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The Environmental Symptom-Attribution Scale: Metric properties and normative data

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ABSTRACT

The objective was to develop, metrically evaluate and establish normative data for the Environmental Symptom-Attribution Scale (ESAS), which is a questionnaire-based instrument for quantifying degree to which health symptoms are attributed to specific environmental exposures and sources. Data were used from 3406 individuals who took part in the Västerbotten Environmental Health Study in Sweden. The responders constitute a random sample, aged 18–79 years. They responded to the ESAS and to questions about physician-based diagnoses for evaluation of concurrent validity of the ESAS. Four dimensions of the ESAS were identified, constituting subscales: the Odorous/Pungent, Building-Related, Sound, and Electromagnetic Field Subscales. A Global Scale is available as well. In general, the distributions of the scores on the scales were positively skewed and leptokurtic in shape. The results demonstrate good reliability and concurrent validity of all five ESAS scales. Percentiles were obtained as normative data. Examples of use of the ESAS applied on individuals are provided. The favorable metric properties of the ESAS and its rapid administration suggest that it is useful for assessment in clinical and epidemiological settings.

1. Introduction

Environmental intolerance is a common condition in the general population. Data from a Swedish population-based survey show that as many as 21.6% of the general population report intolerance attributed to at least one of the four environmental exposures: odorous/pungent chemicals, visits in certain buildings, everyday sounds, and electromagnetic fields (EMFs; Nordin et al., 2012). Clinical cases with these intolerances can be referred to as multiple chemical sensitivity (MCS; Labarge & McCaffrey, 2000), nonspecific building-related symptoms (Hodgson & Addorisio, 2005), sensitivity to sounds (Baguley, 2003), and idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF; Genuis & Lipp, 2012).

Several circumstances contribute to make this research field problematic: no identified dose–response relationship, no characteristic symptom pattern, and no generally agreed on physiological markers. This highlights the need for an individually-based rather than group-based approach as well as a subjective rather than an objective approach. In accordance with these approaches, questionnaire-based instruments have been developed that have good metric properties for assessment of environmental intolerances. These include assessment of affective reactions to and behavioral disruptions by odorous/pungent chemicals, sounds and EMFs (Nordin, Bende, & Millqvist, 2004; Nordin, Millqvist, Löwhagen, & Bende, 2003, 2004; Nordin, Palmquist, Bende, & Millqvist, 2012; Nordin, Palmquist, & Claeson, 2012; Weinstein, 1978); symptom reactions to chemical exposure (Bailer, Witthöft, & Rist, 2006; Miller & Prihoda, 1999); IEI symptomology (Andersson, Andersson, Bende, Millqvist, & Nordin, 2009; Miller & Prihoda, 1999); and impact on quality of life in MCS (Miller & Prihoda, 1999).

Apart from general symptoms (e.g., fatigue) that are very common in environmental intolerances, certain symptoms may be relatively common in a certain type of intolerance. For example, airway symptoms dominate in MCS (Andersson et al., 2009), mucosae and skin symptoms among nonspecific building-related symptoms (Edvardsson et al., 2008), attentional and emotional symptoms in sound sensitivity (Andersson, Lindvall, Hursti, & Carlbring, 2002), and skin symptoms in IEI-EMF (Hillert Berglind, Arnetz, & Bellander, 2002). The adverse impact on quality of life is considerable among severe cases of environmental intolerance (e.g., Söderholm, Söderberg, & Nordin, 2011).

Although several risk factors have been identified and underlying mechanisms have been proposed, environmental intolerances are at large considered as medically unexplained symptoms.

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The mechanisms underlying MCS appear not to be referred to toxicity (Das-Munshi, Rubin, & Wessely, 2006) or allergens (Millqvist, 2008). Apart from effects of microbial volatile organic compounds on eye and upper-airway irritation at relatively high concentrations, it has not been possible to demonstrate that nonspecific building-related symptoms are caused by organic compounds at concentrations measured indoors (Korpi, Järnberg, & Pasanen, 2009). Regarding sound sensitivity, mechanical damage to the auditory system it typically not the cause (Baguley, 2003). Furthermore, there is no evidence for health effects from EMF exposure per se at those low levels to which individuals with IEI-EMF typically attribute their symptoms. Instead there is support for a nocebo effect in triggering acute health effects in IEI-EMF (Rubin, Nieto-Hernandez, & Wessely, 2010). This review highlights the importance of the individual's attribution of symptoms to environmental factors.

