elicited by knowing that oneself is exposed play the dominant role ("Is the exposure associated with good or bad feelings?"). It seems reasonable to assume that people select one of these frames when they assess the risk of an exposure scenario. In other words, the cognitive frame may not necessarily be the dominant frame. People could focus on moral or affective aspects of exposure. This view is in line with the concept of intuitive toxicology developed by Slovic et al. (1995). According to this concept, lay people's risk judgments differ from expert ones because of their different conceptual structure. One example is the insensitivity of lay people to dose-effect relation, which is one of the basic principles in toxicology (see Kraus et al., 1992). Furthermore, the Moral Foundation Theory (Haidt & Joseph 2004) gives some hints about how RF EMF exposure could be viewed in an alternative frame. Moral issues, especially fairness, may play a crucial role. Furthermore, the knowledge that one is exposed to RF EMF may trigger negative feelings, which could amplify risk perceptions (Finucane et al., 2000). In this context Siegrist et al. (2006) suggests that affect is an important factor in risk perception.

A further question is, how lay people link exposure and risk. Do people perceive a higher risk if they perceive higher exposure? A second question concerns the exposure perception itself: Which proxies do lay people use for assessing the exposure? Answers to these questions would provide valuable insights into the cognitive structure of people's RF EMF risk perception.

With respect to RF EMF no study is available that researches the exposure perception of lay people. However, anecdotal knowledge indicates the influence of distance of the EMF source to target on EMF risk perception. For instance, the German RF EMF measurement campaigns in 2003-2006 (IZMF) 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.

On the one hand, the hypothesis is reasonably plausible that exposure and risk perception are correlated: The lower the perceived exposure the lower is the perceived risk. However, on the other hand, it could be that people are insensitive to the exposure dependency of the risk magnitude (Sunstein, 2002). Under these conditions, EMF risk perception focuses solely on the hazard. In other words, if RF EMF is a hazard then it remains a hazard at any distance. Therefore, even a low RF EMF exposure might create a substantial risk perception. This issue is very important for regulatory policy and actions. A precautionary approach by means of RF EMF exposure reduction will only be successful if people believe that exposure strength is influencing the risk. Otherwise, there will be no effect on risk perception or on public acceptance of EMF base stations.

The link between subjective knowledge and risk perception is another topic in the RF EMF social science research. There are some findings from our research group with respect to various RF EMF exposure sources (Freudenstein et al., 2014). They raise doubts as to whether the knowledge of exposure characteristics plays a crucial role in EMF risk perception. MacGregor's et al. (1999) study revealed that higher knowledge is associated with amplified risk perception. In line with that, Freudenstein et al. (2015 1) asked how knowledge of the impact of exposure characteristics – such as number of sources, frequency of exposure, duration of exposure – on potential health risks are reliable predictors of people's RF EMF risk perceptions. Interestingly the distance to the exposure source was not a significant predictor. Furthermore, better knowledge about the impact of exposure characteristics on potential health risks is related to higher RF EMF risk perception.

However, there are some difficulties in relating exposure characteristics to potential health risk. RF EMF measurements indicate that the distance to a base station is not always a reliable indicator for exposure strength (Bornkessel & Wuschek, 2006). Other aspects, such as the effect of duration of exposure on potential health risks, are disputed in science. There is some evidence from the Interphone study (Interphone, 2010) that heavy users of cell phones have an elevated risk for brain tumors. However, there is no evidence for a dose-effect-relationship with respect to RF EMF (SSK, 2011).

2 OBJECTIVES

Conducting two surveys, the following questions were investigated in detail:

- What do non-experts believe about exposure and risks form various RF EMF exposure situations?
- What is most important for RF EMF risk perception: Exposure perception, affective evaluation or moral evaluation of RF EMF exposure situations?
- What do lay people know about the impact of RF EMF exposure characteristics on potential health risks?
- Do people agree with the basic principles of the exposure index?
- How does exposure reduction affect the acceptance of base stations?

We also organized two workshops, one at the beginning of the project in Berlin and one at the end in Brussels, inviting EMF exposure stakeholders in order to investigate what is the risk perception among the stakeholders and how LEXNET project main concepts are perceived and accepted by them.

3 METHODS: WHAT IS UNIQUE?

The first survey was conducted from April 2013 to September 2013 as an online study. Data were gathered in eight European countries, 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).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 of them consider themselves as middle classed 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% of the respondents) is in paid work (employees, self-employed, working for your family business) and 28.9% are in education. The questionnaire consisted of 33 questions.

The second survey was conducted in August 2014 in six European countries as an online study by a professional survey company. A total of 2454 interviewees participated. After quality control 1809 respondents remained for analysis. (German sample n= 274, French sample n= 243, Spanish sample n= 241, Portuguese sample n= 290, Romanian sample n= 276, Serbian sample n= 291, and UK sample n= 194). The survey consists of 28 main questions. Findings of the second survey were consolidated by in-depths interviews organized in Austria and Germany.

Both surveys started with a short introduction describing the topic and the background of the study. Some demographic, political, and economic background related items came from the survey platform called "European Social Survey" (2012). All questions were translated into the languages of the participating countries and double-checked with re-translation back into English. An introduction to the survey informed the participants about the main research aims and what participation in the survey involves, including how anonymity of the survey is ensured. Some questions were introduced with additional information, e.g. a technical background. In addition, we provided some background information about the LEXNET project.

4 LIMITATIONS AND STRENGTHS OF OUR APPROACH

Some limitations of the present study should be clarified. First, both samples are not representative for the general public in the different countries, but they describe 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.
Second, we conducted online surveys that exclude – per definition - all subjects without Internet access. This approach could result in a selection bias towards more technology-accepting people. Moreover, we used a purposive sampling strategy. Therefore, it cannot be the aim of the present studies 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 risk perception, 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.

