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Development and Evaluation of the Electromagnetic Hypersensitivity Questionnaire

Stacy Eltiti,[1]* Denise Wallace,[1] Konstantina Zougkou,[1] Riccardo Russo,[1] Stephen Joseph,[2] Paul Rasor,[1] and Elaine Fox[1]

[1]University of Essex, Colchester, United Kingdom
[2]University of Nottingham, Nottingham, United Kingdom

Electromagnetic hypersensitivity (EHS) syndrome is usually defined as a condition where an individual experiences adverse health effects that he or she believes is due to exposure to objects that emit electromagnetic fields. The aim of this study was to develop a questionnaire that would identify the key symptoms associated with EHS and determine how often these symptoms occur in the general population of the United Kingdom. In the pilot study, an EHS questionnaire was developed and tested. In Study 1 the EHS questionnaire was revised and sent to a randomly selected sample of 20 000 people. Principal components analysis of the symptoms resulted in eight subscales: neurovegetative, skin, auditory, headache, cardiorespiratory, cold related, locomotor, and allergy related symptoms. Study 2 established the validity of the questionnaire in that EHS individuals showed a higher severity of symptoms on all subscales compared to the control group. The two key results of this study were the development of a scale that provides an index of the type and intensity of symptoms commonly experienced by people believing themselves to be EHS and a screening tool that researchers can use to pre-select the most sensitive individuals to take part in their research. Bioelectromagnetics 28:137–151, 2007. © 2006 Wiley-Liss, Inc.

Key words: electromagnetic fields; EHS Screening Tool; symptom subscales

INTRODUCTION

Electromagnetic hypersensitivity (EHS) is a relatively modern syndrome, which was first identified in the 1980s [Hillert et al., 1999]. To date, there is no formal definition though it is usually accepted that EHS is an environmental illness in which individuals experience adverse health effects, which they believe to be due to exposure to electric, electromagnetic, and/or magnetic fields (EMFs) such as those produced by computers, mobile phones, power lines, etc. However, there is no generally accepted diagnostic criterion [e.g., Bergqvist and Vogel, 1997; Hillert et al., 1999; Hillert et al., 2002; Levallois, 2002] and EHS is not commonly recognized as a medical illness. Therefore, EHS is a self-reported syndrome in which people report a variety of symptoms that they believe are caused by EMFs.

The relationship between the symptoms experienced by EHS individuals and exposure to EMFs is yet to be demonstrated conclusively under experimental conditions. In a review conducted by Rubin et al. [2005], 7 out of 31 blind or double-blind provocation experiments resulted in some relationship between exposure to EMFs and symptoms. Of these, two studies resulted in opposite effects (i.e., one showed enhanced mood while the other impaired mood), for two other studies the authors subsequently failed to replicate their original findings, and the results of three studies were probably due to statistical artefacts. In spite of this, the perception of EHS leads to wide-spread health problems and more research is needed to test the hypothesis that these symptoms are due to EMFs.

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*Correspondence to: Stacy Eltiti, Department of Psychology, University of Essex, Wivenhoe Park, Colchester CO4 3SQ, UK. E-mail: seltiti@essex.ac.uk

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Given that there is currently no medical criterion or reliable assessment tool for identifying EHS individuals, researchers into bioelectromagnetics have to rely on the individual's self-diagnosis that the symptoms they experience are caused by exposure to EMFs. Unfortunately, as noted in Rubin et al.'s review [2005], when experimenters are unable to find a relationship between symptoms experienced and exposure to EMFs, their experiments are often criticized by action groups and EHS individuals claiming that the most sensitive individuals were not tested. This is true even when the experiments have taken into account other factors, such as the duration and type of exposure matching that reported by the EHS participants as situations in which they would normally experience negative health effects. The implication is that if the researchers had tested the most sensitive individuals then a positive result would have been found. At the moment there is no reliable self-report measure that allows an assessment of the severity of EHS symptoms.

Part of the problem with developing selection criteria for EHS is that the degree of severity, the type of symptoms, and the type of object(s) that are believed to cause EHS symptoms often differ from person to person [e.g., Bergqvist and Vogel, 1997; Hietanen et al., 2002]. Symptoms range from headaches, memory loss, cardiovascular symptoms, digestive problems, pain/heating sensations in various parts of the body to skin related symptoms, such as skin rash and burning or tingling sensations. These symptoms may be associated with a single object or a combination of two or more objects such as computers, mobile phones, electrical appliances, electrical wiring in the home, fluorescent lighting, microwave ovens, power lines, telecommunication masts, televisions, and so on.

Hillert et al. [1999] have investigated the frequency of various symptoms reported by individuals with EHS. Two symptom indices were identified: skin symptoms (redness, heat or burning sensations, tingling, smarting pain/soreness, swelling/blisters, and dry skin/mucosa) and neurovegetative symptoms (headaches, fatigue, and difficulties in concentrating). Skin symptoms were significantly more frequent in the EHS compared to the control group, as was myalgia, dizziness/vertigo, and nausea. There was no difference between the groups in terms of neurovegetative symptoms. Moreover, no relationship was found between their health survey and measures of mental health or personality traits. In a further study, Hillert et al. [2002] conducted a factor analysis of EHS symptoms and this produced two factors: neurovegetative symptoms (fatigue, sense of heaviness in the head, headache, nausea or dizziness, and difficulties to concentrate) and eyes and airways (eye irritation, runny or stuffy nose, impaired sense of smell, hoarse or dry throat, and coughing).

An obvious problem with the above symptoms as indicators of EHS is that they also occur naturally in the general population. The key distinction, of course, is that EHS individuals attribute the cause of their symptoms to exposure to EMFs. Since so little is currently known about EHS, it is important to utilize exploratory techniques in the general population using multivariate statistical analyses while at the same time attempting to obtain the most parsimonious solution in order to accurately portray the underlying structure of EHS.

Hillert et al. [1999, 2002] have made a good start in determining differences between EHS individuals and the general population in the identification of three symptom indices: skin, neurovegetative, and eyes and airways. However, the results are somewhat inconsistent in that one study found no difference in neurovegetative symptoms between EHS and controls [Hillert et al., 1999], while a larger sample did reveal a significant difference between EHS and control groups. In addition, their list of symptoms was limited in range, focusing mainly on skin and head related symptoms, and did not cover the wide range of symptoms often reported by the EHS individuals, such as sleep disturbances, ringing or buzzing in the ears, and memory difficulties. Given these limitations there is still a need for a reliable classification system that can encompass the multidimensional nature of EHS symptoms.

