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Are media reports able to cause somatic symptoms attributed to WiFi radiation? An experimental test of the negative expectation hypothesis

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ABSTRACT

People suffering from idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF) experience numerous non-specific symptoms that they attribute to EMF. The cause of this condition remains vague and evidence shows that psychological rather than bioelectromagnetic mechanisms are at work. We hypothesized a role of media reports in the etiology of IEI-EMF and investigated how somatosensory perception is affected. 65 healthy participants were instructed that EMF exposure can lead to enhanced somatosensory perception. Participants were randomly assigned to watch either a television report on adverse health effects of EMF or a neutral report. During the following experiment, participants rated stimulus intensities of tactile (electric) stimuli while being exposed to a sham WiFi signal in 50% of the trials. Sham WiFi exposure led to increased intensity ratings of tactile stimuli in the WiFi film group, especially in participants with higher levels of somatosensory amplification. Participants of the WiFi group reported more anxiety concerning WiFi exposure than the Control group and tended to perceive themselves as being more sensitive to EMF after the experiment compared to before. Sensational media reports can facilitate enhanced perception of tactile stimuli in healthy participants. People tending to perceive bodily symptoms as intense, disturbing, and noxious seem most vulnerable. Receiving sensational media reports might sensitize people to develop a nocebo effect and thereby contribute to the development of IEI-EMF. By promoting catastrophizing thoughts and increasing symptom-focused attention, perception might more readily be enhanced and misattributed to EMF.

1. Introduction

Symptom reporting is common in western countries (Hiller et al., 2006) and often attributed to aspects of modern life (e.g. non-audible infrasound noise emitted by wind farms, genetically modified food) (Petrie et al., 2001). In this context, the increase in the use of WiFi or wireless communication has raised concerns about the health effects of weak electromagnetic fields (EMF) which are now commonplace. A considerable amount of people in Western populations (between 1.5% and 10.3%) explicitly report adverse health effects attributed to the exposure of weak EMF (Blettner et al., 2009; Hillert et al., 2002; Levallois et al., 2002; Schreier et al., 2006; Schröttner and Leitgeb, 2008) and this condition has been termed idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF). Persons suffering from IEI-EMF experience non-specific symptoms they attribute to EMF (Röösli et al., 2004). As a consequence, they try to avoid contact with EMF sources, use shielding devices and restrict their range of motion, thus isolating themselves from their physical and social environment. Evidence, however, does not support a bioelectromagnetic mechanism as cause for this phenomenon (Staudenmayer, 2006), in contrast to proven noxious long-term effects of other epiphenomena related to modern life style (e.g., particulate air pollution; (Pope III et al., 2002)). When tested under double blind conditions, affected persons were not able to detect the presence of EMF exposure nor did they report more symptoms during EMF exposure than during sham exposure (Röösli, 2008; Röösli et al., 2010; Rubin et al., 2010). Likewise, EMF exposure had no effect on physiological measures or cognitive functioning in both healthy persons and persons suffering from IEI-EMF (Eltiti et al., 2007, 2009; Rubin et al., 2011). However, it appears that symptom perception of persons suffering from IEI-EMF is closely connected to believed EMF exposure (Szemerszky et al., 2015). While the majority of studies concerning IEI-EMF compared measures of symptom report during open vs. hidden or real vs. sham exposure to EMF, few studies were concerned with possible mechanisms investigating the underlying etiology of this condition. Different processes are considered to contribute to the development of IEI-EMF, for example

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so-called technostress and conditioning (Rubin et al., 2008), misattribution of medically unexplained symptoms (Dieudonné, 2016), expectation. Furthermore, some specific personality characteristics, like somatization, somatosensory amplification, negative affectivity, and anxiety might play a role (Rubin et al., 2008; Szemerszky et al., 2010; Witthöft and Rubin, 2013).

In addition, mass media, like television reports, newspaper articles, and internet sources might play a role in the etiology of IEI-EMF by inducing negative expectations and/or catastrophizing thoughts in vulnerable persons. Content analyses of newspaper reports in Britain and Norway show that information incongruent to scientific evidence is spread, promoting mostly electromagnetic causes of IEI-EMF and recommending EMF-related strategies for treatment (Eldridge-Thomas and Rubin, 2013; Huiberts et al., 2013). At the same time, it has been shown that watching catastrophizing media reports can increase reported symptoms during sham exposure and increase worries about EMF as well as the probability to attribute perceived symptoms to EMF in healthy participants. These effects were mediated by anxiety, somatosensory amplification, and pre-existing worries about EMF (Witthöft and Rubin, 2013). Similarly, worries about EMF as well as heart rate were increased by watching commercial advertisements of supposedly health protecting products like shielding devices (Köteles et al., 2016). It was hypothesized that information from media reports and/or expectations might increase symptom focused attention, symptom detection, as well as catastrophizing cognitions. This might further lead people to misattribute pre-existing or detected symptoms to EMF, promoting increased perceived electrosensitivity and avoidance behavior.

