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Modern health worries and idiopathic environmental intolerance attributed to electromagnetic fields are associated with paranoid ideation

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ABSTRACT

Objective: Paranoid ideation is assumed to characterize worries about possible harmful effects of modern technologies (MHWs) and idiopathic environmental intolerances (IEIs), such as IEI attributed to electromagnetic fields (IEI-EMF). Empirical evidence on these associations is scarce.
Methods: In a cross-sectional on-line survey, participants of a community sample ($n = 700$; mean age: 28.4 ± 12.0; 434 females) completed the Somatosensory Amplification Scale, the Modern Health Worries Scale, and the Paranoid Ideation scale of the Symptom Checklist 90 Revised. They were considered IEI-EMF if (1) they categorized themselves so, (2) they had experienced symptoms that they attributed to the exposure to electromagnetic fields, and (3) the condition impacted their everyday functioning.
Results: Paranoid ideation was significantly positively associated with MHWs (standardized $\beta = 0.150$, $p < .001$) even after controlling for socio-demographic variables and somatosensory amplification tendency, an indicator of somatic symptom distress. Also, paranoid ideation explained significant variability in IEI-EMF (OR = 1.090, 95% CI: 1.006–1.180, $p = .035$) even after statistically controlling for socio-demographic variables and somatosensory amplification.
Conclusions: Paranoid ideation was found to be associated with MHWs and IEI-EMF. This association appears independent of general somatic symptom distress in both cases. This might partly explain the temporal stability of these constructs.

1. Introduction

The term modern health worries (MHWs) refer to "the perceived risk to personal health from technological change and features of modern life" [1]. Such worries about possible harmful effects of modern life and technologies, such as traffic fumes, food additives, mobile phones, appear widespread in the developed countries [2,3]. MHWs are associated with a number of illness-related characteristics, such as worse perceived health status, elevated symptom reports and self-certified sick leave [3–6]. MHWs have been observed to be stable over time [7] and related to other temporally stable characteristics, e.g., health anxiety and somatosensory amplification [5,8,9]. Based on these findings, it was concluded that somatic symptom distress represents a major factor behind MHWs [2,9].

Beyond illness-related characteristics, MHWs are also associated with intuitive-experiential thinking [10] and its indicators, such as holism [9], spirituality [10] and relatedness to nature [11]. Also, associations with paranormal beliefs [12], a negative attitude towards science [13], and medical conspiracy theories [14] were reported. The latter phenomena are characterized by marked paranoid tendencies, such as suspicion of science generally and false accusations [2,14,15]. For example, the public perception of vaccination programmes often includes paranoid ideation [16,17]. In line with this, a recent study reported a medium sized association between MHWs and paranoid tendencies among patients with affective disorders, even after controlling for somatosensory amplification [18]. However, no empirical findings are known on this association in the general population.

MHWs are closely related to perceived hypersensitivities to certain environmental factors, also called idiopathic environmental intolerances (IEIs) [2,19,20], such as multiple chemical sensitivity [19,21] and electrohypersensitivity (EHS) [11,22–25]. These IEIs can be explained as instances of medically unexplained symptoms or functional

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somatic disorders mistakenly attributed to a specific environmental factor [15,19,26,27]. Environmental attribution is often associated with accusing someone (e.g. a landlord, politicians, companies) for the patient's exposure to the environmental factor in question, and/or for not protecting the patient appropriately. In summary, there is a marked tendency to regard other people as ultimately responsible for the suffering of the individual [28]. A number of authors argue that the central feature of different IEIs is a strong belief of being threatened from the outside, and only the content of the attribution is syndrome-specific [27,28]. This firm belief was called an overvalued idea, i.e., a strong preoccupation that is not supported by empirical evidence [26]. In line with this idea, perceived sensitivity to weak electromagnetic fields was associated with magical ideation among healthy people [29]; the latter includes the tendency to favor believing over testing hypotheses [30]. According to Hausteiner and colleagues [26], although IEI cannot be sufficiently explained as a subset of delusional thinking, paranoid tendencies represent a small but important component of the overall picture. For example, the assumption that mobile telecommunication companies conceal research findings on the harmful effects of electromagnetic fields is often part and parcel of the belief system of many individuals with IEI-EMF [31]. This belief might be the consequence of the fact that, contrary to the strong conviction of patients, medical diagnostic procedures are not able to reveal a causal association between actual exposure to EMFs and perceived symptoms. Generally, as scientific research findings do not support the existence of such a direct association, people often suspect that they are not told the truth about the risks of mobile communication. Paranoid tendencies can further increase the likelihood of this conclusion and the individual's sensitivity to such messages [18]. In a recent study, people fulfilling the diagnostic criteria of IEI-EMF showed a higher level of paranoid ideation than a non-IEI comparison group; the authors drew the conclusion that "having thoughts and feelings of being followed or threatened from the outside are relatively common in IEI-EMF" [32]. In line with this conclusion, the prevalence of paranoid hallucinatory psychosis among patients with IEI was 15% in a German study [33] and increased paranoid ideation tendency was reported in other studies [34,35]. Unfortunately, as people with psychotic disorders are typically excluded from IEI-related research [36–38], little is known on the associations between these conditions.