The symptoms commonly reported by EHS individuals are all non-specific and to some degree occur naturally in the general population. Theoretically, we propose that the underlying structure of these non-specific symptoms is similar in EHS individuals and the general population. There is a continuum in the severity of these symptoms in the general population in which some individuals have no symptoms while other may experience severe symptoms. It is not that EHS individuals experience unique symptoms or even unique symptom patterns, but that they experience these symptoms to a greater, sometimes even debilitating degree, compared to most people in the general population.

The present study had three main objectives: (i) to develop an electromagnetic hypersensitivity questionnaire that could identify the symptom indices associated with EHS, (ii) establish whether these indices differ in terms of severity of symptoms between EHS individuals and the general population, and (iii) based on the results of the questionnaire, develop an EHS Screening Tool that could aid researchers in the identification and recruitment of individuals with perceived EHS. In order to achieve these aims, a pilot study was conducted to develop and pilot items for an EHS questionnaire. In Study 1, the EHS subscales were further developed and tested on a large population-based sample. Reliability and validity of the EHS questionnaire was tested in Study 2 through test-retest measures on a sample of EHS individuals and also by comparing the results from EHS individuals to those in the control sample obtained in Study 1.

PILOT STUDY: DEVELOPMENT OF QUESTIONNAIRE ITEMS

Given that the type of symptoms commonly reported by EHS individuals are non-specific in nature and occur to some degree naturally in the general population, the focus of the pilot study was not only to identify the key symptoms associated with EHS, but also to determine whether the severity of these symptoms is greater in EHS individuals than in the general population. Since a key aspect of the definition of EHS is that the individual believes his or her symptoms are caused by exposure to EMFs, several questions were designed to allow the respondent to make an association between their symptoms and exposure to various electrical objects that produce EMFs. A pilot study was conducted that developed and tested items for the EHS questionnaire.

Method

Construction of pilot EHS questionnaire. The pilot electromagnetic hypersensitivity questionnaire had three main sections.

Biographical. The biographical questions obtained information on age, gender, ethnicity, marital status, employment, and number of hours per week the individual worked, volunteered, or spent studying.

Symptoms and causes. A 35-item symptom scale was developed by compiling symptoms published in the literature [e.g., Bergqvist and Vogel, 1997; Hillert et al., 1999, 2002; Flodin et al., 2000; Hietanen et al., 2002] as well as symptoms reported by EHS individuals obtained through personal communication or consultation with local action groups. For each symptom, participants were asked to rate whether they currently suffered from the symptom on a scale ranging from 0 to 4: 'not at all'(0), 'a little bit'(1), 'moderately'(2), 'quite a bit'(3), and 'a great deal'(4). Participants were asked whether they believed their symptoms were associated with exposure to chemicals and a variety of EMF producing objects. In separate questions, they were asked to indicate whether they were sensitive to chemicals and EMFs. Questions about chemicals were included since EHS is often reported to coincide with multiple chemical sensitivity [e.g., Hillert et al., 2002; Levallois et al., 2002].

Participants were asked to indicate how far away they lived from a chemical factory, power lines, radio/television transmitters, and telecommunication masts using the following six-point scale: 'less than one-quarter of a mile'(1), 'one-quarter to one-half mile'(2), 'one-half to three-quarters mile'(3), 'three-quarters to 1 mile'(4), 'more than 1 mile'(5), and 'don't know'(6). A 'yes' or 'no' question asked participants if they had ever experienced a severe electric shock and the following four-point scale: 'less than once a month'(1), 'less than once a week'(2), 'more than once a week'(3), and 'several times a day'(4), assessed how frequently they experienced static shocks. Finally, participants were asked 'are there any negative changes to your health when you are around EMFs?'

General health. Current state of health was measured by having participants place a cross (X) on a 12.8 cm line, which was anchored on one end with the label 'poor' and on the other end 'perfect.' Participants were asked using a 'yes' or 'no' question as to whether they suffered from any chronic illness. In addition, participants completed the 12-item General Heath Questionnaire [GHQ-12; Goldberg, 1978].

Participants. Questionnaires were mailed to 400 individuals randomly selected from the Colchester phone book of which 143 (35.8%) responded. The questionnaire was also completed by a further 118 individuals who were either students or staff at the University of Essex or obtained through personal contact (non-random sample). The total number of symptoms experienced ($t = -0.4$, $P > .05$) as well as the total severity of symptoms reported ($Z = -0.34$, $P > .05$) did not differ between the random and non-random samples. Therefore, the responses from both samples were combined forming the control group for all analyses. Questionnaires were also completed by 50 EHS individuals who were recruited through local action groups, local support groups, or personal contact.

Results

Biographical. The average age for the control group was 52.0 years (SD = 18.8) while the EHS group had an average age of 52.5 years (SD = 12.4). Females made up the majority of both the control (53%) and the EHS group (66%). There was a trend towards more females in the EHS compared to the control group ($\chi^2 = 2.91$,

$P = .088$; $\alpha = 0.05$) with no differences in terms of ethnicity, marital status, type of employment, and time spent working, volunteering, or studying ($Z < 1.5$, $P > .05$). Unless otherwise indicated, non-parametric Mann–Whitney *U*-tests were performed to determine if between-group differences were significant.

Symptoms

Step 1: principal components analysis. An exploratory principal components analysis of the 35 symptoms with direct oblimin rotation was carried out on the control group responses only. Exploratory principal components analysis was chosen because we were interested in the underlying pattern structure of the symptoms and this was used to reduce the 35 symptoms into a smaller number of symptom components. Direct oblimin rotation, instead of the typical Varimax rotation, was chosen from a theoretical perspective that allows the components to be related to one another. In other words, it makes sense that if an individual is experiencing symptoms on one component (e.g., headaches), the occurrence or severity of this symptom may be related to another component (e.g., stress). A factor loading value of 0.4 was chosen to determine if an item loaded onto any given component [Stevens, 1992]. This resulted in 11 components with eigenvalues greater than one and accounted for 66.3% of the variance.

Step 2: forced factor solutions. Inspection of the scree plot showed only one component above a marked elbow. From a statistical point of view, therefore, the most parsimonious solution would be a one-factor solution, since the first component accounted for 22% of the variance. However, EHS is a complex syndrome and little is currently known about the EHS symptom pattern structure. Our aim was to develop a measure that will enable research into the specific aspects of EHS, and thus we deemed it more appropriate to explore several multivariate solutions. In order to do this, several forced factor solutions with direct oblimin rotation were sought. This was done with 10-, 9-, 8-, 7-, and 6-factor forced solutions.