While evidence shows that symptoms can be induced and perceived electrosensitivity can be increased in healthy participants by manipulation of expectations and after watching a television report (Szemerszky et al., 2010; Witthöft and Rubin, 2013), it remains unknown how symptoms that are already present are affected. However, amplification of random symptoms (e.g. due to changes in physiological arousal) after receiving specific information might be a valid model showing how IEI-EMF could develop in healthy participants. Therefore, the aims of the present study in healthy participants were to test whether watching a television report, which suggested adverse health effects caused by EMF exposure, 1) enhances the somatosensory perception of tactile stimuli applied to the hand, 2) whether illusory perceptions can be induced, and 3) whether these effects are strongest in participants with high levels of anxiety and somatosensory amplification. We further tested 4) whether the television report increases concerns about EMF and the likelihood of the participants to perceive themselves as electrosensitive.

2. Methods

2.1. Study design

In an experimental between-groups design, participants were assigned to the experimental or control group by a computerized random allocation process. Participants in the experimental group (N = 33) watched a report concerning the adverse health effects of electromagnetic radiation (‘WiFi group’). In this film, a health physicist tested the impact of electromagnetic radiation on a patient with Multiple Sclerosis in a pseudoscientific setting and the extent of electromagnetic radiation in an ordinary family's home was measured by an environmental engineer. Participants in the control group (N = 32) watched a report concerning the illegal trade of mobile phones (‘Control group’). In this film, people's reactions were displayed when they were offered stolen mobile phones. Both reports lasted approximately six minutes and had been broadcasted on public German TV. Randomization was performed with Random Allocation Software (available online http://mahmoodsaghaei.tripod.com/Softwares/randalloc.html), using a block size of 20. Testing took place between March and May 2016 at the University of Mainz, Germany.

2.2. Participants

Participants were recruited with a note on the local university campus, via e-mail, Facebook, and a press release in the local newspaper. Exclusion criteria were chronic or acute pain that could complicate a regular execution of the experiment (e.g. pain in the hand), regular intake of painkillers or psychopharmacological medication, use of illegal drugs, chronic diseases as diabetes, high blood pressure, coronary heart disease, tachycardia, cardiac arrhythmia, cardiac arrest, thyroid disease, kidney failure, liver dysfunction, epilepsy, stroke, Parkinson's disease, and Multiple Sclerosis. Exclusion criteria were checked via a questionnaire.

All participants signed an informed consent before starting the experiment. Deception of the participants was necessary due to the purpose of the experiment. After completing the experiment, all participants were fully informed and signed a second informed consent. Participants were compensated monetarily. Ethical approval for the study was granted by the local Ethics Committee.

2.3. Questionnaires

In order to assess state and trait anxiety, we used the trait (Cronbach's at T0: $\alpha = .88$) and 6-item state version ((Marteau and Bekker, 1992); Cronbach's α at T0: $\alpha = .66$, T1: $\alpha = .62$, T2: $\alpha = .72$) of the State Trait Anxiety Inventory (Spielberger et al., 1983). Somatosensory amplification was assessed with the Somatosensory Amplification Scale (SSA; (Barsky et al., 1990); Cronbach's at T0: $\alpha = .81$). Worries about adverse health effects of new technologies were assessed with the Modern Health Worries Scale (MHWS; (Petrie et al., 2001); Cronbach's α at T0 $\alpha = .94$, T1: $\alpha = .93$, T2: $\alpha = .95$), including subscales for toxic interventions (11 items), environmental pollution (6 items), tainted food (5 items), and radiation (3 items). The EMF version of the Sensitive Soma Assessment Scale (SSAS; (Nieto-Hernandez et al., 2008); Cronbach's α at T0: $\alpha = .96$, T2: $\alpha = .96$), including 5 items, was used to assess sensitivity to EMF.

We assessed the perception of the films with a self-generated questionnaire (Cronbach's α at T1: $\alpha = .87$) with the subscales absorption (3 items), interest (1 item), novelty (3 items), perception of danger (2 items), personal relevance (3 items), concreteness (3 items), and reliability (3 items), rated on 5-point scales from “not at all” to “very much”.