In summary, no study has directly explored the association between paranoid ideation and MHWs in the general population to date, whereas empirical findings with respect to IEI-EMF are also scarce. Thus, more empirical evidence is needed in order to understand potential associations between these phenomena in a more comprehensive way. The present study tested two hypotheses. It was expected that paranoid ideation would show a significant positive association with MHWs (Hypothesis 1) and IEI-EMF (Hypothesis 2).

2. Methods

2.1. Participants

Participants (n = 700; mean age: 28.4 ± 12.0 yrs.; 434 (62%) females) were recruited via the social media. Advertisements of the study were published in multiple Facebook groups; however, groups focusing on the focal points of the current study (i.e., modernity-related issues and electromagnetic hypersensitivity) were avoided. The survey was presented online via Google Forms in Hungarian; data collection was finished before February 2020 (i.e. the appearance of Covid-19 pandemic). The study was described as a research focusing on determinants of healthy life-style. Participants completed a number of additional questionnaires assessing various components of healthy lifestyle, such as smoking and consumption of alcohol, that are not included in the present report. The study was approved by the Research Ethics Board of the university; all individuals indicated that they voluntarily and anonymously participated in the study.

2.1.1. Questionnaires and questions

The *Modern Health Worries Scale* (MHWS) [3,39] is a 25-item scale that measures people's concerns of modernity (e.g. amalgam dental fillings, overuse of antibiotics, electromagnetic radiation) negatively affecting their health. Items are rated on a 5-point Likert scale (1: *not at all* … 5: *extremely*), higher scores indicate more worries. In the present study, Cronbach's alpha coefficient of the scale was 0.94.

The *Somatosensory Amplification Scale* (SSAS) [40,41] assesses the tendency to experience somatic sensation as intense, noxious, and disturbing. The SSAS consists of 10 items that are rated on a 5-point Likert scale (1: *not at all* … 5: *extremely*); higher scores refer to higher levels of amplification tendency. Internal consistency of the scale was 0.79 in the present study.

The *Paranoid Ideation scale of Symptom Checklist 90 Revised* (SCL-90-R) [42–44] was used to assess paranoid thinking. Symptoms of paranoid ideation with respect to the last seven days are assessed on a 5-point scale (0: *not at all* … 4: *extremely*). Higher scores indicate higher level of paranoid ideation. Internal consistency of the scale was 0.79.

2.1.2. IEI-EMF-related questions

In accordance with the definition of the WHO, the condition was assessed through its three core features [45]:

Self-diagnosis of IEI-EMF (*IEI-EMF Self diagnosis*) was measured with a single yes-or-no question: "*Many people experience unpleasant symptoms (e.g. headache, nausea, concentration problems, palpitation, etc.) when staying in the vicinity of electromagnetic fields (e.g. near electric devices, computers, electric power lines, or during mobile phone calls). This phenomenon is called electromagnetic hypersensitivity or electrosensitivity. Do you consider yourself to be electrosensitive?*" (0 = no, 1 = yes).

The impact of the condition on everyday functioning (*EMF Impact*) was measured with the following question: "*On the whole to what extent do EMF-related symptoms affect your everyday life?*" (0 = no impact at all, 1 = some impact, 2 = medium impact, 3 = high impact).

The frequency of EMF-related symptoms (*EMF Symptoms*) was assessed with the following question: "*How often do you experience symptoms in the proximity of electric devices?*" (0 = never, 1 = it happened once, 2 = rarely, 3 = often, 4 = every time).