The forced eight-factor solution resulted in the best multivariate solution for the following four reasons: it contained the least number of cross loaded items, the highest number of items loading onto each component, the items that loaded onto each component formed cohesive symptom categories, and it was able to account for 60.5% of the variance. On inspection of the items within each component it was determined that the components were characterized as: (1) neurovegetative; (2) skin sensitivity; (3) skin sensations; (4) allergy related; (5) cold related; (6) symptoms of aging; (7) cardiac related; and (8) headache. See Table 1 for eigenvalues, variance explained, and component loadings. The following items loaded onto more than one component: allergies, difficulty in concentration, facial prickling, impaired sense of smell, nausea, and pain/warmth in the head. Cardiac pains and sleep disturbances did not load onto any of the components. As part of data cleaning, three items were not included in the analysis (digestive problems, dizziness, and runny/stuffy nose) because they each had a communalities value of less than 0.3.

Subscale construction. In order to obtain scores for each of the eight components, subscale scores were calculated by adding up the score for all the items that loaded onto each component, except for cross loaded items, such as difficulty in concentration, for every respondent. For example, the score for the neurovegetative subscale was created by summing an individual's score for anxiety, depression, fatigue, and stress. This means that the neurovegetative subscale contained four items, skin sensitivity contained two items, skin sensations contained three items, allergy related contained two items, cold related contained four items, symptoms of aging contained five items, cardiac related contained two items, and headache contained three items. A total symptom score was also calculated by adding up the scores for the eight subscales. There was a significant difference between the control and EHS group for seven subscales and the total symptom score (see Table 2 for descriptive statistics and Z values). Allergy related was the only subscale not to show a significant difference. To avoid making Type 1 errors Bonferroni corrections were applied whenever multiple tests were conducted. See associated tables for corrected alpha values.

Causes. The majority of control respondents did not believe there was a link between their symptoms and exposure to the specified range of environmental factors. However for the EHS group, a majority did believe there was some relationship between exposure to those objects (except detergents/soaps) and the occurrence of their symptoms (See Supplemental Table S1 [www.interscience.wiley.com/jpages/0197-8462/suppmat]). The difference between the groups was significant for all the objects except for detergents/soaps ($Z = -2.19$, $P = .028$).

There was a significant difference between the groups with 41.4% of the control compared to 54.0% of the EHS group indicating that they were to some degree sensitive to chemicals ($Z = -3.25$, $P < .01$). When asked 'Are you sensitive to EMFs?', 10.7% of the control while 90.0% of the EHS group responded that

TABLE 1. Forced Eight-Factor Principal Component Analysis Eigenvalues, Percentage Variance Explained and Factor Loadings for the Pilot Study

Factor	1	2	3	4	5	6	7	8
Eigenvalues	7.2	2.5	2.0	1.9	1.7	1.5	1.4	1.3
Percentage	22.5	7.8	6.2	5.8	5.2	4.6	4.3	4.2
Allergies		0.43		0.56				
Anxiety	0.86							
Asthma				0.86				
Back pain						0.65		
Breathing difficulties				0.86				
Depression	0.77							
Difficulty in concentrating	0.50					0.37	−0.30	
Dry cough						0.70		
Eye problems						0.67		
Facial prickling						0.53	0.30	
Fatigue	0.48							
Headaches								0.64
Heart palpitations							0.54	
Heaviness in the head								0.60
High blood pressure							0.55	
Hoarse dry throat					0.77			
Impaired sense of smell		0.43			0.43			
Impaired sense of taste					0.73			
Memory difficulties						0.65		
Migraines								0.72
Nausea							0.54	0.41
Pain in joints						0.61		
Pain/warmth in head							−0.44	0.52
Pressure in the ear					0.51			
Skin burning sensation			−0.77					
Skin irritation		0.63						
Skin numbness			−0.76					
Skin rash		0.79						
Stress	0.82							
Tingling sensations			−0.76					

they were sensitive to EMFs. The other 10.0% of the EHS group did not respond to this question. Not surprisingly, this resulted in a significant difference between the two groups ($Z = -13.91$, $P < .01$). For the EHS, but not the control group, there was a significant correlation between the degree of sensitivity to chemicals and sensitivity to EMFs ($r = 0.318$, $P < .05$). For the question, ‘are there any negative changes to your health when you are around EMFs?,’ there was a significant difference with 89.3% of the control group compared to 2.0% of the EHS group responding ‘not at all’ ($Z = -14.54$, $P < .01$).

Interestingly, there was not a significant difference between the control and EHS groups in the distance they lived to both chemical factories ($Z = -1.24$, $P > .05$) and power lines ($Z = -1.01$, $P > .05$); however, there was a significant difference for telecommunication masts ($Z = -5.44$, $P < .001$) and a trend towards a significant difference for radio/television transmitters ($Z = -2.23$, $P = .026$; alpha level set to 0.01 after Bonferroni correction). This was due to a larger percentage of EHS respondents indicating that they lived within 1 mile of a telecommunications mast and/or radio/television transmitters while almost half of the control group did not know how far away they lived from telecommunication masts (45.6%) or radio/television transmitters (47.1%).

This raises the question as to whether there is an actual difference or whether EHS individuals are more aware that they are living in close proximity to radio/television transmitters and telecommunication masts. In order to determine how far respondents live from telecommunication masts, respondents’ post codes were entered into Ofcom’s Sitefinder website, which contains the location of all telecommunication masts in the United Kingdom, and individuals were divided into those who live within 100 m of a mast (near) and those who live farther away (far). Chi-square analysis revealed that there was no difference in the percentage of control (35.5%) and EHS (46.8%) respondents who

TABLE 2. Descriptives and Z-scores for the Subscales and Total Symptom Score for the Control and EHS Respondents in the Pilot and Studies 1 and 2

	Control			EHS[a]			
Subscale	Mean	Median	SD	Mean	Median	SD	Z[b]
Pilot Study							
Neurovegetative	3.2	3.0	2.9	7.2	6.0	4.5	−5.7**
Skin sensitivity	0.8	0.0	1.4	3.0	2.0	7.8	−5.5**
Skin sensations	0.5	0.0	1.4	4.3	3.0	3.9	−8.5**
Allergy related	0.6	0.0	1.4	1.0	0.0	1.8	−1.8
Cold related	1.1	0.0	1.8	4.0	3.0	3.9	−5.6**
Symptoms of aging	3.5	3.0	2.8	7.0	8.0	4.4	−4.8**
Cardiac related	0.7	0.0	1.1	1.9	1.5	1.8	−4.9**
Headache	1.3	1.0	1.7	4.5	4.0	3.2	−6.9**
Total symptom score	11.2	9.0	8.7	31.2	31.0	20.4	−6.0**
Studies 1 and 2							
Neurovegetative	6.6	5.0	6.3	15.4	16.0	9.2	−9.0**
Skin	2.1	1.0	3.4	6.2	3.5	6.7	−7.3**
Auditory	1.1	0.0	2.0	5.1	3.0	5.0	−9.3**
Headache	2.9	2.0	3.8	8.4	7.0	6.2	−9.7**
Cardiorespiratory	1.0	0.0	1.8	2.7	1.5	3.0	−7.4**
Cold related	1.7	1.0	2.2	3.2	2.0	3.3	−4.6**
Locomotor	3.4	3.0	3.1	5.2	5.0	4.0	−4.3**
Allergy related	0.7	0.0	1.0	1.2	1.0	1.4	−3.8**
Total symptom score	19.4	15.0	16.4	47.4	45.0	27.9	−10.1**