2.4. Tactile (Electric) stimuli and apparatus

During the cued exposure experiment (please refer to Section 2.5) tactile stimuli were presented. The tactile modality was chosen because people suffering from IEI-EMF typically experience tingling and paresthesia. On a more general note, evidence shows a relationship between distorted perceptual processing and medically unexplained symptoms and somatoform disorder (Brown et al., 2010; Katzer et al., 2011, 2012). Tactile stimulation therefore lends itself for serving as a model for IEI-EMF in healthy participants. Electric stimuli were applied by a bipolar constant-current stimulator (DS5; Digitimer, Welwyn Garden City, Hertfordshire, United Kingdom) and delivered to the palm of the non-dominant hand, through a pair of Ag/AgCl electrodes. The stimulator was coupled to a data acquisition system (DT9812-10V; Data Translation, Inc., Marlborough, Massachusetts, United States), which was controlled by a laptop computer. Each stimulus consisted of one mono-phasic square wave pulse with a duration of one millisecond, defined in MATLAB (MATLAB and Data Acquisition Toolbox Release 2015b, The MathWorks, Inc., Natick, Massachusetts, United States). The exact intensities of the stimuli applied were determined with the following calibration procedure. Each participants' detection threshold for the electric stimuli was computed three times according to the method of limits (Levitt, 1971). Then the mean of these three thresholds was used as the final threshold. During the remainder of the experiment, two intensities were used. The intensity level of the participants' detection threshold was multiplied with 1.2 for the low tactile stimulus and with 1.8 for the high tactile stimulus. No stimulus was rated as painful (equals 100 on the VAS) by any of the participants.

2.5. Procedure

After screening for exclusion criteria, participants completed the SSA, MHWS, STAI-T, and SSAS at home via Sosci Survey ((Leiner, 2014); T0). Upon arrival in the testing room, participants were asked to shut down their mobile phone "due to interference with electromagnetic radiation" and were told that the purpose of the experiment was to test body and symptom perception during electromagnetic radiation. In the testing room, a "WiFi signal booster router" was placed on the left-hand side of participant's seat, and a big antenna was attached on right side "in order to achieve a homogeneous EMF" around the participant. The experimenter took place behind a movable wall, covered with aluminum foil. This set-up was intended to make the participants believe that "an electromagnetic WiFi field will be created in the room, twice as strong as a regular one". Once seated, the participants read the (first) study information and signed the first informed consent. We instructed the participants that some people experience transient symptoms (like dizziness, headache, etc.) under exposure with EMF and that some evidence exists showing enhancement of somatosensory perception by EMF.

The automatized protocol started with the assessment of the STAI-6 (T0). Then, either the WiFi film or the control film was shown. Directly afterwards, participants completed the MHWS and again the STAI-6 (T1). Then, participants were familiarized with the visual analog scale (VAS), which was labelled with 0 'not noticeable' and 100 'just painful'. Subsequently, an automatized calibration procedure computed the participants' detection threshold for the tactile stimulus (cf. 2.4). When this was set, the experiment started and participants repeatedly had to rate stimulus intensities in six different kinds of trials. In half of the trials participants were told that the router was switched on, indicated by a picture with an antenna surrounded by radiation waves and in the other half of the trials the router was supposedly switched off, indicated by a picture of the antenna without radiation waves (Fig. 1). In each case, three different stimulus intensities of the tactile stimuli were applied to the palm of the participants' non-dominant hand: high tactile (12 trials), low tactile (12 trials) and no stimulation (24 trials). This resulted in a total of 96 trials presented in random order. Every trial lasted 24 s and started with four seconds of anticipation time during which the picture was shown indicating a WiFi ON or OFF trial. Then an interval of four, six or eight seconds of sham exposure or no exposure followed, during which the background of the picture turned green or red. In half of the participants green indicated 'WiFi ON', in the other half of the participants green indicated 'WiFi OFF' in order to control for possible effects induced by the colors. Subsequently, the participants had eight seconds to rate the perceived intensity on the VAS, and finally for four, six or eight seconds (depending on the length of the sham exposure/no exposure interval) a fixation cross was displayed (Fig. 1).

After the experiment, participants filled in the SSAS, MHWS, and STAI-6 (T2) and answered a funnel debriefing procedure (Chartrand et al., 2006) in order to assess whether they believed the cover story. In this context, participants also rated their anxiety concerning the tactile stimuli and the WiFi radiation and their belief in WiFi exposure during the experiment.

At the end, participants were fully informed about the true nature of the experiment. They signed the second informed consent and received a monetary reward. The experimental session lasted approximately 80 min.