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 calculations.

5 RESULTS: WHAT IS NEW?

5.1 What non-experts believe about risks from various RF EMF exposure situations

First we were interested in lay people's risk perception of various RF EMF devices and systems. In Survey 1, we asked our respondents about their risk perception regarding various exposure situations (see Figure 1). We analyzed the perception of health risks of exposure sources, such as mobile communication mast on school roofs, being exposed by another person's mobile phone use, being exposed by WLAN router in 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.

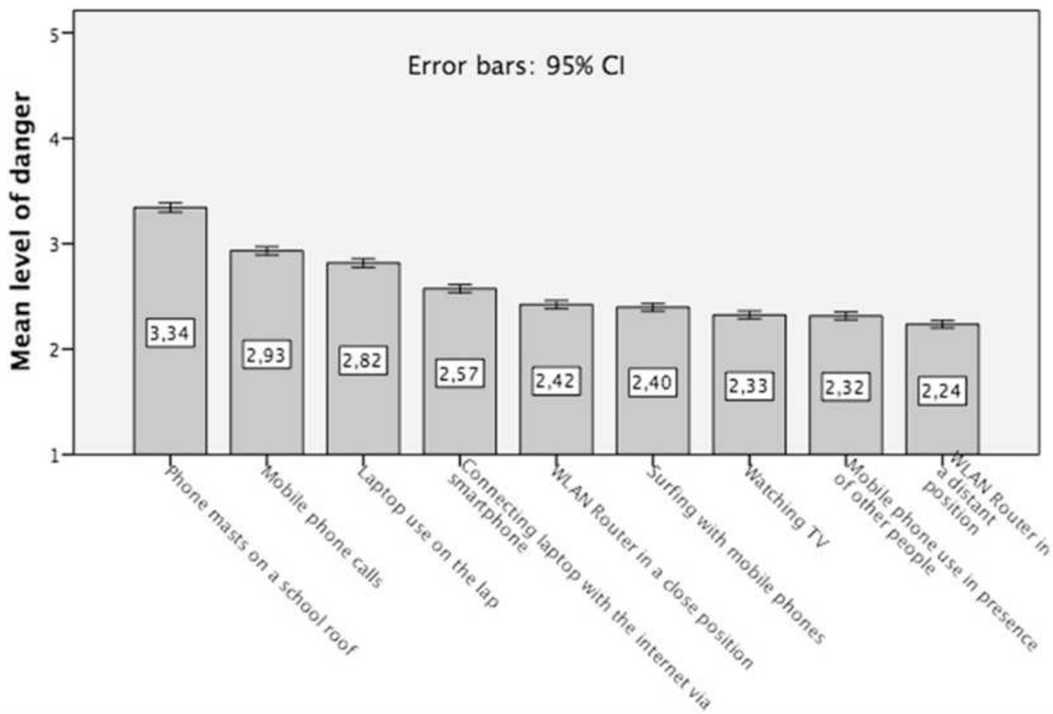

Figure 1: Mean risk perception of various EMF sources, measured on a 5-point Likert scale: 1=not dangerous, 2=not really dangerous, 3=either nor, 4=rather dangerous, 5=very dangerous (Question: "How dangerous are the following situations to health?").

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 risk perception score for base station is 3.34. 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 risk perception is 2.82. The perceived health risks from all other sources are lower.

5.2 Frames of RF EMF risk perception

The question is, do people – when they assess the riskiness of an exposure situation – take exposure levels into account or are their risk perceptions rather influenced by moral or affective evaluation of RF EMF exposure situation? This question was researched in survey 2.

Table 1: Means and variance of affective and moral evaluation, subjective exposure perception and risk perception of various exposure situations, on 5-point Likert scale from 1= "Very positive", to 5= "Very negative" for affective evaluation; from 1= "Not at all", to 5= "Yes absolutely" for moral evaluation; from 1= "Low", to 5= "High" for exposure evaluation; and from 1= "Not dangerous", to 5= very dangerous" for risk perception.

Evaluation of various sources of EMF exposure	N	Mean	Variance
Mobile phone (MP) calls:			
Affective evaluation	1536	3.03	.862
Moral evaluation	1648	2.81	1.648
Subjective exposure perception	1643	3.34	1.472
Risk perception	1654	3.01	1.268
WLAN close position			
Affective evaluation	1546	2.90	.836
Moral evaluation	1630	2.67	1.411
Subjective exposure perception	1639	2.90	1.359
Risk perception	1627	2.76	1.296
MP use by others			
Affective evaluation	1547	3.05	.893
Moral evaluation	1659	2.59	1.383
Subjective exposure perception	1632	2.55	1.350
Risk perception	1640	2.44	1.231
Laptop use on the lap			
Affective evaluation	1572	2.91	1.025
Moral evaluation	1655	2.69	1.535
Subjective exposure perception	1637	2.91	1.482
Risk perception	1642	2.81	1.448
Base stations			
Affective evaluation	1629	3.59	1.423
Moral evaluation	1672	3.64	1.593
Subjective exposure perception	1657	3.86	1.389
Risk perception	1667	3.76	1.393

Five exposure situations were investigated: Using a mobile phone (MP) for calls, exposure through the use of cell phones by others, laptop use, using WLAN router in a close position, and exposure from a base station, see Table 1. As demonstrated by Table 1 the base station is perceived as the most dangerous source out of the five (mean=3.67 on the risk perception scale). It is also the source with the highest exposure perception (mean=3.86), elicits the highest moral concerns (mean=3.64) and has the highest negative affective scoring (mean=3.59).