**$P < .001$; EHS, electromagnetic hypersensitivity.
[a]The EHS sample in the lower half of the table refers to respondents in Study 2.
[b]Mann–Whitney *U*-tests, alpha level = 0.005.

lived within 100 m of a mast ($\chi^2 = 2.11$, $P > .05$). It appears that EHS individuals do not live closer, but are more aware of the location of telecommunication masts. Further analysis revealed no difference in the severity of symptoms experienced by those living near compared to those living farther away from telecommunication mast ($Z < -1.0$, $P < .05$).

There was no significant difference between the control (25.7%) and EHS (34.0%) groups in terms of the frequency of individuals who had experienced a severe electric shock ($\chi^2 = 1.58$, $P > .05$). However, there was a significant difference between the groups in the occurrence of static shocks ($Z = -3.20$, $P < .01$). For the control group 61.7% experienced static shocks 'less than once a month,' 16.9% 'less than once a week,' 13.0% 'more than once a week,' and 5.0% experienced static shocks 'several times a day.' In comparison, the EHS group responded that 40.0% experienced static shocks 'less than once a month,' 16.0% 'less than once a week,' 8.0% 'more than once a week,' and 26.0% experienced static shocks 'several times a day.'

General health. In terms of general health there was a significant difference between the control and EHS groups. For the question in which the respondents were instructed to indicate their current state of health (poor—perfect), the control group responded with significantly better current health (M = 8.90, SD = 2.71) than the EHS group (M = 5.54, SD = 3.80; $t = 6.88$, $P < .01$). There was also a significant difference between the groups on the GHQ-12 ($t = -3.14$, $P < .01$) with the EHS group scoring higher (M = 15.19, SD = 5.95) than the control group (M = 10.99, SD = 4.99) indicating poorer general mental health. In addition, a bivariate correlation between the GHQ-12 and the total symptom score revealed a significant correlation for both the control ($r = .57$, $P < .01$) and EHS group ($r = .87$, $P < .01$). Lastly, there was a significant difference between the groups in terms of chronic illness ($\chi^2 = 8.39$, $P < .01$) in which 14.6% of the controls compared to 32.0% of the EHS group had a chronic illness.

Discussion

The results indicated that EHS individuals experience a greater severity of symptoms, suffer from poorer general health, and attribute the cause of their symptoms to exposure to objects emitting EMFs and chemicals to a greater extent than most members of the general public. Using exploratory principle components analysis, the symptoms were classified into eight key components. It was observed, however, that five out of the eight would contain less than four items if the cross loaded items were removed from the factor structure. Components should have at least four items with a loading of 0.6 in order to be reliable unless there is a larger sample size, that is, at least 300 [Stevens, 1992]. In addition, many EHS respondents reported symptoms that were not part of the original list of 35 symptoms. Given the small number of items loading onto each component as well as the discovery of additional self-reported EHS symptoms, it was clear that further development of the scale was needed in order to determine the reliability of the initial eight components and gain a more comprehensive picture of the underlying structure of EHS.

STUDY 1: DEVELOPMENT OF EHS SUBSCALES

The aim of Study 1 was to further develop and test the reliability of the eight symptom subscales identified in the pilot study on a large random population sample. Twenty-two new symptoms were included (e.g., bad taste in the mouth, blurry vision, foggy thinking, ringing and/or buzzing in the ear, and skin redness). These additional symptoms were obtained by examining EHS responses in the pilot study to the open question ‘if you are sensitive to electromagnetic fields, what electrical equipment . . . bothers you the most and what are the symptoms that you experience when you are exposed to the electromagnetic field?’ and extracting any symptoms that were not part of the original list of symptoms. This resulted in a 57-item questionnaire. In addition, three new general health questions were included dealing with: current well being, general health, and sleep quality, while the questions relating to chemical sensitivity and how far an individual lived from various environmental objects were removed. See on-line Supplemental Table S2 (www.interscience.wiley.com/jpages/0197-8462/suppmat) for a complete copy of the questionnaire.

Method

Participants. Questionnaires were sent to 20 000 individuals randomly selected from the edited electoral roll who lived within a 20 mile radius of Colchester. From this population 4431 (22.2%) were returned. Of the questionnaires returned, 3633 (18.2%) were completed and 798 (4.0%) were uncompleted for various reasons; in the majority of cases the individual no longer resided at that address (709). Although measures were taken to encourage compliance, the response rate to our study was low, a problem not uncommon with postal surveys [Newell et al., 2004] and not limited to a particular subject matter [e.g., Angus et al., 2003; Jacoby and Jacoby, 2004]. The respondents had an average age of 52.8 years (SD = 14.30) with 2009 (55.3%) being female and 1624 (44.7%) being male. The majority of the group were White British (97.1%), married (82.5%), employed (62.5%), and the largest percentage of respondents indicated that they worked, volunteered, or studied 0 hours per week (26.0%).

Results

Symptoms. The methods employed for the principal components analysis of the 57 symptoms was the same as that used in the pilot study, which resulted in 12 components and accounted for 56.6% of the total variance. Similar to the pilot study, alternative multivariate forced factor solutions were sought. The forced eight-factor solution proved to be the best solution with which to develop a multifactorial measure because each component except one contained at least four items, while at the same time having the least number of cross loaded items, and still being able to account for more than 50% of the variance. In addition, the items that loaded onto each component formed theoretically cohesive symptom categories.

Forced eight-factor solution. The eight-factor forced solution accounted for 52.8% of the variance. Eigenvalues, variance explained, and item loadings are listed in Table 3. On inspection of the items within each component, it was determined that the components were characterized as (1) neurovegetative; (2) skin; (3) auditory; (4) headache; (5) cardiorespiratory; (6) cold related; (7) locomotor; and (8) allergy related. As part of the data cleaning any symptoms with a commonality extraction less than 0.3 were excluded, which resulted in the exclusion of the following eight symptoms: bad taste in the mouth, blisters on the skin, blurry vision, cold sweat, digestive problems, eye problems, facial prickling, and high blood pressure.