2.6. Data analysis

We tested for differences between the WiFi and Control group at baseline using χ^2-test, T-tests, or Mann-Whitney-*U*-tests, where applicable. We used Mann-Whitney-*U*-tests to test the differences between the WiFi and Control film in the film rating. Repeated measures ANOVA's with one within factor 'time' (T0, T1, T2) and one between factor 'group' (WiFi, Control), were used to analyze increases in worries about EMF (MHW-R), modern health worries (MHWS), and state anxiety (STAI-6), respectively. A similar ANOVA, only with a two-leveled factor 'time' (T0, T2), was employed to analyze increases in perceived sensitivity to EMF. Greenhouse-Geisser correction and Bonferroni-correction for post-hoc tests were applied where appropriate.

The effects of the experimental manipulations on the rating of the tactile stimuli were tested with repeated measures ANOVA with two within factors, 'time' (T0, T1, T2) and 'exposure' (WiFi ON, WiFi OFF), and one between factor 'group' (WiFi, Control). To test whether somatosensory amplification and state anxiety, respectively, influenced the perception of the tactile stimulation as moderators, we used linear regression analyses with the difference score of the VAS ratings (WiFi ON minus WiFi OFF) as the dependent variable and group, somatosensory amplification and STAI-6 scores, respectively, and their two-way interactions as predictors.

To test for differences between groups concerning fear of WiFi exposure, fear of tactile stimuli, and the belief that a WiFi exposure had taken place, Mann-Whitney-*U*-tests were applied.

Data were analyzed with IBM SPSS Statistics (Version 22).

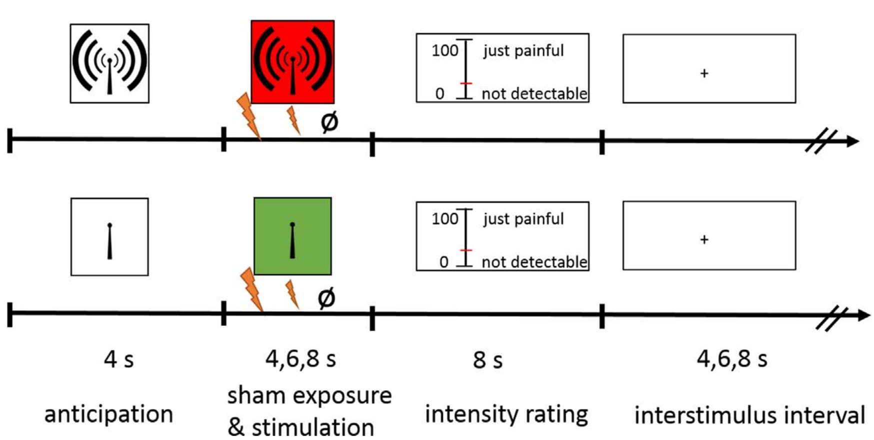

Fig. 1. Experimental design showing trials with (above) and without (below) sham WiFi exposure, as indicated by the symbol (anticipation). The background coloring of the symbol indicated that exposure started (in case of sham exposure) and that a tactile stimulus could be applied during this interval (high, low or no). Subsequently, the participants had to rate their sensation on a visual analog scale (intensity rating) before the interstimulus interval. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

3. Results

3.1. Participants

A total of 65 participants were enrolled in the study. Two were excluded from the final analyses due to deficient language proficiency and implausible data entry during the experiment (both WiFi group). Tables 1 and 2 show the demographics of the included participants, their mean detection threshold for the tactile stimulation, and the questionnaire data. Members of the WiFi film and the Control film group did not differ on any of the reported items at baseline (T0).

3.2. The WiFi television report increases worries about EMF

Participants evaluated the WiFi film as being more personally relevant ($U = 314.0$, $p = .012$; $r = .32$) and worrisome ($U = 314.0$, $p = .012$; $r = .28$) compared to the control film, whereas the other subscales of the film rating did not differ significantly between both groups. Worries about EMF (MHW-R scores, Table 2) increased in both the WiFi and Control group after watching the film (main effect of time: $F(1.7, 104.5) = 23.9$, $p < .001$), but to a larger degree in the WiFi group, where it remained elevated after the experiment (i.e., T2; interaction between time and group: $F(2, 122) = 5.2$, $p = .007$, post hoc tests WiFi group: T0 < T1, $p < .001$; T0 < T2, $p < .001$; T1 = T2, $p = .489$; control group: T0 < T1, $p = .046$; T0 = T2, $p = .184$; T1 = T2, $p > .999$). Modern health worries in general increased after the film (MHWS scores, Table 2) but did not differ between both groups (no significant interaction effects; main effects of time for MHWS total: $F(1.3, 78.9) = 21.1$, $p < .001$; subscales toxic interventions: $F(1.3, 80.6) = 5.8$, $p < .011$; environmental pollutants: $F(1.3, 81) = 25.2$, $p < .001$; tainted food: $F(1.3, 79.8) = 11.4$, $p < .001$). State anxiety remained stable after watching the film and dropped after completing the experiment in both groups (STAI-6 scores, Table 2; no significant interaction effect; main effect of time: $F(1.7, 103.5) = 4.1$, $p < .026$, post hoc tests: T0 = T1, $p = .469$; T0 = T2, $p = .562$; T1 > T2, $p = .008$). These results indicate that the films were largely comparable and that the WiFi film induced more worries about EMF than the Control film without augmenting general anxiety.