2.2. Statistical analysis

Statistical analyses were conducted using the JASP v0.14.1 software [46]. Individuals were considered to belong to the IEI-EMF group if they (1) diagnosed themselves so (*IEI-EMF Self diagnosis* = 1), and reported (2) at least a minimal impact on everyday life (*EMF Impact* > 0) and (3) at least the rare occurrence of symptoms attributed to exposure to EMF (*EMF Symptoms* > 1). Hypothesis 1 was tested using the Spearman correlation coefficient and a linear regression analysis with the MHWS score as criterion variable and sex (0: female, 1: male), age, educational qualification (1: elementary school, 2: high school, 3: university degree), somatosensory amplification and paranoid ideation as predictor variables (variables were entered in one step using the ENTER method). Hypothesis 2 was tested with the Mann-Whitney test with rank-biserial correlation as indicator of effect size and a binary logistic regression analysis. In the latter analysis, the criterion variable was IEI-EMF, whereas predictor variables were sex, age, educational qualification, somatosensory amplification, and paranoid ideation (variables were entered in one step using the ENTER method).

3. Results

The vast majority of participants reported no regular occurrence of symptoms attributed to exposure to EMF (80.7%), no impact of EMFs on everyday life (82.9%) and did not regard themselves as electrosensitive (93.3%). The IEI-EMF group consisted of 31 individuals of the 700 (4.4%). Descriptive statistics of the assessed variables are presented in Table 1.

Table 1
Descriptive statistics of the questionnaire scores for the total sample as well as for the subgroups of people with and without IEI-EMF.

	Total sample (n = 700)		People without IEI-EMF (n = 669)		People with IEI-EMF (n = 31)	
	M ± SD	minimum-maximum	M ± SD	minimum-maximum	M ± SD	minimum-maximum
MHWS	68.2 ± 19.0	25–125	67.7 ± 19.02	25–125	78.6 ± 15.33	47–112
SSAS	15.8 ± 7.13	0–39	15.6 ± 7.09	0–39	20.3 ± 6.58	10–35
Paranoid ideation	2.8 ± 3.65	0–24	2.7 ± 3.6	0–24	5.0 ± 4.1	0–14

Note: MHWS: Modern Health Worries Scale; SSAS: Somatosensory Amplification Scale; Paranoid ideation: Paranoid Ideation scale of the Symptom Checklist 90 Revised.

The MHWS score showed a weak significant positive association with paranoid ideation (Spearman's rho = 0.190, $p < .001$). The linear regression analysis with MHWS score as criterion variable explained 10.3% of the total variance ($F(5,693) = 15.998$, $p < .001$). Both somatosensory amplification (standardized $\beta = 0.164$, $p < .001$) and paranoid ideation (standardized $\beta = 0.150$, $p < .001$) were significant predictors of MHWs after controlling for sex, gender, and educational qualification (for details, see Table 2).

According to the result of Mann-Whitney tests, there was a significant difference between the two groups with respect to MHWS (W = 6938.5, $p = .01$, rank-biserial correlation = −0.331) and SSAS (W = 6539.5, $p < .001$, rank-biserial correlation = −0.369) score. The IEI-EMF group scored higher than the comparison group in both cases (Table 1). Also, the IEI-EMF and the comparison group significantly differed with respect to paranoid ideation (W = 6475.0, $p < .001$, rank-biserial correlation = −0.376). A similar difference was found for *IEI-EMF Self diagnosis* (W = 11,015.500, $p < .001$, rank-biserial correlation = −0.282). Also, paranoid ideation was significantly associated with *EMF Symptoms* (Spearman's rho = 0.227, $p < .001$) and *EMF Impact* (Spearman's rho = 0.184, $p < .001$). Thus, all three components of IEI-EMF showed a significant association with paranoid thinking.

The binary regression analysis with IEI-EMF as criterion variable explained 10.1% of the total variance (Nagelkerke R^2; $p < .001$). Somatosensory amplification (OR = 1.069, $p = .02$) and paranoid thinking (OR = 1.090, $p = .04$) were significant predictors of the condition after controlling for sex, gender, and educational qualification (for details, see Table 3).

4. Discussion

In a cross-sectional questionnaire study assessing a large community sample, paranoid ideation was found to be significantly associated with MHWs and IEI-EMF even after statistically controlling for socio-demographic characteristics and somatosensory amplification tendency, an indicator of somatic symptom distress.

Table 2
Results of the multiple linear regression analysis with MHWS score as criterion variable.