To analyze whether peoples' risk perceptions of various sources of EMF exposure are based on affective and moral frames or on a cognitive (taking exposure into account) frame, linear regressions were computed for all five exposure situations using risk perception as the dependent variable and the affective and moral evaluation as well as the subjective exposure perception as independent variables. Table 3 indicates that the regression model provides a good explanation of the variance across all RF EMF exposure situations (R^2 from .672 for mobile phones to .822 for Laptop use). A look at the Beta values (β) reveals a robust pattern. Exposure frames seem to influence the risk perception to a high amount (mobile phone calls: β=.584, p=.000; WLAN close position: β=.629, p=.000; mobile phone use by others: β=.718, p=.000; Laptop use on the lap: β=.670, p=.000 and base station: β=.711, p=.000).

Table 2: Linear regression of affective, moral and exposure evaluation on concerns about various sources of EMF exposure (risk perception), Beta values (β) are indicated. β represents the relative importance of the independent variable (affective and moral evaluation and subjective exposure perception) in predicting the dependent variable (EMF risk perception), the maximum β is 1, *statistically significant (level 0.05); significance levels: $p \le 0.05$ = sign., $p \le 0.01$ = high sign., $p \le 0.001$ = highly sign. R^2 describes the explained variance.

Dependent variable risk perception of:	β-values for situation evaluation: Affective	Moral	Exposure	R^2
Mobile phone (MP) calls	.092*	.302*	.584*	.672
WLAN close position	.051*	.292*	.629*	.756
MP use by others	.004	.222*	.718*	.790
Laptop use on the lap	.072*	.269*	.670*	.822
Base station	.061*	.208*	.711*	.811

Furthermore, as indicated by the Beta values in the regressions, the influence of the affective frame on RF EMF risk perceptions is more or less negligible while the moral frame plays a role, (β-value: β=.302, (p=.000) for mobile phones; β=.292, (p=.000) for WLAN close position; β=.222, (p=.000) for the use of a mobile phone by others; β=.269 (p=.000) for Laptop use on the lap; and β= .208, (p=.000) for base stations. These findings point towards a consistent relationship. The RF EMF risk perceptions are mainly dependent on a cognitive frame, i.e. on exposure strength perception. Higher is the perceived RF EMF exposure, higher is the perceived risk. The same is true for moral concerns. The more moral concerns involved, the higher the risk perception. However, the most important predictor of RF EMF risk perception is the perceived exposure strength.

The Impact of the three exposure perception frames on RF EMF risk perception is also illustrated in Figure 2:

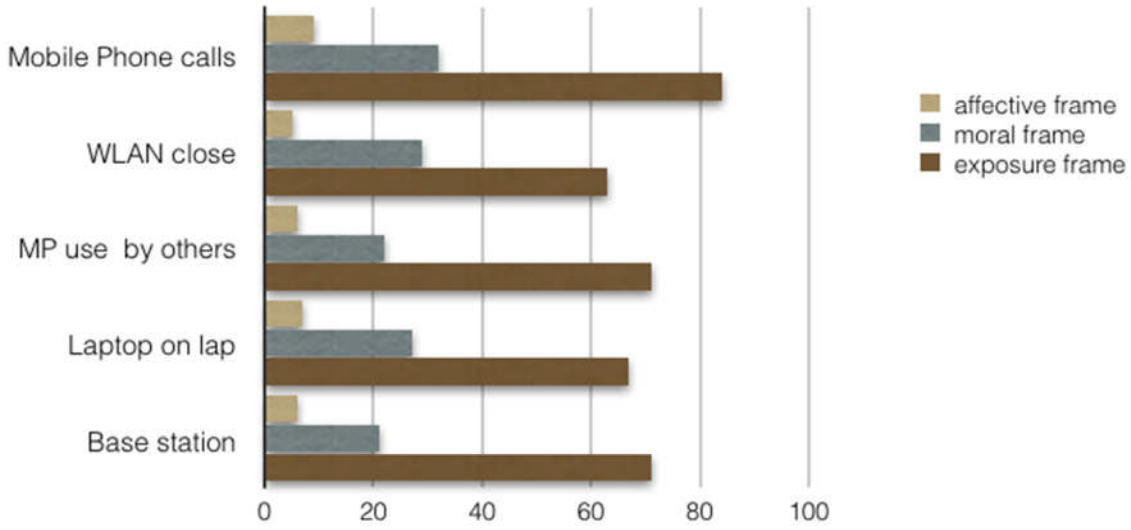

Figure 2: Impact of the three frames on RF EMF risk perception with respect to five exposure situations based on the transformed Beta values from Table 2.

Figure 2 demonstrates that the exposure perception counts lead to a new question. The question is, which aspects of the exposure situations determines risk perception?

5.3 Subjective exposure impact knowledge and risk perception

An important factor for an adequate assessment of possible adverse effects in exposure situations is the respondents' subjective knowledge about the impact of exposure features on potential health risks. As indicated in Figure 3, the exposure characteristics (1) duration of exposure (mean=4.47), (2) the strength of exposure (mean=4.47), (3) the distance (mean=4.37), (4) the frequency of exposure (how often you are exposed) (mean= 4.28), and (5) the number of exposure sources (mean = 4.05) are seen as crucial for health risks. The physical size of the exposure source and the time of the day of exposure, were ranked lower by the respondents (mean=2.65 and mean=1.93, respectively). The intervals plotted above the bars in Figure 3 represent the 95% confidence interval, *i.e.*, the interval of values with 95% of probability of containing the population mean.