3.3. The WiFi television report leads to increased intensity ratings of the tactile stimuli

Sham WiFi exposure led to higher intensity ratings of tactile stimuli in the WiFi group (Fig. 2; main effect of exposure: $F(1, 61) = 6.1$, $p = .016$; interaction between exposure and group: $F(1, 61) = 4.8$, $p = .032$; post hoc tests comparing WiFi ON vs. OFF for WiFi film: $p = .002$, for Control film: $p = .842$). The different stimulation intensities (no stimulation, low, and high tactile) were differentiated successfully by the participants (main effect of intensity: $F(1.2, 74.5) = 109.4$, $p < .001$). No other effects reached significance.[1]

3.4. Higher intensity ratings by the WiFi television report are moderated by somatosensory amplification but not anxiety

The increase in intensity ratings of the tactile stimuli (mean of high, low, and no conditions) during sham WiFi exposure in the WiFi group was more pronounced for participants with higher levels of somatosensory amplification (Fig. 3; interaction between SA and group: $\beta = -1.157$, $p = .003$) as well as for participants with higher levels of somatosensory amplification in general (main effect of SA: $\beta = 1.131$, $p = .004$). This influence of somatosensory amplification was confirmed in separate analyses for the high tactile stimulus condition (main effect of SA: $\beta = .864$, $p = .032$; interaction between SA and group: $\beta = -.927$, $p = .021$) and the low tactile stimulus condition (main effect of SA: $\beta = .978$, $p = .020$; interaction between SA and group: $\beta = -.949$, $p = .023$, after exclusion of two outliers identified by Mahalanobis Distance; results with outliers included: main effect of SA: $\beta = .772$, $p = .063$; interaction between SA and group: $\beta = -.820$, $p = .048$). As no difference between WiFi ON and WiFi OFF appeared for the no stimulation condition ($W = 606.5$, $p = .452$; high intensity: $t(62) = 2.1$, $p = .047$; low intensity: $W = 584$, $p = .004$), this condition was not analyzed separately.

Other than expected, state anxiety before (T0) or after watching the film (T1) did not moderate the relation between the effect of the film and the rating of the tactile stimuli (interaction between STAI-6 at T0 and group: $\beta = -.183$, $p = .641$; interaction between STAI-6 at T1 and group: $\beta = .006$, $p = .988$) and higher levels of state anxiety in general did not influence the rating of the tactile stimuli (main effect of STAI-6 at T0: $\beta = .237$, $p = .546$; main effect of STAI-6 at T1: $\beta = .187$, $p = .632$).

Table 1
Demographics and detection threshold for the tactile stimuli (mean and standard deviation).

	Experimental film condition		Test statistic for differences between groups (*p*-value)
	WiFi film ($n = 31$)	Control film ($n = 32$)	
Number of female participants (%)	20 (64.5)	24 (75.0)	.822 (.365)[a]
Mean age (standard deviation)	25.8 (6.83)	24.5 (6.50)	421.0 (.300)[b]
Detection threshold for tactile stimuli (in mA)	1.0 (.24)	1.1 (.28)	600.5 (.149)[b]

[a] chi square test.
[b] Mann-Whitney-*U*-test due to non-normally distributed data.

3.5. The WiFi television report increases perceived sensitivity to EMF

After watching the film and completing the experiment (T2), participants of the WiFi film group showed a tendency towards perceiving themselves as being more sensitive to EMF than before (T0), indicated by increased scores on the SSAS in the WiFi film group (no main effect of time; interaction effect between time and group: $F(1, 61) = 3.1$, $p = .083$). Supporting these results, in the funnel debriefing, participants of the WiFi film group ($M = 21$, $SD = 20.4$) reported significantly more anxiety concerning WiFi exposure than the control group ($M = 7$, $SD = 12.3$; $U = 286.5$, $p = .003$; $r = .38$), whereas anxiety concerning the tactile stimuli did not differ in both groups (WiFi: $M = 24$, $SD = 25.6$; Control: $M = 13$, $SD = 17.1$; $U = 412$, $p = .241$).