A few validated questionnaire instruments are available for quantifying degree to which the afflicted person experiences that specific odorous/pungent chemicals have a negative impact on health. Kipen, Hallman, Kelly McNeil, and Fiedler (1995) developed a scale of chemical sensitivity based on ratings of subjective reactions to 122 odorous/pungent chemicals. Partly due to its extensive time consumption, five of these chemicals were extracted to constitute the Chemical Odor Intolerance Index (Szarek, Bell, & Schwartz, 1997). For each odorous/pungent chemical, the respondent rates on a 5-point scale the frequency of feeling ill from the substance. The Quick Environmental Exposure and Sensitivity Inventory was subsequently developed by Miller and Prihoda (1999), and includes a subscale for quantifying the impact of ten odorous/pungent chemicals on health, to be rated on an 11-point scale.

Instruments for assessment of specific environmental exposures and sources to which symptoms are attributed are limited to odorous/pungent chemicals. Since it is common to have symptoms attributed to several types of environmental exposure (odorous/pungent chemicals, certain buildings, sounds and EMFs; Carlsson, Karlsson, Orbaek, Österberg, & Östergren, 2005; Hillert et al., 2002; Nordin et al., 2012), it would be of considerable value to have a questionnaire instrument that can assess symptoms attributed to all these factors. Although not assessing symptoms per se, a broad environmental approach was taken in the late 1980s by Schmidt and Gifford (1989) who developed the Environmental Appraisal Inventory. This inventory was designed to measure appraisal of (i) environmental threat to self, (ii) threat to the environment posed by environmental hazards, and (iii) perceived control over environmental hazards. Some of its items (e.g., chemical dumps, noise and fluorescent lighting) refer to environments of direct relevance for environmental intolerance.

An objective of the present work was to develop a questionnaire-based instrument, called the Environmental Symptom-Attribution Scale (ESAS), for quantifying extent to which symptoms are attributed to environmental exposures and sources of relevance for environmental intolerances. Other objectives were to evaluate its metric properties, and to provide normative data. Examples of application of the ESAS on single individuals are given as well. The ESAS is intended as an inexpensive and time-efficient (≤5 min) instrument to be used in clinical and epidemiological settings for quantifying degree to which health symptoms are attributed to specific environmental exposures. These exposures refer to (i) odorous/pungent chemicals, (ii) environmental aspects related to buildings, (iii) sounds, and (iv) EMF sources. Factor analysis was performed to identify subscales for different types of symptom-attributing factors. In addition to subscales, the ESAS was aimed at providing a global measure of health symptoms attributed to environmental exposures.

The psychometric evaluation was performed with respect to the scales' frequency distribution of scores, reliability (internal consistency), and concurrent validity. The concurrent validity was represented by the ability of the ESAS to differentiate groups of persons with a physician-based diagnosis of environmental intolerance from referents (persons without these diagnoses). In addition to normative data for a general population, reference data were obtained for combinations of specific age groups and gender. Finally, two intolerant individuals are given as examples to illustrate how the ESAS can be used to identify specific environmental exposures to which the individual attributes his/her health symptoms. This was conducted by means of a population-based study, the Västerbotten Environmental Health Study.

2. Methods

2.1. Study population and sample

The Västerbotten Environmental Health Study is an embracing name for different investigations on the same general population regarding various forms of environmental intolerance in Sweden. The study population, inhabitants in the county of Västerbotten in Northern Sweden, has an age and gender distribution that is very similar to that of Sweden in general (Statistics Sweden, 2012). A random sample, drawn from the municipal register, of 8520 individuals aged 18–79 years was invited to participate. The sample was stratified for age and gender according to the following age strata: 18–29, 30–39, 40–49, 50–59, 60–69, and 70–79 years. Of the 8520 individuals, 3406 (40.0%) participated. Age and gender distributions for the sample are given in Table 1. The highest non-response rate is found among men aged 18–29 years. The sample is further described in Table 2 with respect to demographic, environmental and health issues of relevance to environmental intolerance.