Hillert et al. [2002] split their population sample into a control group and EHS group based on whether the individual said they were hypersensitive or allergic to electric or magnetic fields. They conducted a principal component analysis on the control group and then replicated the factor structure on the EHS group. In the EHS questionnaire, question 67 ‘Are you sensitive to EMFs?’ is similar to that of Hillert et al. and was used to extract a large scale EHS group in order to determine if the above forced eight-factor solution could be replicated in a large sample EHS group. There were 698 individuals who made a positive response to this question and their symptom scores were subjected to a forced eight-factor solution with direct oblimin rotation. The results for this EHS group were similar to those of the general population with most items loading together on the same component. The only substantial

TABLE 3. Forced 8-Factor Principal Component Analysis Eigenvalues, Percentage Variance Explained and Factor Loadings for Study 1

Factor	1	2	3	4	5	6	7	8
Eigenvalue	12.75	2.89	2.16	2.03	1.76	1.60	1.40	1.29
Percentage	26.0	5.9	4.4	4.1	3.6	3.3	2.9	2.6
Allergies								0.48
Anxiety	0.73							
Asthma					0.43			0.41
Back pain							−0.61	
Breathing difficulties					0.63			
Cardiac pains					0.84			
Chest pains					0.77			
Depression	0.73							
Difficulty in concentrating	0.83							
Difficulty in focusing attention	0.79							
Dry cough						0.41		
Dry skin		0.48						
Dull headache				−0.74				
Exhaustion	0.53							
Fatigue	0.54							
Foggy thinking	0.66							
Headaches				−0.84				
Heart palpitations					0.41			
Heaviness in the head				−0.53				
Impaired sense of smell						0.77		
Impaired sense of taste						0.76		
Memory difficulties	0.59							
Migraines				−0.81				
Muscle tension							−0.47	
Muscle weakness							−0.52	
Pain in the ear			0.74					
Pain in joints							−0.71	
Pain/Soreness of the skin		0.72						
Pain/Warmth in head				−0.44				
Pressure in the ear			0.77					
Ringing/Buzzing in the ear			0.62					
Runny or stuffy nose						0.43		
Sharp pain in the head				−0.63				
Skin burning sensation		0.57						
Skin irritation		0.81						
Skin rash		0.85						
Skin redness		0.86						
Skin swelling		0.59						
Sleep disturbances	0.40						−0.33	
Stress	0.69							
Warmth in the ear			0.66					

difference was component eight 'allergy related symptoms' in which allergies and asthma no longer loaded onto this component, but instead nausea (−0.49) and sickness (−0.54) formed the items for this component. See Table 4 for item loadings for the eight components for both the general population and EHS subgroup.

Subscale construction. Just as in the pilot study, the eight subscales were calculated by adding up each symptom that loaded on that component. Sleep disturbances and asthma cross loaded onto two components; therefore, they were not included in the subscale scores. This resulted in the neurovegetative subscale containing nine items, skin containing seven items, auditory containing four items, headache containing six items, cardiorespiratory containing four items, cold related containing four items, locomotor containing five items, and allergy related containing one item. See Table 2 for descriptive statistics.

TABLE 4. Factor Loadings for the General Population and EHS Group Identified Using Question 67 for the Forced Eight-Factor Solution in Study 1

Symptom	Group	
Neurovegetative	General population	EHS[a]
Anxiety	0.73	0.63
Depression	0.73	0.67
Difficulty in concentrating	0.83	0.86
Difficulty in focusing attention	0.79	0.78
Exhaustion	0.53	0.52
Fatigue	0.54	0.49
Foggy thinking	0.66	0.69
Memory difficulties	0.59	0.59
Sleep disturbances	0.40	0.33
Stress	0.69	0.57
Skin		
Dry skin	0.48	0.51
Pain/Soreness on the skin	0.72	0.74
Skin burning sensation	0.57	0.59
Skin irritation	0.81	0.80
Skin rash	0.85	0.82
Skin redness	0.86	0.85
Skin swelling	0.59	0.66
Auditory		
Pain in the ear	0.74	0.67
Pressure in the ear	0.77	0.74
Ringing/Buzzing in the ear	0.62	0.59
Warmth in the ear	0.66	0.70
Headache		
Dull headache	−0.74	0.77
Headaches	−0.84	0.87
Heaviness in the head	−0.53	0.56
Migraines	−0.81	0.82
Pain/Warmth in head	−0.44	0.37
Sharp Pain in the head	−0.63	0.57
Cardiorespiratory		
Asthma	0.43	0.41
Breathing difficulties	0.63	0.67
Cardiac pains	0.84	0.76
Chest pains	0.77	0.75
Heart palpitations	0.41	0.31
Cold related		
Dry Cough	0.41	0.49
Impaired sense of smell	0.77	0.68
Impaired sense of taste	0.76	0.63
Runny or stuffy nose	0.43	0.42
Locomotor		
Back pain	−0.61	−0.64
Muscle tension	−0.47	−0.43
Muscle weakness	−0.52	−0.48
Pain in joints	−0.71	−0.73
Sleep disturbances	−0.33	−0.36
Allergy related		
Allergies	0.48	0.34
Asthma	0.41	0.21

[a]EHS group represents the 698 individuals identified using question 67.

Component 1 accounted for half of the total explained variance. From a statistical perspective it would follow that all the items could be accounted for by a single component solution. Therefore, a forced one-factor solution with direct oblimin rotation was conducted to determine if, ultimately, the eight subscales could be condensed into one. This resulted in all eight subscales loading onto one component with an eigenvalue of 3.43, which accounted for 42.9% of the total variance with the following factor loadings: neurovegetative (0.77), skin (0.62), auditory (0.63), headache (0.72), cardiorespiratory (0.64), cold related (0.67), locomotor (0.72), and allergy related (0.41). Since all eight subscales can be reduced to one component it is possible to combine the subscale scores into a single or total symptom score.

Causes. Similar to the pilot study, the majority of the control respondents indicated that they did not believe that there was a link between the occurrence of symptoms (1–57) and exposure to various objects that produce EMFs. However, the pattern fluctuated depending on the type of object. See Table 5 for full details of frequency of responses by objects.

The majority of respondents indicated that they were 'not at all' sensitive to EMFs (80.3%) nor did they experience any negative changes to their health when around EMFs (81.8%). In response to the open question 68 'if you are sensitive to EMFs, what electrical equipment . . .bothers you the most . . .,' 5.2% indicated that they were sensitive to computers, 4.2% to mobile phones, 1.9% to power lines, 1.6% to televisions, 1.2% to fluorescent lighting, 0.6% to microwave ovens, 0.4% to electrical appliances, 0.3% to radio/television transmitters, and 0.3% to telecommunication masts.