3.6. Participants accepted supposed WiFi exposure

Most participants believed that the purpose of the study was to test the impact of WiFi exposure on somatosensory perception (WiFi group: $n = 22\%$, 71%; Control group $n = 23\%$, 72%). Five participants of the WiFi group (16%) and 7 participants of the Control group (22%) considered some kind of placebo test and four participants of the WiFi group (13%) and one subject of the control group (3%) had other ideas with regards to the purpose of the study. Asked in the funnel debriefing for their belief whether during the experiment a WiFi exposure had taken place, the participants of both the WiFi and the Control group expressed a moderate to high level of belief (WiFi: $M = 56$, $SD = 34.0$; Control: $M = 57$, $SD = 31.2$; $U = 505.5$, $p = .896$). Nine participants of the Wifi group (29%) and six participants of the Control group (19%) were skeptical (rating $< = 25$, $M = 11.3$, $SD = 8.77$) about the WiFi signal, whereas 14 participants of the WiFi group (45%) and 12 participants of

[1] Repeating the same analysis including an additional factor for color assignment of the WiFi picture (between subject factor 'color') confirmed the results of the previous analyses while the color assignment did not influence the ratings of the tactile stimuli (main effect of color: $F(1, 59) = .0$, $p = .965$) and therefore was disregarded in the following analyses.

Table 2
Questionnaire data at baseline (T0), after watching the film (T1) and after completing the experiment (T2; mean and standard deviation).

Questionnaire	Experimental film condition						Test statistic for differences between groups at T0
	WiFi film			Control film			
	T0	T1	T2	T0	T1	T2	
Trait anxiety (STAI-T)	37.9 (8.05)	–	–	39.6 (10.03)	–	–	−.737 (.464)[a]
Somatosensory amplification (SSA)	27.8 (6.95)	–	–	28.8 (7.47)	–	–	−.518 (.606)[a]
State anxiety (STAI-6)[b]	10.3 (2.15)	10.6 (2.18)	9.7 (2.32)	10.0 (2.01)	10.3 (2.15)	9.5 (2.20)	434.0 (.389)[c]
Sensitive Soma Assessment Scale (SSAS)	8.9 (3.84)	–	10.5 (4.37)	9.3 (4.19)	–	8.9 (3.56)	523.0 (.700)[c]
Modern Health Worries (MHWS)	56.6 (16.88)	65.7 (13.90)	64.5 (16.16)	57.1 (19.31)	64.7 (18.10)	62.4 (19.75)	501.0 (.945)[c]
Radiation worries (MHW-R)	5.0 (1.71)	6.5 (1.93)	6.8 (2.28)	5.2 (2.21)	5.6 (1.84)	5.6 (1.79)	494.5 (.983)[c]

[a] two sample-*t*-test.
[b] STAI-6 assessed directly before the video presentation.
[c] Mann-Whitney-*U*-test due to non-normally distributed data.

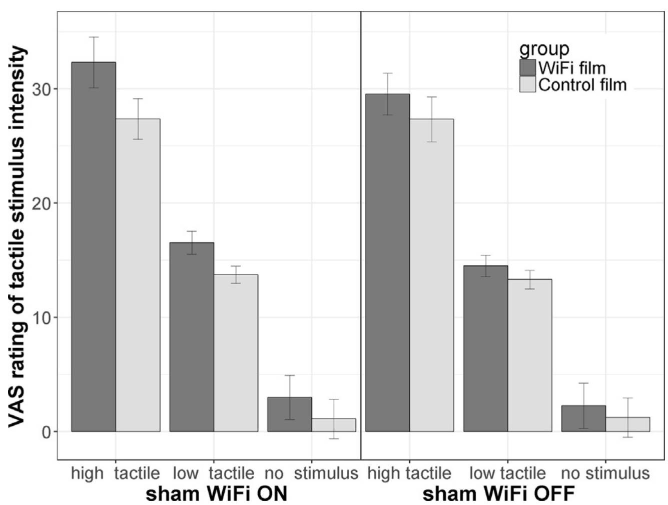

Fig. 2. Mean visual analog scale (VAS) ratings of the intensity of the tactile (electric) stimuli of the WiFi and Control group across experimental conditions. Error bars represent standard errors of the mean.