2.2. The Environmental Symptom-Attribution Scale

The items of the ESAS are forty environments and sources to which persons with MCS, nonspecific building-related symptoms, sound sensitivity, and IEI-EMF often attribute their health symptoms (e.g., Andersson et al., 2002; Hansson Mild, 2006; Miller, 2001; Norbäck, 2009). The ESAS items and their relative order are presented in Table 3. The general instruction for the ESAS is "Rate to what extent the following environments/sources bother you." Each environment is rated on the Environmental Annoyance Scale, which is a category scale with seven semantic descriptors: "Not at all (0)", "a little (1)", "partly (2)", "pretty much (3)", "rather much (4)", "to a large extent (5)", and "extremely much (6)". It has ratio-scale properties and good reliability and validity (Nordin, Lidén, & Gidlöf-Gunnarsson, 2009).

2.3. Additional questions

A questionnaire was used that included questions on background information pertaining to the demographic, environmental and health issues (Table 2). The questions about diagnoses were

Table 1
Numbers of responders (and response percentages) across age and gender strata.

Age strata (years)	Women	Men
18–29	307 (32.7%)	179 (17.7%)
30–39	266 (40.9%)	177 (25.2%)
40–49	288 (40.7%)	230 (31.3%)
50–59	367 (51.0%)	295 (39.7%)
60–69	405 (58.6%)	356 (50.7%)
70–79	265 (53.8%)	271 (63.9%)
18–79	1898 (45.2%)	1508 (34.9%)

Table 2
Description of the responders ($n = 3406$).

Age (years; mean ± SD)	51.2 ± 16.8
Women/men, *n* (%)	1898/1508 (55.7/44.3%)
Education (highest), *n* (%)	
Primary school	823 (24.5%)
High school	1137 (33.8%)
University	1405 (41.8%)
Smoker	298 (8.8%)
General health status, *n* (%)	
Very good or excellent	1349 (40.0%)
Good	1152 (34.2%)
Somewhat good or poor	868 (25.8%)
Diagnosis,[a] *n* (%)	
Multiple chemical sensitivity or sensory hyperreactivity	112 (3.3%)
Nonspecific building-related symptoms	47 (1.4%)
Sound sensitivity	96 (2.8%)
IEI-EMF[b]	15 (0.4%)
Asthma due to allergy	164 (4.8%)
Asthma without allergy as known cause	129 (3.8%)
Allergic rhinitis	298 (8.7%)
Chronic sinusitis	26 (0.8%)
Tinnitus	256 (7.5%)
Migraine	151 (4.4%)
ADHD[c]	17 (0.5%)
Bell's palsy	13 (0.4%)

[a] Self-report of having been given a diagnosis by a physician.
[b] Idiopathic environmental intolerance attributed to electromagnetic fields.
[c] Attention-deficit/hyperactivity disorder.

stated as "Have you been diagnosed by a physician for the following conditions?" Among these conditions were those used for assessing concurrent validity: MCS and sensory hyperreactivity (SHR, a subgroup of MCS; Millqvist, 2008), nonspecific building-related symptoms, sound sensitivity, and IEI-EMF.

2.4. Procedure

The respondents were mailed the questionnaire, to be returned by mail with prepaid postage. Non-responders received up to two reminders. All participants responded to the questionnaire during the period March–April, 2010, before the onset of the pollen season in Västerbotten. The study was approved by the Umeå Regional Ethics Board, and has therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. All respondents gave their informed consent prior to their inclusion in the study.

2.5. Statistical analysis

Factor analysis with Varimax rotation of the ESAS data was conducted to study dimensionality, and thus identify subscales of the ESAS. A scree test plot was made to identify the number of factors to be extracted (Cattell, 1966). Descriptive statistics and Cronbach α coefficients were computed for the identified subscales and global scale of the ESAS. Separate Mann–Whitney U tests (due to non-normal distributions) for scores on each subscale and the global scale were conducted between groups with scale-relevant diagnosis and scale-relevant reference groups. IBM SPSS Statistics 19 (IBM Corporation, New York) was used for statistical analysis.