A minority of 32.6% indicated that they had experienced a severe electric shock while the occurrence of static shocks was more diverse with 25.5% indicating that they never experience static shocks, 34.4% 'less than once a month,' 17.7% 'less than once a week,' 17.0% 'more than once a week,' and 5.0% 'several times a day.'

General health. Most of the respondents indicated that they believed their well being and general health was moderately good or better and that they felt refreshed after a night's sleep. In addition, a vast majority of the sample (80.3%) did not suffer from any chronic illness.

Discussion

Comparable to the results of the pilot study, the best multivariate solution for the exploratory principle

TABLE 5. Frequency of Responses and Mann–Whitney *U*-Tests for Control and EHS Respondents by Objects the Emit EMFs for Studies 1 and 2

	Not at all	A little bit	Moderately	Quite a bit	A great deal	
Objects	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	Z^a
Computers						
Control	2357 (64.9%)	794 (21.9%)	286 (7.9%)	124 (3.4%)	44 (1.2%)	
EHS	27 (30.7%)	19 (21.6%)	10 (11.4%)	12 (13.6%)	18 (20.5%)	−8.39**
Electrical appliances						
Control	3111 (85.6%)	351 (9.7%)	98 (2.7%)	36 (1.0%)	8 (0.2%)	
EHS	42 (47.7%)	23 (26.1%)	4 (4.5%)	10 (11.4%)	9 (10.2%)	−10.22**
Fluorescent lighting						
Control	2393 (65.9%)	762 (21.0%)	275 (7.6%)	120 (3.3%)	55 (1.5%)	
EHS	38 (43.2%)	12 (13.6%)	11 (12.5%)	8 (9.1%)	18 (20.5%)	−6.10**
Microwave ovens						
Control	2938 (80.9%)	457 (12.6%)	138 (3.8%)	48 (1.3%)	19 (0.5%)	
EHS	46 (52.3%)	17 (19.3%)	8 (9.1%)	4 (4.5%)	12 (13.6%)	−7.30**
Mobile phones						
Control	2459 (67.7%)	640 (17.6%)	284 (7.8%)	150 (4.1%)	66 (1.8%)	
EHS	13 (14.8%)	13 (14.8%)	16 (18.2%)	13 (14.8%)	32 (36.4%)	−12.84**
Power lines						
Control	2688 (74.0%)	458 (12.6%)	244 (6.7%)	143 (3.9%)	61 (1.7%)	
EHS	33 (37.5%)	11 (12.5%)	16 (18.2%)	8 (9.1%)	18 (20.5%)	−8.79**
Radio/Television transmitters						
Control	2889 (79.5%)	402 (11.1%)	186 (5.1%)	91 (2.5%)	28 (0.8%)	
EHS	41 (46.6%)	14 (15.9%)	7 (8.0%)	8 (9.1%)	11 (12.5%)	−8.36**
Telecommunication masts						
Control	2728 (75.1%)	452 (12.4%)	234 (6.4%)	127 (3.5%)	55 (1.5%)	
EHS	17 (19.3%)	9 (10.2%)	10 (11.4%)	11 (12.5%)	36 (40.9%)	−13.89**
Televisions						
Control	2796 (77.0%)	584 (16.1%)	162 (4.5%)	41 (1.1%)	18 (0.5%)	
EHS	37 (42.0%)	25 (28.4%)	8 (9.1%)	8 (9.1%)	10 (11.4%)	−8.29**

**$P < .001$; EHS, electromagnetic hypersensitivity; EMF, electromagnetic fields.
[a]Mann–Whitney *U*-tests; alpha level = 0.006.

components analysis of the 57 symptoms was a forced eight-factor solution. The eight subscales were: neurovegetative, skin, auditory, headache, cardiorespiratory, cold related, locomotor, and allergy related. Ultimately these items could be reduced to a single component solution resulting in a total symptom score.

Now that we had a better understanding of the underlying structure of these symptoms it was important to determine whether, in terms of EHS, the scale is both valid and reliable.

STUDY 2: RELIABILITY AND VALIDITY OF EHS QUESTIONNAIRE

In order to establish the validity and reliability, the EHS questionnaire was completed by individuals who self-reported being sensitive to EMFs. If the symptom scales are valid, then EHS respondents should experience a greater severity of these symptoms compared to the normative data obtained in Study 1. The test-retest method was utilized to determine whether an individual's symptom score remained relatively constant over different periods of time thereby giving us a measurement of reliability.

Method

Participants. The EHS questionnaire was completed by 88 EHS individuals who were recruited through local action groups, local support groups, or personal contact and had not participated in the pilot study. The average age was 48.7 years (SD = 14.0) with 47 (53.4%) being female. Thirty-two of these respondents took part in the retest. The retest questionnaires were completed between 1 and 8 months after the original questionnaire. The responses were divided into two groups: short term (1–3 months) and long term (4–8 months). This was done in order to determine the short term and long term reliability of the questionnaire. In addition, six non-EHS respondents who were either family members or friends of the EHS respondent also took part in the test-retest, all of whom completed the retest 1–3 months after the initial questionnaire. The majority of respondents were White British (84.1%), married (54.5%), employed (55.6%), and the largest percentage worked, volunteered, or studied 31–40 h per week (22.7%).

Results

Validity. Validity was determined by comparing the EHS responses with those from the control group obtained in Study 1. The EHS group had a greater severity of symptoms than the control group for all eight subscales and for the total symptom score (see Table 2 for descriptive statistics and Mann–Whitney *U*-tests). A majority of the EHS respondents indicated that they believed there was a link between the occurrence of their symptoms (1–57) and exposure to various objects that produce EMF, except for microwave ovens. There was a significant difference between the groups for all objects in that more EHS respondents believed there was a relationship between the occurrence of their symptoms and exposure to those objects compared to the control group (see Table 5 for full details).

Importantly, a larger proportion of EHS (90.9%) than control respondents (17.5%) indicated that they were to some degree sensitive to EMFs ($Z = -18.2$, $P < .001$). Additionally, more EHS (92.1%) compared to control participants (16.0%) reported negative changes to their health when around EMFs ($Z = -20.3$, $P < .001$). There was a tendency for more EHS respondents (42.0%) compared to the control group (32.9%) to have experienced a severe electric shock ($\chi^2 = 3.6$, $P = .06$) and the occurrence of static shocks was higher among the EHS than the control group, which resulted in a significance difference ($Z = -3.2$, $P < .001$).