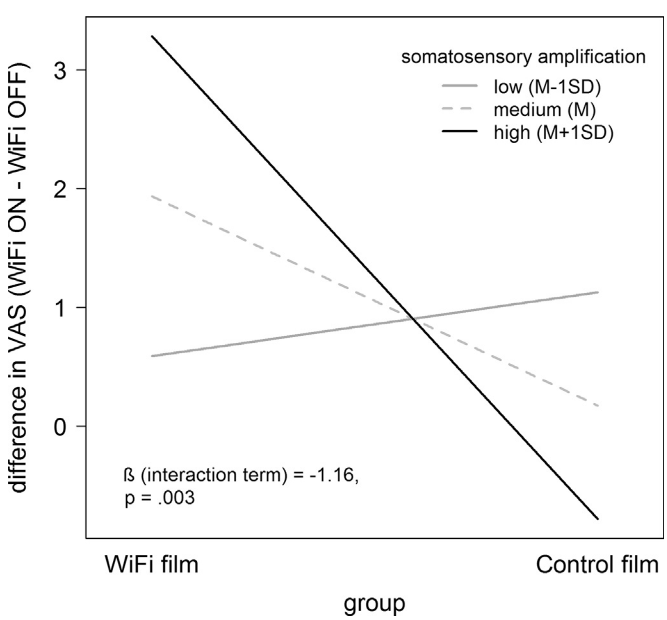

Fig. 3. Moderation of the increase in perception (difference of the VAS ratings between WiFi ON and WiFi OFF conditions) by somatosensory amplification as a function of experimental group (WiFi or Control film group).

the Control group (38%) were rather convinced (rating > =75; $M = 89.1$, $SD = 9.86$) that a WiFi signal had been applied.

4. Discussion

Symptoms are common in the general population even in the absence of illness (Ladwig et al., 2000; Petrie et al., 2014). Mostly, bodily symptoms are transient and without adverse consequences. It is conceivable, however, that the experience of symptoms in some people initiates a vicious circle leading to heightened symptom-focused attention, catastrophizing cognitions, and avoidance behavior (Bailer et al., 2007). The results of this study suggest that in the long run, such a development could result in conditions like IEI-EMF, especially if perceived symptoms occur in association with alleged EMF exposure and relevant and disturbing information on adverse health effects of EMF. Accordingly, after watching a short television report of 6 min that promoted adverse health effects of EMF, participants perceived tactile stimuli as more intense during sham compared to no WiFi exposure. Moreover, they tended to increase their self-evaluation as electrosensitive, similar to results of previous studies (Szemerszky et al., 2010; Witthöft and Rubin, 2013), were more concerned about EMF in general, and more anxious regarding the WiFi signal after the experiment compared to the Control group. Participants high in somatosensory amplification were more susceptible to the perception-enhancing effect, in line with previous research suggesting a potential moderating role of somatosensory amplification (as a personality trait) for the development of nocebo effects (Dömötör et al., 2016; Szemerszky et al., 2010; Witthöft and Rubin, 2013).

Media reports exert a large influence on symptom perception and health behavior in general (Faasse et al., 2012). Newspaper articles, television reports, and official general health warnings can induce negative expectations, which in turn are powerful determinants of nocebo effects (Benedetti et al., 2007; Crichton et al., 2014a, 2014b; Webster et al., 2016; Winters et al., 2003; Witthöft and Rubin, 2013). The results of this study give insight into how EMF-IEI could develop in healthy participants and suggest that negative expectations induced by a television report can modulate somatosensory perception. The findings suggest an increase of tactile sensitivity as a consequence of creating negative expectations in terms of adverse effects of WiFi radiation. This observed increase in tactile sensitivity is in line with the generalized hypervigilance model which states that threat signals are able to decrease sensory perception thresholds across different modalities including the somatosensory modality (Hollins et al., 2009; McDermid et al., 1996; Van Damme et al., 2015). While influencing different levels of response and leading to a vicious circle, the negative expectation possibly led to catastrophizing cognitions and increased worries concerning EMF (cognitive level), augmented symptom-focused attention (attentional level) and anxiety regarding WiFi stimulation (emotional level), in sum leading to enhanced perception and increased rating of the tactile stimuli (behavioral level). Although speculative, it seems probable that participants, if they had not been debriefed, would have avoided exposure to EMF sources in the future, as a consequence of their increased self-evaluation as electrosensitive. This theorized chain of events emphasizes the triggering role of information in the form of written instruction or television reports.

An alternative view was put forward in a recent qualitative study that was, however, based on retrospective data. When interviewing persons that were suffering from IEI-EMF, the author came to the conclusion that attribution processes in the face of present symptoms play a crucial role in the etiology of IEI-EMF instead of a priori negative expectation (Dieudonné, 2016). In the present study, stimulus perception of participants who watched a neutral instead of the sensational report, were not affected by the sham WiFi exposure, which contradicts the above model. Furthermore, the current findings demonstrate that not only the attribution of certain sensations (as potential signs of IEI-EMF) but also the somatosensory perception process per se is influenced by external information. These observations speak against a pure attribution process in which pre-existing sensations are simply retrospectively "re-labelled". In contrast, the findings are in agreement with recent models of symptom perception as an inferential process that is highly dependent upon pre-existing beliefs and expectations (Van den Bergh et al., 2017; Van den Bergh et al., in press).