3. Results

3.1. Dimensionality

The factor analyses identified six factors with an eigenvalue above 1. Their eigenvalues were 16.25 (40.63% explained variance), 3.41 (8.52%), 1.94 (4.86%), 1.67 (4.17%), 1.09 (2.72%), and 1.02 (2.55%). However, a scree-test plot suggests only four factors to be extracted (Fig. 1; the number of factors preceding the last "elbow"). The factor loadings of each ESAS item on each of the four factors are presented in Table 3. The ten items that loaded strongest on Factor 1 can be referred to EMF sources; the thirteen items that loaded strongest on Factor 2 can be referred to environmental aspects related to buildings; the nine items that loaded strongest on Factor 3 can be referred to sounds; and the eight items that loaded strongest on Factor 4 can be referred to odorous/pungent chemicals. Based on these results, an Odorous/Pungent Subscale (Factor 4), a Building-Related Subscale (Factor 2), a Sound Subscale (Factor 3), and an EMF Subscale (Factor 1) were established for the ESAS (Table 3). A global scale consists of all 40 items.

3.2. Scoring of the Environmental Symptom-Attribution Scale

As a first step, the unweighted sum of the 8 odorous/pungent, 13 building-related, 9 sound, and 10 EMF items are calculated to constitute the score on each subscale. The unweighted sum of all 40 items is calculated to constitute the score on the global scale. For enhanced comparability between scales, the sum is multiplied with a certain factor for each scale. This factor is 100/48 for the Odorous/Pungent Subscale, 100/78 for the Building-Related Subscale, 100/54 for the Sound Subscale, 100/60 for the EMF Subscale, and 100/240 for the Global Scale. Thereby, each scale ranges from 0 to 100 (high score representing high attribution of health symptoms).

3.3. Frequency distributions and normative data

Descriptive statistics for the four subscales and global scale of the ESAS are presented in Tables 4–8. Data are given for combinations of specific age groups [young (18–34 years), middle-aged (35–54 years), and elderly (55–79 years)] and gender, for the three age groups separately, for gender separately, and for the total sample. The values for skewness and kurtosis suggest positively skewed and leptokurtic distributions for four of the scales. Therefore, scale scores representing percentiles are given to constitute normative data (Tables 4–8). Since the distributions for the Building-Related Subscale are approximately normal in shape means and standard deviations are given as well for this subscale.

3.4. Reliability

Cronbach α coefficients of internal consistency are given in Tables 4–8 for combinations of specific age groups and gender, for the three age groups separately, for gender separately, and for the total sample. These coefficients range from 0.849 to 0.964, suggesting good to excellent reliability of the four subscales and the global scale of the ESAS.

3.5. Validity

Table 2 shows the number of respondents who reported a physician-based diagnosis of a certain form of environmental intolerance (MCS, nonspecific building-related symptoms, sound sensitivity, and IEI-EMF). These respondents were compared on the diagnosis-relevant ESAS subscale with a group of referents (remaining of the 3406 participants who reported no such diagnosis). For example, the 112 respondents with a diagnosis of MCS or SHR were compared on the Odorous/Pungent Subscale with 3294 referents without an MCS or SHR diagnosis, and the 47 respondents with a diagnosis of nonspecific building-related symptoms were compared on the Building-Related Subscale with 3359 referents without a diagnosis of nonspecific building-related symptoms. Median scores on the four subscales and the global scale for the

Table 3
Factor loadings after rotation for the four major factors for each item of the Environmental Symptom-Attribution Scale. The strongest factor loading for each item is given in bold.