Lastly, there was a significant difference between the control and EHS samples with the control group reporting higher levels of current state of well being (Median: control = 3, EHS = 2), good health (Median: control = 3, EHS = 2), and sleep (Median: control = 2, EHS = 1; all Z's > -4.5, P's < .001). A larger percentage of EHS (37.5%) compared to control (17.9%) respondents suffered from a chronic illness ($\chi^2 = 20.9$, $P < .01$).

Reliability. The internal consistency reliability among the retest symptoms were calculated using Cronbach alpha for the total symptom score and symptoms subscales, except allergy related. According to Nunnaly [1978], a Cronbach alpha of 0.70 or higher is considered acceptable or satisfactory. Additionally, test–retest correlations were calculated for the following items: eight symptoms subscales, total symptom score, questions regarding the relationship between symptoms and various EMF-producing objects, sensitive to EMF, negative health changes around EMF, and the three general health questions. See Table 6 for a complete list of Cronbach alphas and correlation coefficients. Overall, both the internal consistency and test–retest correlations were good for most of the above measures. The cardiorespiratory subscale resulted in a low internal consistency for both the short term ($\alpha = 0.52$) and long term group ($\alpha = 0.44$). The auditory subscale resulted in low internal consistency for the short term group ($\alpha = 0.56$), while the locomotor subscale resulted in low internal consistency for the long term group ($\alpha = 0.63$). The test–retest correlation for the neurovegetative subscale was not significant for the long term group ($r = 0.37$). In addition, the test-retest reliability regarding the series of questions in which respondents indicated whether they believed there was a link between their symptoms and exposure to different objects was widely varied with higher values among the long term group ($r = 0.50$–0.87) than the short term group ($r = 0.28$–0.74).

Discussion

The validity of the EHS questionnaire was established in that the EHS group suffered a greater severity of symptoms than the control group for the total symptom score and for all eight subscales. More EHS individuals than controls responded positively to questions that asked them to indicate if they believed there was a relationship between the occurrence of their symptoms and exposure to various objects, whether they believed they were sensitive to EMFs, and that they experienced negative changes to their health when exposed to EMFs.

The reliability of the EHS questionnaire was demonstrated in the test-retest analysis. Overall, good internal consistency and test-retest reliability was obtained for the subscales and the total symptom score. In addition, the two main questions regarding the degree of sensitivity to EMFs also resulted in a high level of reliability. The reliability measures were stronger for the short term group than the long term group. Responses in the long term group showed that the severity of symptoms and sensitive to EMFs decreased slightly between the time of test and retest. What is unclear is the reason behind this decrease. Through personal communication with EHS sufferers, we know that many of them have adopted new behaviors aimed at protecting themselves from exposure to EMFs or

TABLE 6. Cronbach Alpha's and Spearman Correlations for Short Term and Long Term Response Groups for Study 2

	Short term (1–3months)		Long term (4–8months)	
Questionnaire items	α[a]	r[b]	α	r
Subscales				
Neurovegetative	0.93	0.95**	0.90	0.37
Skin	0.94	0.89**	0.73	0.88**
Auditory	0.56	0.71**	0.85	0.91**
Headache	0.86	0.86**	0.88	0.65**
Cardiorespiratory	0.52	0.85**	0.44	0.67**
Cold related	0.70	0.62**	0.88	0.76**
Locomotor	0.77	0.86**	0.63	0.76**
Allergy related		0.79**		0.81**
Total symptom score	0.82	0.91**	0.81	0.70**
EMF objects				
Computers		0.59**		0.81**
Electrical appliances		0.69**		0.87**
Fluorescent lighting		0.28		0.83**
Microwave ovens		0.38		0.55*
Mobile phones		0.65**		0.50
Power lines		0.41		0.82**
Radio/Television transmitters		0.41		0.72**
Telecommunication masts		0.74**		0.83**
Television		0.66**		0.81**
EHS questions				
Sensitive to EMF		0.82**		0.52
Negative health around EMF		0.94**		0.53*
General health				
Well being		0.65**		0.73**
Good health		0.66**		0.76**
Sleep		0.78**		0.61*

*$P = .05$(two-tailed).
**$P = .01$(two-tailed).
[a]α = Cronbach alpha.
[b]Spearman correlation.

reducing the severity of symptoms experienced. For example, the respondent no longer uses a mobile phone, spends fewer hours on the computer, eats organic food, or takes homeopathic remedies, which, in some cases, may decrease the severity of symptoms experienced and thereby reduce the reliability of the questionnaire. Another possible explanation is that we are seeing a regression towards the mean.

GENERAL DISCUSSION

Five components were the same for both the pilot study and Study 1: neurovegetative, skin, allergy related, cold related, and headache. In Study 1, the two components: skin sensitivity and skin sensations combined to form only one component: skin. Symptoms of aging became locomotor and cardiac related became cardiorespiratory in Study 1. One new component, auditory, emerged in Study 1. This was primarily due to the inclusion of more ear related symptoms. The addition of 22 symptoms in Study 1 boosted the number of items that loaded onto each component with only one component (allergy related) having less than four items. There was a significant difference between the control and EHS groups for all subscales, except allergy related in the pilot study. The EHS consistently reported a greater severity of symptoms in comparison to the control group.

Based on the precedent set by Hillert et al. [2002], we used question 67 to select from our population group in Study 1 individuals who to some extent reported being sensitive to EMFs. A forced eight-factor solution was then performed on this subsample, which resulted in a similar pattern of symptoms to that obtained for the general population. This result supports the theoretical assumption that the symptom structure is similar for both groups. However, given that only one question was used to identify EHS individuals we are reluctant to draw any firm conclusions based solely on this analysis. Do these randomly selected individuals provide a representative sample of those who self-report being EHS as in Study 2? Unfortunately, reliable principal components analysis could not be conducted on the EHS group in Study 2 due to the small sample size [Tabachnick and Fidell, 1996]. If, in future research, larger self-reported samples of EHS individuals could be obtained, that is, at least 500 it would be beneficial to replicate the forced eight-factor solution to determine if there are any differences in the underlying pattern of symptoms between the groups.

A significantly larger proportion of EHS respondents suffered from a chronic illness compared to the control groups in both the pilot study and Study 1. A variety of chronic illnesses were listed, with some of the more common responses from Study 2 being: chronic fatigue syndrome (9.1%), diabetes (8.0%), back/spine/joint diseases (6.8%), and deficient/overactive thyroid (4.5%). From our study, it is impossible to determine what relationship, if any, there is between EHS and other chronic illnesses, such as chronic fatigue syndrome; however, it does merit further investigation given the large number of EHS individuals who also suffer from chronic illnesses.