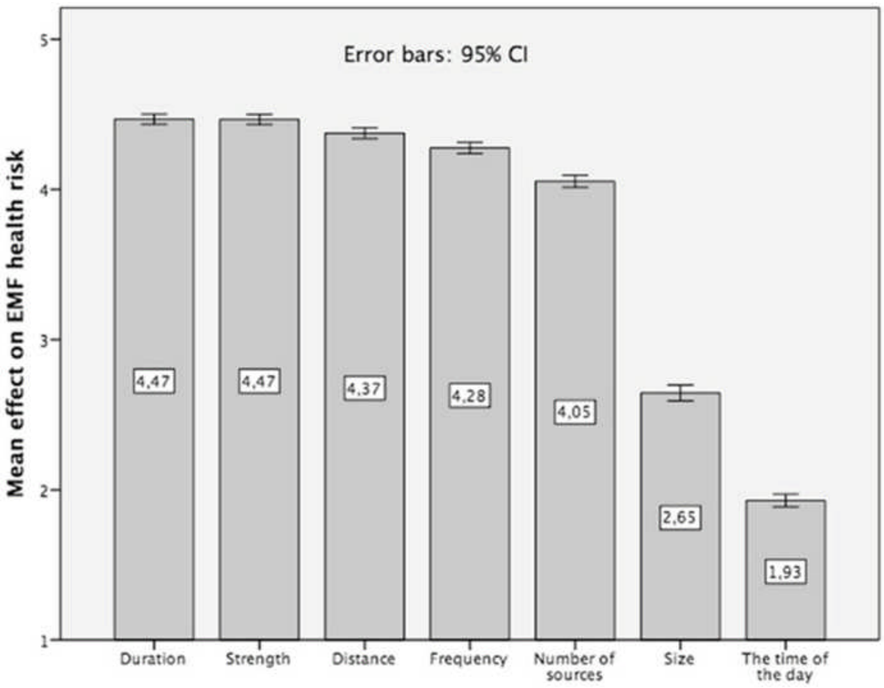

Figure 3. Subjective knowledge about the impact of EMF exposure characteristics on the EMF health risk, 5-point Likert scale 1 = disagree totally to 5 = agree totally (question: “What do the potential health risks of electro-magnetic fields from exposure sources like mobile phones, mobile communication masts, or other devices depend on?”).

On first glance, the results presented in Figure 3 indicate a quite appropriate lay people’s understanding of how exposure factors may impact potential EMF health risks.

Of special interest is how RF EMF risk perception of various exposure sources is actually affected by the respondents’ views regarding the impact of exposure features on potential health risks. Therefore, several regression analyses for different exposure situations were calculated, to investigate the impact of exposure characteristics on EMF risk perception of base stations (i.e. dependent variable is risk perception of base stations, independent variables are the various exposure characteristics), see Table 3.

Table 3. Linear regression exposure characteristics: Dependent variable is risk perception of base stations. *= significant (level .05). R^2=0.105, β *represents the relative importance of the predictor variable (various exposure scenarios) in predicting the dependent variable (resulting health concerns); maximum* β *is 1. p represents the significance level; p ≤ 0.05 = sign., p ≤ 0.01 = high sign., p ≤ 0.001 = highly sign.* R^2 *quantifies the explained variance.*

Regression exposure characteristics, base station	β-value	p
Duration	0.051	0.091
Distance	0.014	0.593
Frequency	**0.120**	**0.000***
Strength	-0.023	0.406
Number of sources	**0.101**	**0.000***
Time of day	**0.061**	**0.002***
Size	**0.177**	**0.000***

The results for base stations demonstrate that the respondents´ risk perception regarding base stations is only slightly affected by factors that are relevant in practical exposure mechanism. Overall, the amount of the explained variance by the regression model is about

10%.

Most striking is that the belief about the strength of the exposure as a factor influencing potential health risks from EMF exposure is not a significant predictor for risk perception (β= -0.023 and p= 0.406). Frequency seems to play a significant role (β=0.120, p=0.000) in influencing risk perception of the respondents. This seems not to be an acceptable view because base stations do not operate in an on- or off-mode like cell phones. The number of sources is also a significant factor (β=0.101, p=0.000).
Furthermore, the size of the base station seems to play an important role. The time of the day during the RF EMF exposure is also a relevant predictor for lay people.

A different picture is seen for the regression analyses of cell phones and other devices and varies across the samples of the different participating countries. These results are available in Freudenstein et al. (2014) and Freudenstein et al. (2015 2).

5.4 Exposure reduction and acceptance

Regarding the acceptance of RF EMF technologies we focused on the question whether reduction of RF EMF exposure could influence the acceptance of base station in one's own neighborhood. Specifically, we asked the respondents for the minimal distance (in meters) to which they would accept a base station close to their home for four different exposure conditions: (1) current exposure level without any reduction, (2) exposure level is reduced by 30%, (3) exposure level is reduced by 50% and (4) exposure level is reduced by 70%.
For the analysis we excluded subjects answering a distance higher than 10 000 meters, i.e. people who are in fundamental opposition to base stations (n=70).

The comparison between the four exposure situations indicates a clear picture: The higher the exposure reduction the lower is the distance in which a base station in the vicinity of one's home is accepted. While the mean distance for the baseline exposure situation (0=% reduction) is at 1889 meters, the distance decreases to 1532 meters for 30% exposure reduction, to 1278 meters for 50% exposure reduction, and finally to 1052 meters for the highest exposure reduction of 70% (see Figure 4).