Item order	Item	Factor 1	Factor 2	Factor 3	Factor 4
32	EMFs from home electronics (e.g. TV/radio/stereo)[1]	**0.781**	0.090	0.247	0.199
12	EMFs from cell towers for cell phones[1]	**0.778**	0.267	0.075	0.105
8	EMFs from wireless phones[1]	**0.769**	0.189	0.133	0.135
19	EMFs from computers/computer screens[1]	**0.764**	0.146	0.201	0.228
31	EMFs from fluorescent lamps/low energy lamps[1]	**0.740**	0.141	0.223	0.170
2	EMFs from other persons' cell phones[1]	**0.726**	0.087	0.143	0.217
26	EMFs from train trips[1]	**0.713**	0.107	0.262	0.205
28	EMFs from own use of cell phones[1]	**0.689**	0.157	0.168	0.100
34	EMFs from office machines (e.g. copy machines)[1]	**0.673**	0.124	0.256	0.162
37	EMFs high-voltage transmission lines[1]	**0.593**	0.440	0.137	0.035
35	Smell from mold[2]	0.105	**0.763**	0.123	0.160
6	Stale ("bad") air[2]	0.135	**0.700**	0.278	0.214
11	Dust and dirt[2]	0.147	**0.594**	0.171	0.318
5	Mechanical, monotone sounds/buzzing machines[2]	0.267	**0.578**	0.141	0.158
38	Draft[2]	0.188	**0.527**	0.316	0.153
40	Dry air[2]	0.168	**0.505**	0.312	0.253
9	Smell from tobacco smoke[2]	0.070	**0.499**	0.128	0.303
3	Damp air[2]	0.341	**0.462**	0.213	0.413
4	Visual damage from damp (e.g. stains, condensation on windows, carpets coming off)[2]	0.189	**0.451**	0.450	0.148
24	Light that is dim or gives off glare or reflects[2]	0.182	**0.447**	0.404	0.237
13	Plastic[2]	0.333	**0.395**	0.251	0.384
17	Low room temperature[2]	0.123	**0.350**	0.300	0.138
14	High room temperature[2]	0.114	**0.349**	0.290	0.226
7	Chinking from chinaware/clanking/clattering sounds[3]	0.181	0.316	**0.669**	0.158
25	Sound from hammer strokes[3]	0.172	0.285	**0.623**	0.139
15	Background sounds from radio/stereo/TV[3]	0.233	0.195	**0.587**	0.228
18	Speech sounds[3]	0.297	0.129	**0.583**	0.277
33	Paper rustling[3]	0.354	0.103	**0.578**	0.260
36	Traffic noise[3]	0.252	0.500	**0.567**	0.104
39	Alarm signals and similar unexpected sounds[3]	0.186	0.415	**0.534**	0.100
27	Sounds from cell phones (ring signals/conversations)[3]	0.389	0.214	**0.523**	0.197
21	Surging ventilation/dull fan sounds[3]	0.189	0.365	**0.523**	0.179
16	Smell from cleaning agents[4]	0.231	0.263	0.215	**0.672**
10	Smell from flowers/plants[4]	0.202	0.182	0.163	**0.659**
22	Smell from newly painted surfaces[4]	0.174	0.331	0.250	**0.639**
1	Smell from perfume[4]	0.097	0.230	0.116	**0.634**
20	Smell from newly laid carpets[4]	0.318	0.208	0.254	**0.614**
23	Smell from solvents[4]	0.148	0.445	0.213	**0.571**
30	Smell from car exhaust[4]	0.235	0.472	0.229	**0.509**
29	Smell from newly printed newspapers[4]	0.298	0.204	0.233	**0.480**

Included in the [1]EMF, [2]Building-Related, [3]Sound, and [4]Odorous/Pungent Subscale.

subgroups are shown in Fig. 2. Mann–Whitney *U* tests yielded significant differences in scores between the subscale-relevant diagnosis group and corresponding reference group for all ESAS subscales ($p < 0.001$). Two-hundred and fourteen respondents reported having been given at least one of the four diagnoses of environmental intolerance (168 reported having been given one of the diagnoses, 37 reported two diagnoses, eight reported three diagnoses, and one reported all four diagnoses). A Mann–Whitney *U* test of scores on the Global Scale showed a significant difference between the 214 respondents with an environmental intolerance diagnosis and the 3192 participants without a diagnosis, constituting a reference group ($p < 0.001$). The higher scores for the diagnosis groups suggest good concurrent validity of the ESAS.

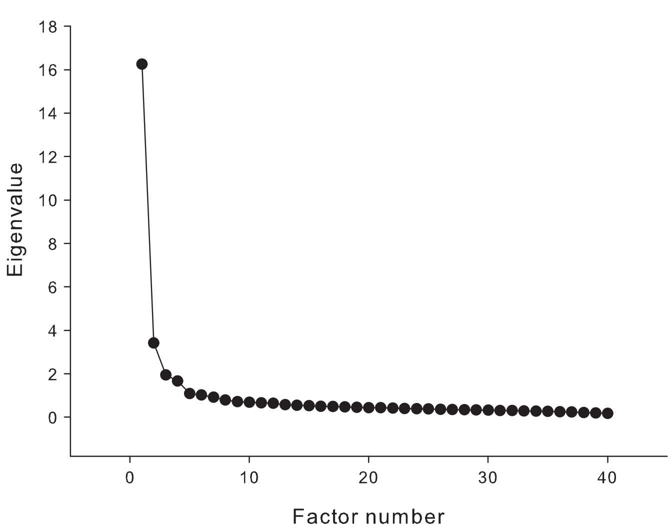

Fig. 1. Scree test plot of eigenvalues for the 40 factors.