However, different routes leading to IEI-EMF are conceivable and the exact interplay between risk factors (e.g., personality traits like somatosensory amplification, negative affectivity), triggering conditions that lead to (increased) symptom perception (e.g., information by media, expectation, conditioning, "traumatic" experiences, technostress), and maintenance (e.g., attribution processes, attention, somatosensory amplification, avoidance) remain to be determined in detail.

Whereas previous research in the context of IEI-EMF (Witthöft and Rubin, 2013) suggests a role of anxiety, unexpectedly, state anxiety did not moderate the perception of the tactile stimuli in this study. Yet, in the post-experimental inquiry, the WiFi group reported increased anxiety in the face of WiFi exposure. Somatosensory amplification, on the other hand, was an important predictor and moderator in this study indicating that participants with a stronger tendency to perceive normal somatic and visceral sensations as intense, disturbing, and noxious (Barsky et al., 1988) perceived the tactile stimuli as more intense under sham WiFi, especially if they had watched the WiFi film. Somatosensory amplification has not been associated with increased physiological sensitivity but rather mirrors a cognitive bias to misinterpret bodily sensations (Mailloux and Brener, 2002). It has been shown to predict symptom severity in persons suffering from IEI (Bailer et al., 2007) and predict self-rated electrosensitivity in healthy subjects (Szemerszky et al., 2010). Further, according to a recent evolutionary approach, somatosensory amplification is assumed to serve the awareness of bodily sensations that are evaluated as threatening (Ferentzi et al., 2017). The present data support the linear model proposed by Köteles and Simor (2013), which postulates that persons prone to somatosensory amplification more readily experience symptoms, leading to increased modern health worries. Worries about EMF (MHW-R) increased in both groups, possibly due to the instructions ("(…) evidence exists showing enhancement of somatosensory perception by EMF"), the request to switch off the mobile phone before entering the experimental room, and the experimental set-up with aluminum foil placed between participant and experimenter. However, worries about EMF increased steeper and more stable for the WiFi group than for the control group, indicating that the manipulation by the television report was effective over and above possible overall effects induced by instructions and the general experimental set-up.

In previous research, just focusing on possible symptoms during sham WiFi exposure without further stimulation led to the perception of symptoms (Landgrebe et al., 2008; Witthöft and Rubin, 2013). In contrast, in the no stimulation condition of this study, no significant illusory somatosensory perceptions during sham exposure were noted. This could be due to the different experimental set-ups and tasks: In the first case, an antenna was mounted on healthy participants' heads and they monitored their perception (Witthöft and Rubin, 2013) or participants suffered from IEI-EMF and were placed in a scanner environment (Landgrebe et al., 2008). Yet, in the present case, healthy participants expected to receive tactile stimuli and had the concrete task to rate their sensations in response to these stimuli. Participants' attention was supposedly focused on the stimulation site, enabling the discrimination between stimulation and lack of stimulation. Further, in the present study, participants were sham exposed for intervals lasting only a few seconds and longer blocks of stimulation might be necessary to produce an effect in this case.

The following limitations have to be considered while interpreting the current findings: As we studied a sample of healthy participants, we cannot definitely verify that IEI-EMF can develop via the route suggested here (i.e., negative expectation due to sensational media reports). Because no physiological recordings were used, effects of the experimental manipulations were only evident on a self-report level (it has to be noted that no objective physiological indicator of somatic symptom experiences exists though). Furthermore, the ratings of the electric stimuli focused on the intensity of the stimuli. We do not know whether the experimental manipulations also affected the affective quality of the presented stimuli. Further studies should therefore aim at testing the affective component (in addition to the intensity component) of the somatosensory perception process. Finally, because participants were debriefed immediately after the experiment, the current findings contain no information regarding the duration of the biased perception process demonstrated in this study. Longer post-assessment periods should be included in future studies to clarify this point.

In sum, this study shows that mass media reports, such as television reports broadcasted on TV, are able to increase concerns about EMF and, most importantly, can influence the perception of innocuous somatosensory stimulation during sham exposure of an EMF source. As EMFs are a side product of technology that is all around, virtually everybody, and especially people high in somatosensory amplification, can potentially be compromised. The media should be more aware of their responsibility when reporting on highly controversial and scientifically unsupported health effects of new technologies, including EMF (Witthöft and Rubin, 2013) and wind turbines (Crichton et al., 2014a, 2014b), or environmental pollution (Winters et al., 2003) in order to avoid the induction or amplification of symptoms and concerns in the general population.

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