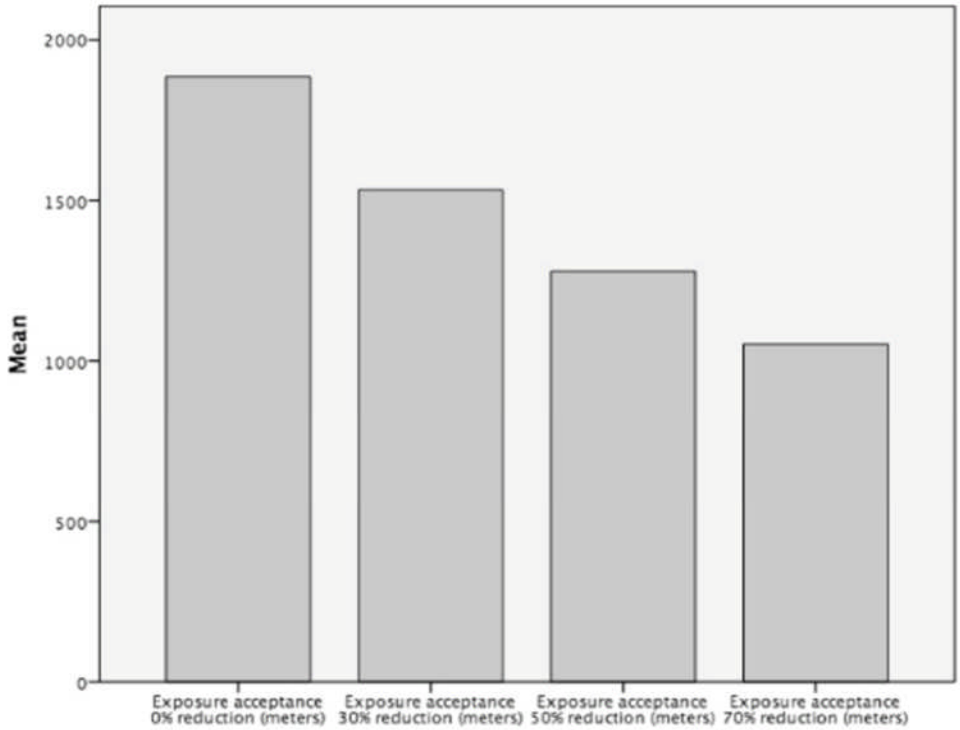

Figure 4: Mean of distance in meters in which a base station close to one's home is accepted for 0%, 30%, 50% and 70% exposure reduction. For respondents with distance < 10 000 meters (n= 1627). Question: "Roughly at what distance (meters) would you accept a base station close to your home?", "...if the exposure was reduced by 30%?", "...if the exposure was reduced by 50%?", "…if the exposure was reduced by 70%?".

It seems reasonable to assume that RF EMF risk perception will influence the required distances across to the four exposure reduction scenarios. In order to test this hypothesis five risk perception groups are distinguished based on the scores for the perceived risk of base stations. The scores refer to one of above-mentioned pictured-guided scenarios that focused on the exposure by having a mobile communication mast (base stations) on a roof close to one's home.

The different colored lines presented in Figure 5 display the required distances from the base station for the risk perception groups for the various degrees of exposure reduction (blue = 0% exposure reduction, green = 30% exposure reduction, yellow = 50% exposure reduction, violet = 70% exposure reduction).

A general linear model with repeated measures was calculated using the different risk perceptions of base stations as "between subject factor" and the four exposure reduction scenarios as "within subject factor". The required distance to one's own home was used as the dependent variable. The results show a significant main effect for the repeated factor exposure scenario ($F=148.884$, $p=.000$ using Greenhouse-Geisser, empirical effect: $\eta^2=.089$), as well as for the between subject effect for risk perception: $F=20.054$, $p=.000$, $\eta^2=.050$. The interaction between the main effect and the non-repeated factor risk perception shows also a significant result: $F = 12.160$ and $p=.000$, using Greenhouse-Geisser, $\eta^2=.031$. This means that the factors "exposure reduction" and "risk perception" have a statistically significant influence on the accepted distance from the base station, and that the impact of the exposure reduction on this distance depends on the level of risk perception. Higher is the risk perception, higher is the impact of exposure reduction.