3.6. *Examples of individual application of the Environmental Symptom-Attribution Scale*

Fig. 3 exemplifies with two individuals, Subject A and Subject B, how the ESAS can be used to better understand a case of environmental intolerance. The figure also shows normative data (median scores) for comparison.

Subject A is a 21 year old, non-smoking woman who reported intolerance to environmental odorous/pungent chemicals and to certain buildings. She had not sought medical attention for her environmental intolerances. Her predominant symptoms attributed to the environmental exposure were shortness of breath and fatigue. Her score was 35 on the Odorous/Pungent Subscale, 36 on the Building-Related Subscale, 33 on the Sound Subscale, 15 on the

Table 4
Descriptive statistics for scores on the Odorous/Pungent Subscale of the Environmental Symptom-Attribution Scale constituting normative data, and the scale's reliability (Cronbach α) for various subgroups and for the total sample.

	Young women (n = 441)	Young men (n = 265)	Middle-aged women (n = 597)	Middle aged men (n = 455)	Elderly women (n = 860)	Elderly men (n = 788)	All young (n = 706)	All middle aged (n = 1052)	All elderly (n = 1648)	All women (n = 1898)	All men (n = 1508)	Total sample (n = 3406)
Percentile												
5	0	0	0	0	2.1	0	0	0	2.1	0	0	0
10	2.1	0	2.1	1.2	6.2	4.2	0	2.1	4.2	2.1	2.1	2.1
25	6.2	2.1	8.3	6.2	12.5	8.3	4.2	8.3	10.4	10.4	6.2	8.3
50	14.6	10.4	18.7	14.6	22.9	16.7	12.5	16.7	20.8	18.7	14.6	16.7
75	27.1	18.5	31.2	25.0	39.6	30.8	22.9	29.2	35.4	33.3	27.1	31.2
90	39.6	30.0	45.8	41.7	60.4	45.8	35.4	43.7	54.2	50.0	41.7	45.8
95	45.8	35.4	56.5	50.0	68.7	60.4	45.8	54.2	66.7	62.6	52.1	60.4
Min–Max	0–79.2	0–77.1	0–87.5	0–100	0–95.8	0–100	0–79.2	0–100	0–100	0–95.8	0–100	0–100
Skewness	1.17	1.73	1.11	1.53	0.96	1.39	1.35	1.27	1.15	1.12	1.51	1.27
Kurtosis	1.50	4.13	1.15	3.13	0.48	2.03	2.11	1.82	1.03	1.06	2.68	1.61
Cronbach α	0.849	0.859	0.882	0.883	0.905	0.905	0.856	0.883	0.907	0.894	0.898	0.897

Young = 18–34 years, middle-aged = 35–54 years, elderly = 55–79 years.

EMF Subscale, and 30 on the Global Scale of the ESAS. Based on normative ESAS data for young women (Tables 4–8), she falls between the 75th and 90th percentile for the Odorous/Pungent, Sound and EMF Subscales and Global Scale, and between the 50th and 75th on the Building-Related Subscale. At first sight it may seem inconsistent to be intolerant to certain buildings, yet not score particularly high on the Building-Related Subscale. However, when obtaining a general picture based on the ratings on the four subscales (Fig. 3) it seems to be predominantly the activities of persons in certain buildings, more than the buildings per se, that are underlying the intolerance to certain buildings. Thus, cleaning agents and perfume as odorous/pungent chemicals, clinking/clanking/clattering and possibly traffic noise reaching the indoor environment as sounds, and computers and screens as EMF sources may be explaining much of Subject A's complaints toward certain buildings.

Subject B is a 56 year old, non-smoking woman who reported having the physician-based diagnoses MCS, sound sensitivity, and IEI-EMF. Her predominant symptoms attributed to the exposure were nasal congestion/discharge and facial redness. Her score was 62 on the Odorous/Pungent Subscale, 69 on the Building-Related Subscale, 62 on the Sound Subscale, 65 on the EMF Subscale, and 65 on the Global Scale of the ESAS. Based on normative ESAS data for old women (Tables 4–8), she falls between the 90th and 95th percentile for the Odorous/Pungent and Sound Subscales, and above the 95th percentile for Building-Related and EMF Subscales and the Global Scale. Compared to normative data she rates practically all 40 exposures as highly symptom triggering (Fig. 3). In terms of intervention, this suggests that an approach focusing on individual factors (e.g., stress and environmental health worry) may be an alternative to attempting to remove single odorous/pungent chemicals, sound sources, and EMF sources.