It has been suggested that a severe electric shock may be a contributing factor to some individuals becoming sensitive to EMF (Anne Silk, personal communication). However, in the pilot study, there was no significant difference between the control (32.9%) and EHS (39.1%) groups, although there was a trend towards a significant difference in Study 2, in that 42.0% of EHS compared to 32.9% of control respondents (Study 1) had suffered a severe electric shock. For both studies, EHS respondents experienced static shocks significantly more often than the control respondents. One possible explanation is that perhaps EHS individuals are more self-aware than control individuals and this awareness leads to a greater reporting of static shocks. It would be interesting to determine if the occurrence of static shocks were more frequent before or after the individual became sensitive to EMFs.

EHS Criterion

Two key aspects of the definition of EHS are that the individual experiences symptoms and he or she believes that these symptoms are the result of exposure to EMFs. Therefore, the selection criteria for identifying EHS must take into account both the severity and attributed cause(s) of those symptoms. In order to determine the severity of a respondent's symptoms, the total symptom score provides the best overall measure. From the control data obtained in Study 1, it was evident that these symptoms naturally occur to varying degrees in the general population. In other words, there was a continuum of symptom severity ranging from individuals who experience mild or no symptoms to those with moderate symptoms to those with severe symptoms. The typical way in which distributions are normally divided into different groups is to use the mean plus or minus one standard deviation. However, the distribution of total symptom scores in Study 1 was skewed to the lower end with a large proportion of respondents having no or mild symptoms. Therefore, we divided the distribution into three symptom severity groups using quartiles to approximate a normal distribution. The bottom 25th percentile (total symptom score ≤ 7) represented no or mild symptoms, the 25th to 75th percentile (total symptom score 8–25) represented moderate symptoms, and the 75th percentile and over (total symptom score ≥ 26) represented severe symptoms. Using these cutoff points, 1 (1.1%) of the EHS respondents (from Study 2) was classified as having mild symptoms, 22 (25.0%) with moderate symptoms, and 65 (73.9%) with severe symptoms.

The best way to assess if individuals believe their symptoms are caused by EMFs is to see how they respond to question 68 'if you are sensitive to EMFs, what electrical equipment . . . bothers you the most and what are the symptoms that you experience when you are exposed to the EMF?' Typical EHS sufferers will explicitly describe the object(s) and what symptom(s) occur when they are exposed to that object. Among the EHS respondents in Study 2, only 5 (5.7%) out of the 88 respondents did not openly describe the type of electrical objects they were sensitive to and the symptoms that they experienced when exposed to those objects.

Another important issue to consider when developing an EHS screening tool is that the symptoms cannot be explained by a pre-existing condition. Based on the EHS responses in Study 2, 33 (37.5%) were currently suffering from a chronic illness. Of these, 8 (9.1%) individuals had moderate symptoms and 25 (28.4%) had severe symptoms.

We propose that the following EHS Screening Tool be used to identify individuals who are EHS: (1) a total symptom score greater than or equal to 26, (2) the individual explicitly attributes his or her symptoms to exposure to EMF-producing object(s), and (3) current symptoms cannot be explained by a pre-existing chronic illness. Using these criteria, 38 (43.2%) EHS individuals in Study 2 would fit the profile of someone who is sensitive to EMFs.

It is important to note that almost 40% of our original EHS sample also reported suffering from a chronic illness and this is the primary reason why less than half of the original sample would be classified as fitting the profile of someone who is EHS using the above proposed EHS Screening Tool.

Estimates of the prevalence of EHS have varied dramatically in the media from a few percent up to 30% [Bergqvist and Vogel, 1997]. Population surveys utilizing one question to identify EHS individuals have reported an incidence rate of 1.5% in Sweden [Hillert et al., 2002] and 3.0% in California, USA [Levallois et al., 2002]. Using our EHS Screening Tool, 145 (4.0%) of our random sample in Study 1 fit the profile of individuals who are sensitive to EMFs.

It is important to note that the above EHS Screening Tool is still reliant on the individuals' self-report of the symptoms they experience and their belief that these symptoms are caused by exposure to EMFs. However, until there is reliable evidence that EMFs do cause negative health effects and laboratory tests can measure these effects, self-report is the only way in which EHS individuals can be identified. Previous studies have classified individuals as being EHS based on their response to just one question [e.g., Hillert et al., 2002; Levallois et al., 2002]. The main benefit of the proposed EHS Screening Tool is that it not only takes into account the individual's belief as to the cause of their symptoms but also includes the degree of symptom severity. These criteria therefore provide a more stringent and accurate measure of identifying an EHS individual. Although these criteria are not able to determine actual sensitivity to EMF, they serve as a good indicator of the subjective severity of symptoms experienced by EHS individuals when exposed to EMFs.

Importantly, these criteria can be used as a reliable tool in bioelectromagnetic research to identify those individuals that fit the profile of EHS. By using the EHS Screening Tool researchers can pre-select the most sensitive individuals in terms of their response to EMF exposure to participate in double-blind studies measuring possible health effects from EMF exposure. Researchers can also use the eight subscales identified in Study 1 to investigate what affect EMF exposure has on different symptom groups. Leitgeb and Schröttner [2003] have demonstrated that there are large individual differences in the perception threshold of electric 50 Hz currents with women being more electrosensible than men. Experimenters could examine if there is a relationship between the intensity of the EMF stimulation and perceived severity of symptoms by using this questionnaire measure. The multifaceted symptom indices may also be useful in assessing variations in symptoms in response to different therapeutic interventions such as cognitive behavioral therapy.

In conclusion, individuals with EHS experience a wide range of non-specific health symptoms that occur naturally in the general population. When compared with the general public, EHS sufferers reported a greater severity of symptoms, poorer levels of general health and well being, and attributed the cause of their symptoms to exposure to objects that emit EMFs. A higher percentage of respondents with a chronic illness were found in the EHS group. In addition, a larger proportion of EHS respondents indicated that they had at one time experienced a severe electric shock. Through exploratory factor analysis we have been able to group these symptoms into eight key subscales and developed a valid and reliable screening tool that can be used to identify individuals who are sensitive to EMFs. The EHS Screening Tool includes a symptom scale providing an index for both the type and intensity of symptoms commonly reported by EHS individuals. Future development of the EHS Questionnaire may involve the inclusion of information regarding aspects of illness behavior, coping strategies, and duration and progress of the illness to further refine our understanding of EHS. This tool will be of great value to researchers in bioelectromagnetics in terms of improving the selection and classification of EHS individuals.

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