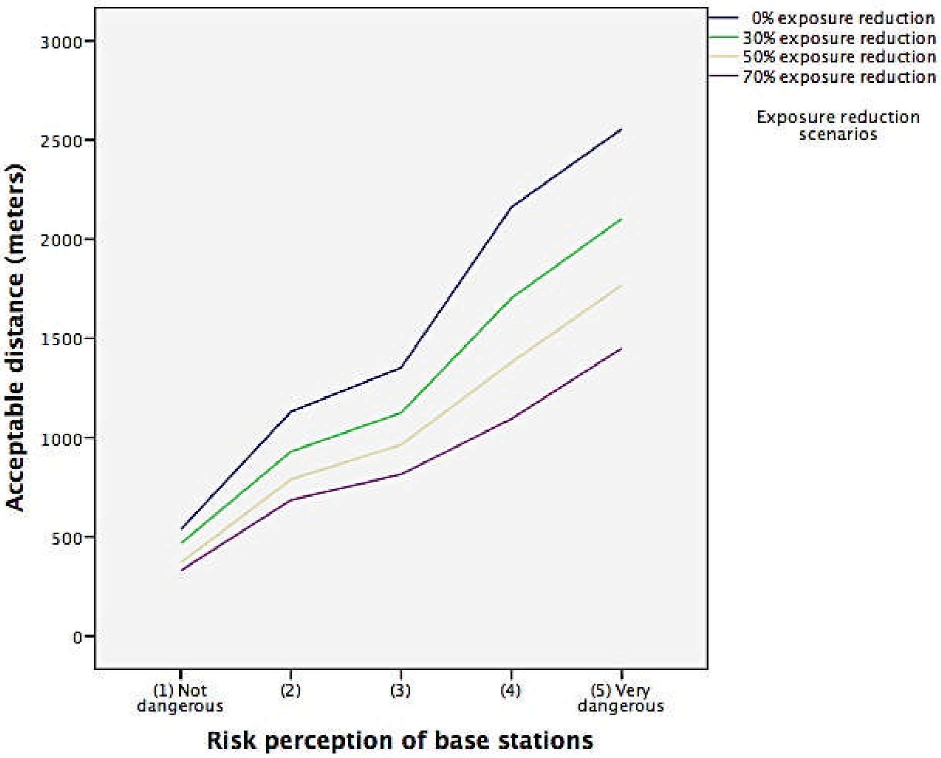

Figure 5: Effects of RF EMF exposure reduction on the acceptance of base stations in dependency of risk perception groups – Acceptance measured by the question: "Roughly at what distance (meters) would you accept a base station close to your home?", "...if the exposure was reduced by 30%?", "...if the exposure was reduced by 50%?", "…if the exposure was reduced by 70%?"). Risk perception measured by "How dangerous do you consider living close to the building with the antennas", on 5-point Likert scale from "1 = Not dangerous" to "5 = very dangerous". Meaning of lines: blue = 0% exposure reduction, green = 30% exposure reduction, yellow = 50% exposure reduction, violet = 70% exposure reduction.

In addition we conducted Bonferroni adjusted post-hoc tests for above reported linear model analyses between the independent variable risk perception and acceptance in meters (dependent variable) for every scenario to examine the differences between the risk perception groups. The results indicate constant significant differences in the between group comparison among respondents with lower (1), (2) and higher risk perception (4), (5) (range from p=.000 to p=.010; except group (2) and (4) for the 70% reduction scenario). This is also true for the differences between the risk perception scale midpoint of (3) and the groups of (4), (5) (from p=.000 to p=.038).

5.5 Acceptance of the Exposure Index

The exposure index (EI) is a new exposure metric proposed by LEXNET. The EI is aggregating the downlink exposure induced by the base stations; the uplink exposure induced by the devices in communication; the different usage patterns; the category of users (children or adults); the user posture and device position with respect to the body of user; the different environments, such as indoor or outdoor; the different RATs (Radio Access Technology) and layers in the network; and the different periods of the day as described by Varsier et al. (2015).

One important question was, whether the EI is understandable and acceptable for all the stakeholders from the general public to regulatory bodies? In the following, we present our findings regarding the public acceptance of the EI (see Figure 6):

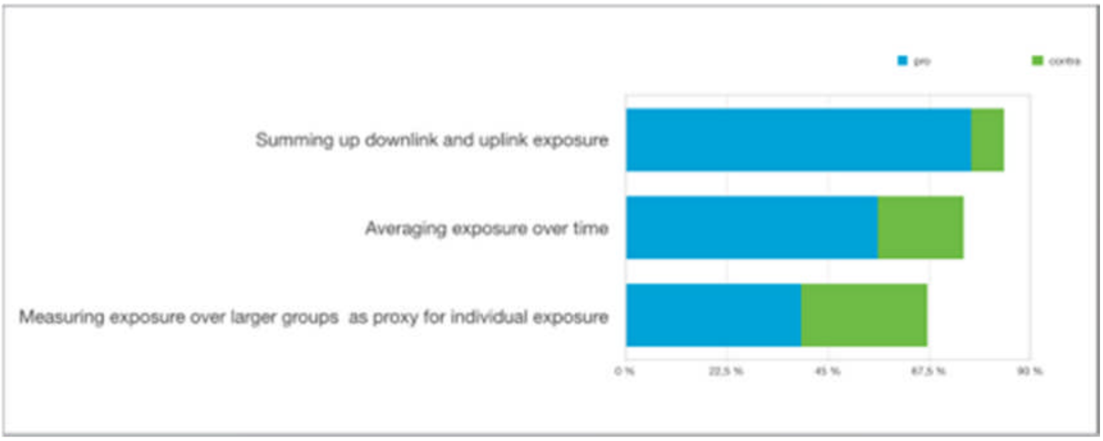

Figure 6: Acceptance of the Exposure index

We first asked our respondents if they "think [that] the exposure from personal wireless devices and the exposure from base stations should be added up when evaluating [their] exposure to EMF". The results indicated that about two thirds of the respondents agree that it is useful to include both up and down-link RF EMF exposure of wireless telecommunication technologies to get information about their personal exposure.

A further important question refers to the issue whether people agree with the statement "… it makes sense to characterize [their] day-to-day exposure to EMF by averaging it over time". Over 50% of the respondents agree with the statement that it makes sense to characterize your day-to-day exposure to EMF by averaging it over time as indicated in Figure 4.

Another core concept of LEXNET is to average the exposure over space and persons, which was tested in the following question: "Do you think that an individual exposure to EMF can be approximated by measuring the exposure over a large population?" To guarantee better understanding we gave an example: "Let's say you live in Paris 14th district [exchanged with districts of capitals in all countries]. The average exposure over the entire population in Paris 14th district is then used as an indicator for your individual exposure to EMF." Over one third of the subjects (39%) agreed with this approach.

6 Stakeholders' EMF and Risk perception – Lessons from Berlin and Brussels workshops

Besides technical issues, exposure perception, exposure reduction and the understandability of the Exposure Index were also discussed with stakeholders' at the beginning of the project and at the end during the two workshops organized in Berlin, in September 2013 and in Brussels in October 2015. Abstracts and minutes of these workshops are part of deliverables D7.2 and D7.4.