4. Discussion

The objectives of this study was to develop and metrically evaluate the ESAS for quantifying degree of self-reported health effects attributed to specific types of environmental exposure of relevance for common forms of environmental intolerance. Based on data from a large population-based survey (n = 3406) and subsequent factor analysis, four subscales of the ESAS were established pertaining to odorous/pungent chemicals (Odorous/Pungent Subscale), buildings (Building-Related Subscale), sounds (Sound Subscale), and EMF sources (EMF Subscale). The 40 items together constitute the Global Scale of the ESAS. The metric evaluation showed very good reliability (internal consistency) of all five ESAS scales. Based on the assumption that the diagnoses of environmental intolerance given by a physician are valid, the significantly higher scores for the subscale-relevant diagnosis groups compared to corresponding reference groups suggest good concurrent validity of all five ESAS scales. Due to predominantly positively skewed and leptokurtic distributions, percentiles were provided to

Table 5
Descriptive statistics for scores on the Building-Related Subscale of the Environmental Symptom-Attribution Scale constituting normative data, and the scale's reliability (Cronbach α) for various subgroups and for the total sample.

	Young women (n = 441)	Young men (n = 265)	Middle-aged women (n = 597)	Middle aged men (n = 455)	Elderly women (n = 860)	Elderly men (n = 788)	All young (n = 706)	All middle aged (n = 1052)	All elderly (n = 1648)	All women (n = 1898)	All men (n = 1508)	Total sample (n = 3406)
Percentile												
5	4.0	1.7	6.4	3.6	9.0	6.4	2.6	3.8	6.4	6.4	3.8	5.1
10	9.0	6.4	11.3	5.9	11.5	9.0	7.7	7.7	10.3	11.5	7.7	9.0
25	17.9	10.3	17.9	14.1	20.5	17.9	15.4	15.4	19.2	19.2	15.4	16.7
50	30.8	21.8	29.5	24.4	34.6	28.2	25.6	26.9	30.8	32.1	25.6	29.5
75	42.3	30.8	43.6	37.2	47.4	41.0	38.5	41.0	43.6	44.9	38.5	42.3
90	52.6	42.3	56.7	48.0	61.5	52.6	51.3	52.6	57.7	57.7	50.0	55.1
95	58.8	50.9	62.8	57.7	67.9	59.0	56.4	61.5	65.4	65.4	57.7	62.8
Mean	31.9	22.7	31.7	26.2	35.3	29.8	27.7	29.3	32.7	33.1	27.5	30.6
SD	16.6	15.2	17.3	16.6	18.2	16.3	16.5	17.2	17.5	17.7	16.4	17.4
Min–Max	0–80.8	0–80.8	0–92.3	0–85.9	0–83.3	0–84.6	0–80.8	0–92.3	0–84.6	0–92.3	0–85.9	0–92.3
Skewness	0.27	0.88	0.43	0.68	0.31	0.43	0.48	0.53	0.41	0.36	0.57	0.46
Kurtosis	−0.44	0.89	−0.33	0.20	−0.52	−0.27	−0.23	−0.17	−0.38	−0.42	−0.03	−0.29
Cronbach α	0.873	0.889	0.892	0.900	0.897	0.896	0.883	0.898	0.899	0.891	0.899	0.896

Young = 18–34 years, middle-aged = 35–54 years, elderly = 55–79 years.

Table 6
Descriptive statistics for scores on the Sound Subscale of the Environmental Symptom-Attribution Scale constituting normative data, and the scale's reliability (Cronbach α) for various subgroups and for the total sample.