	B ± SE	95% C.I. for B	Standardized β	p
(Intercept)	55.15 ± 3.670	47.95–62.36		< 0.001
sex	5.69 ± 1.462	2.82–8.56	0.145	< 0.001
age	0.17 ± 0.064	0.04–0.29	0.105	0.01
educational qualification	−1.83 ± 1.509	−4.79 - 1.13	−0.049	0.23
SSAS	0.44 ± 0.104	0.23–0.64	0.164	< 0.001
Paranoid ideation	0.78 ± 0.198	0.39–1.17	0.150	< 0.001

Note: MHWS: Modern Health Worries Scale; SSAS: Somatosensory Amplification Scale; Paranoid ideation: Paranoid Ideation scale of the Symptom Checklist 90 Revised.

Table 3
Results of the binary logistic regression analysis with IEI-EMF as criterion variable.

	Estimate±SE	Odds Ratio	95% C.I. for OR	p
(Intercept)	−4.33 ± 1.086	0.013	0.002–0.111	< 0.001
sex	0.94 ± 0.509	2.548	0.939–6.913	0.07
age	0.04 ± 0.015	1.041	1.011–1.071	0.006
educational qualification	−0.93 ± 0.380	0.397	0.188–0.836	0.02
SSAS	0.07 ± 0.029	1.069	1.011–1.131	0.02
Paranoid ideation	0.09 ± 0.041	1.090	1.006–1.180	0.04

Note: MHWS: Modern Health Worries Scale; SSAS: Somatosensory Amplification Scale; Paranoid ideation: Paranoid Ideation scale of the Symptom Checklist 90 Revised.

The association between MHWs and paranoid ideation appears theoretically plausible [2,15]; however, this is the first study that empirically demonstrates the direct connection between these constructs in a community sample. The association remained significant even after controlling for a number of variables that are usually associated with MHWs, most importantly gender and somatosensory amplification tendency; this suggests that paranoid ideation might independently contribute to the construct.

MHWs are assumed to play a role in the development and maintenance of various IEIs [2], thus it appears logical that paranoid ideation contributes to IEI-EMF too. Empirical findings also support this idea [32–35]. Results of the present study obtained from a community sample are in line with earlier findings. All three major features of IEI-EMF, i.e., the tendency to attribute symptoms to EMF, the perceived negative impact of exposure to EMF on everyday functioning, and the acceptance of the IEI-EMF label, were related to paranoid ideation. Also, those characterized by all three features showed higher levels of paranoid ideation than controls after controlling for socio-economic variables and somatic symptom distress. However, these associations are typically weak, which indicates that paranoid ideation represents only one underlying factor behind the IEI-EMF and cannot completely explain the condition [26].

The existence of significant associations between paranoid ideation (as a part of the psychosis spectrum) and facets of IEI are also compatible with a predictive processing account of IEI [20]. Accordingly, very concrete and precise negative expectations ("priors") concerning the harmfulness of IEI together with rather imprecise somatic input may determine the conscious experience of IEI-related symptoms. Paranoid ideation is also hypothesized to rely on altered perceptual priors [47] and may thereby contribute to biased perceptual experiences that are dominated by strong (i.e. precise) priors.

Unfortunately, paranoid ideation has a marked genetic background [48,49], is very stable over time and resists contrary information well [50]. This can contribute to the considerable temporal stability of MHWs [7], which could not have been explained based on their illness-related characteristics [51]. Messages intended to reduce MHWs, for example vaccination-related worries, should take into consideration and perhaps appropriately address this feature [16].

Patients with IEI-EMF do not respond well to traditional psychotherapy [52–54]; perhaps this tendency can also partly be ascribed to paranoid ideation. A novel psychotherapeutic intervention for IEI based on the predictive processing model has been proposed recently [55] but not yet systematically empirically tested. In the treatment of patients with IEI-EMF, health professionals should consider the possible existence of paranoid tendencies. Beyond their direct contribution to the condition, they can also decrease adherence to the therapy and confidence in medical treatments [18].

This study relies on a community sample that is not representative of the general population; thus, its generalizability is limited. Also, identification of IEI-EMF was based on participants' self-report and not on a clinical diagnostic procedure.

5. Conclusion

Paranoid ideation is associated with worries about the harmful effects of modern technologies and idiopathic environmental intolerance attributed to electromagnetic fields (aka electrohypersensitivity). This association is independent from illness-related aspects in both cases; it can partly explain the temporal stability of the aforementioned constructs.

Declaration of Competing Interest

All authors declare that there is no conflict of interest.

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