During Berlin workshop, it has been suggested that different uses of the Exposure Index should be discussed; at the end of the project we have now a clear vision as a value for network design but also for public information on real exposure. The challenge to describe the parameters causing people's exposure levels to RF EMF was mastered successfully.
Furthermore it was pointed out that the Index must be understood correctly. As shown before, the core concepts of LEXNET Exposure Index are accepted by the public and comprehensible for lay people. Of course therefore a clear communication strategy is needed.

During LEXNET final workshop in Brussels, the LEXNET project received positive feedback from stakeholders about the newly developed global exposure metric although its usability was discussed and the need for simplification was stressed out.
Many stakeholders expressed in particular their interest in the EI as a way to communicate about the population day to day exposure to EMFs.

Finally it has to be pointed out that risk perception is complex and risk communication is a very important task. Outputs from our studies are of great importance for exposure communication and risk communication.

7 Insights for RF EMF risk communication

In general, good risk communication has to:

- provide the correct risk information
- reach the target audience
- support the audience in making more accurate risk evaluations

However, there are at least three different approaches to RF EMF risk communication as depicted by Figure 7. Risk communication can focus on (1) the RF EMF risk assessment, (2) the limit values for RF EMF exposure and (3) the level of RF EMF exposure.

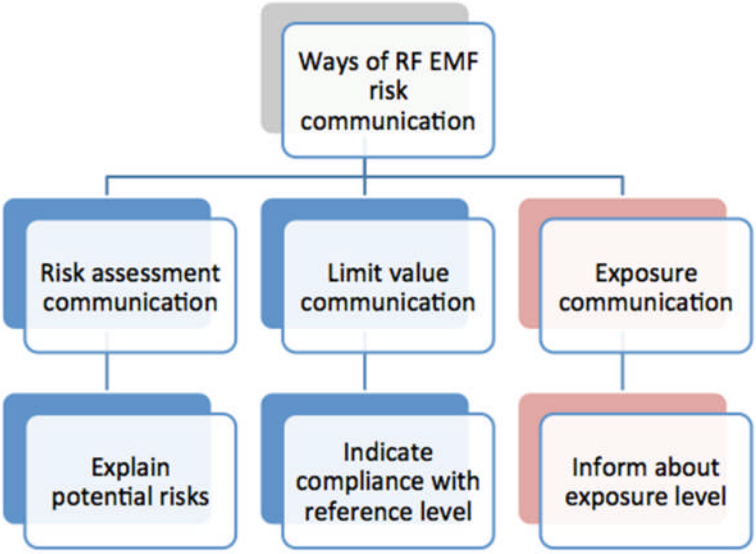

Figure 7: Three approaches to RF EMF risk communication

In the first case, risk communication aims to explain the potential health risk of RF EMF. As mentioned before, in May 2011 the International Agency for Research on Cancer (IARC) released their official report, concluding that the usage of cell phones is "possibly carcinogenic to humans". Risk communication should provide information into how the classification of RF EMF as possibly carcinogenic should be understood (see Wiedemann et al., 2014). From a communications standpoint, it is necessary to inform concisely and transparently about the pro and con arguments that have led to the evaluation of RF EMF as possibly carcinogenic to humans. In addition, a further major issue for RF EMF risk communication is the challenge in informing people about the trustworthiness of the risk assessment. It is obvious that risk assessment communication is not an easy task. A big challenge stems from the fact that risk assessment information is usually complex and based on concepts that are difficult to understand for non-experts. Therefore, explaining the findings of risk assessments needs careful preparation and even then remains a difficult task.

The second approach focuses on value limits, i.e., on the compliance with the often legally-prescribed exposure limits. The aim for this type of risk communication is to indicate that the RF EMF level – to which people are exposed to – complies with the reference levels. In other words, the core message of this risk communication approach is to reassure people that their exposure to RF EMF does not pose a health risk to them. The key to this type of risk communication is confidence. Without confidence that the value limits provide an appropriate protection against detrimental health effects, this communication strategy fails.

The third approach refers to RF EMF exposure and informs non-experts about the level of exposure, and, if possible, about the amount of exposure reduction. Here, people are informed about exposure levels and how they can be reduced or are already being reduced by technological means. This kind of approach can be achieved using LEXNET outputs. The main task is to provide reliable information about how and to what level the everyday RF EMF exposure to the general public has been reduced.

In our view, exposure communication seems to be a promising way to help the general public make informed decisions about the safety and acceptability of wireless technologies. Therefore, exposure communication as a third approach of RF EMF risk communication will be described in more detail.

Exposure communication: What does it mean?

- Help people to recognize what is a source of RF EMF exposure.
- Help people to understand how the RF EMF exposure characteristics of a RF EMF source interact which each other to determine the amount of exposure
- Help people to compare the exposure from various RF EMF exposure sources.
- Inform people about exposure reduction if possible

Box 1: Maxims of RF EMF exposure communication.

First of all, exposure communication should inform about the various sources of RF EMF in everyday life situations for the general public: What is and what is not a source of RF EMF exposure? This is important because we know from the EU Eurobarometer Study on EMF (Eurobarometer, 2010) that laypeople have difficulties in deciding whether a certain device – such a TV set, a base station, a microwave oven or a broadcasting antenna in their environment – is actually a RF EMF exposure source. This issue becomes even more exaggerated when people are asked to differentiate between RF EMF and ELF EMF exposure sources. Therefore, the first task of exposure communication is to disseminate information about the various sources of RF EMF exposure that then enables the general public to make correct judgments about what is and what is not a RF EMF source.

Second, RF EMF exposure communication should support the general public in assessing how the relevant exposure characteristics – such as distance from the EMF source, frequency and duration of exposure as well as the strength of exposure source – contribute to the total RF EMF exposure. Close attention is particularly important for the characteristics distance and duration. It should be communicated that the strength of RF fields is greatest at their source, and that the strength of the fields reduces quickly with distance. Duration is another challenging topic. A common argument of opponents is that base stations are dangerous because people are continuously exposed to RF EMF from them. However, the evidence for the assumption that the duration of RF EMF exposure is a critical factor for potential health risk is inconclusive and controversial at the very least (see Interphone Study 2010). Countering this resistance against the common sense belief of the role of exposure duration should be a focus of communications. A further goal for exposure communication is to improve the basic understanding of how critical exposure characteristics interact with each other.

Third, people should be made aware of the importance to consider the exposure as a sum of contributions of various RF EMF exposure sources. The EI could be a very helpful way to communicate about the importance to consider both uplink and downlink exposures.

Fourth and most importantly, exposure reductions should be communicated to the lay person. This is in line with LEXNET´s main target, i.e. to reduce RF EMF exposure without compromising the quality of service, the effects of the technical efforts to reduce RF EMF exposure should be highlighted. However, there are still some open questions. One of these refers to the format: It is currently not clear which indicator is most appropriate. For instance, whether the often-used indicator "percentage of exhaustion of the reference level" is better than a simple indicator which just expresses the percentage of exposure reduction with respect to the previous exposure before reduction should be tested. Further research is needed regarding this.

Finally, it is important to underline that the goal of risk communication is to improve fact-oriented beliefs about risks and to find solutions to risk controversies. However, it would be a mistake to believe that these goals can be reached simply by supplying objective risk information. The success of risk communication depends also on openness, empathy, and fairness.

8 Conclusion

Our research provides new insights in the field of lay people's risk and exposure perception as well as the acceptance and understandability of the Exposure Index by all, from the public to the regulator or the mobile network operator.

Regarding risk perception of base stations, we could show, that they are evaluated as the most dangerous exposure source, i.e. more dangerous than mobile phones. Even if the typical exposure levels from base stations are generally several orders of magnitude lower than from cell phones (Neubauer et al., 2007, Lauer et al., 2013 and Tesanovic et al., 2013). For risk communication it has to be taken into account that subjective and objective evaluations of RF EMF exposure are different.

The determinants of intuitive EMF risk perception were analyzed by linear regressions across the four exposure situations. A consistent picture emerged: EMF risk perception is mainly affected by exposure perception and also to a certain degree by moral concerns. The affective evaluation of the exposure situations plays only a minor role. Both the high proportion of explained variances and high influence of exposure perception in our regressions models clearly support this interpretation. In terms of risk communication, these findings provide a positive message. They suggest that, in principle, people should be sensitive to exposure reductions, simply because the level of exposure is an important factor when they evaluate EMF risks.

Furthermore, we investigated the subjective exposure impact knowledge of our respondents. The results for base stations demonstrate that the respondents´ risk perception regarding base stations is only slightly affected by factors that are relevant.
While the strength of the exposure is not a factor influencing potential health risks from EMF exposure frequency, the number of sources, the size and the time of the day during the RF EMF exposure seems to play a significant role influencing risk perception of the respondents.

This is in contrast to the responses when you ask people directly on what the potential health risks of electro-magnetic fields depend on. Here duration, strength and distance are also highly ranked while the non-relevant factors size and time of the day do not play an important role.

Concerning exposure reduction and acceptance of base stations we could find that the higher the reduction, the shorter gets the required distance. This effect is the highest for people with elevated risk perceptions. However, even a 70% exposure reduction reduces the required distance in the average only to about 1000 meters, which is unrealistic for a populated city. But it seems that people are sensitive to exposure reduction, so if possible, exposure reduction should be implemented in risk communication strategies.

Finally the understandability and acceptability of LEXNET´s core concepts seems to be promising. The majority of our respondents accepted these approaches, this is especially important for the questions aiming on the acceptance of exposure reduction and measurement of RF EMF at the average and not the maximum peak exposure.
The EI was well accepted also among stakeholders and they started to perceive how such a metric could be of great use for communicating the real exposure of the population to RF-EMF.

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APPENDIX 1: INTERNAL REVIEW

	Reviewer 1: S. Bories			Reviewer 2: N. Favre		
	Answer	**Comments**	**Type***	**Answer**	**Comments**	**Type***
1. Is the deliverable in accordance with						
(i) the Description of Work?	☒ Yes ☐ No		☐ M ☐ m ☐ a	☒ Yes ☐ No		☐ M ☐ m ☐ a
(ii) the international State of the Art?	☒ Yes ☐ No		☐ M ☐ m ☐ a	☒Yes ☐ No		☐ M ☐ m ☐ a
2. Is the quality of the deliverable in a status						
(i) that allows to send it to EC?	☐ Yes ☒ No		☐ M ☐ m ☐ a	☐ Yes ☒ No		☐ M ☐ m ☐ a
(ii) that needs improvement of the writing by the editor of the deliverable?	☒ Yes ☐ No	2 minors comments to be fixed: -explain briefly the metrics used in the linear regressions -About the EMF strength, you should clarify the shade between 'impact of EMF exposure characteristics on the EMF health risk' Fig.3 and be significant predictor for risk perception (p.13) see the comments p.14	☐ M ☒m ☐ a	☒Yes ☐ No	Comments sent in Track change	☒ M ☐ m ☐ a
(iii) that needs further work by the partners responsible for the deliverable?	☐ Yes ☐ No		☐ M ☐ m ☐ a	☐ Yes ☐ No		☐ M ☐ m ☐ a

* Type of comments: M = Major comment; m = minor comment; a = advice