	Young women ($n = 441$)	Young men ($n = 265$)	Middle-aged women ($n = 597$)	Middle aged men ($n = 455$)	Elderly women ($n = 860$)	Elderly men ($n = 788$)	All young ($n = 706$)	All middle aged ($n = 1052$)	All elderly ($n = 1648$)	All women ($n = 1898$)	All men ($n = 1508$)	Total sample ($n = 3406$)
Percentile												
5	0	0	0	0	1.9	0.8	0	0	1.9	0	0	0
10	1.9	0	3.7	1.9	3.7	3.7	1.9	2.4	3.7	3.7	1.9	1.9
25	7.4	5.6	9.3	5.6	9.3	9.3	5.6	7.4	9.3	9.3	7.4	9.3
50	16.7	13.0	18.5	14.8	20.4	18.5	14.8	16.7	20.4	18.5	16.7	18.5
75	27.8	24.1	33.3	27.8	33.3	31.5	25.9	29.6	33.3	31.5	29.6	31.5
90	42.2	37.0	48.1	38.9	51.9	46.3	38.9	46.3	48.1	48.1	40.7	46.3
95	51.9	44.4	55.6	50,7	63.0	57.4	50.0	55.6	61.1	57.4	53.7	57.4
Min–Max	0–81.5	0–75.9	0–92.6	0–100	0–94.4	0–94.4	0–81.5	0–100	0–94.4	0–94.4	0–100	0–100
Skewness	1.10	1.28	0.90	1.42	0.90	1.03	1.16	1.11	1.06	1.05	1.18	1.11
Kurtosis	1.25	1.84	0.44	2.75	0.84	0.82	1.43	1.26	0.92	0.95	1.07	1.16
Cronbach α	0.870	0.888	0.886	0.895	0.908	0.901	0.877	0.890	0.905	0.895	0.899	0.896

Young = 18–34 years, middle-aged = 35–54 years, elderly = 55–79 years.

constitute normative data for young, middle-aged and elderly adults, for women and men, for various combinations of age groups and gender, and for the general population.

Based on ESAS data alone it is not possible to determine the mechanisms underlying the health problems that are mediated by the identified environment. Sensitization (Eriksen & Ursin, 2004), neurogenic inflammation (Bascom et al., 1997), and classical conditioning (Bolla-Wilson, Wilson, & Bleecker, 1988) are commonly proposed mechanisms in environmental intolerance. However, toxicity, allergens, mechanical impact and radiation, for example, cannot be fully ruled out as mechanisms. In fact, attribution of symptoms to a specific environment is no guarantee for that environment at all being involved in the genesis of the health problem. Nevertheless, the EASA can provide valuable information about potential attribution or exposure problems in the investigation of individual cases or groups of individuals. The two examples of individual cases given above illustrate how the ESAS can be used to provide useful information for clinical investigation and

Table 7
Descriptive statistics for scores on the EMF Subscale of the Environmental Symptom-Attribution Scale constituting normative data, and the scale's reliability (Cronbach α) for various subgroups and for the total sample.

	Young women ($n = 441$)	Young men ($n = 265$)	Middle-aged women ($n = 597$)	Middle aged men ($n = 455$)	Elderly women ($n = 860$)	Elderly men ($n = 788$)	All young ($n = 706$)	All middle aged ($n = 1052$)	All elderly ($n = 1648$)	All women ($n = 1898$)	All men ($n = 1508$)	Total sample ($n = 3406$)
Percentile												
5	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0
50	1.7	1.7	3.3	1.7	6.7	5.0	1.7	3.3	5.0	3.3	3.3	3.3
75	11.7	6.7	15.0	11.7	20.0	16.7	10.0	13.3	18.3	16.7	15.0	15.0
90	26.7	18.3	30.0	25.0	38.3	31.7	22.2	26.6	35.0	31.7	28.3	30.0
95	33.2	31.2	46.7	36.7	53.3	44.2	31.7	42.3	50.0	46.7	39.3	45.0
Min–Max	0–63.3	0–96.7	0–93.3	0–100	0–100	0–96.7	0–96.7	0–100	0–100	0–100	0–100	0–100
Skewness	2.17	3.55	2.19	2.79	1.76	1.98	2.67	2.43	1.87	2.00	2.40	2.16
Kurtosis	5.01	16.07	5.28	9.57	3.06	4.28	8.84	6.99	3.63	4.28	6.84	4.65
Cronbach α	0.914	0.945	0.933	0.943	0.934	0.936	0.925	0.937	0.936	0.932	0.940	0.935

Young = 18–34 years, middle-aged = 35–54 years, elderly = 55–79 years.

Table 8
Descriptive statistics for scores on the Global Scale of the Environmental Symptom-Attribution Scale constituting normative data, and the scale's reliability (Cronbach α) for various subgroups and for the total sample.

	Young women ($n = 441$)	Young men ($n = 265$)	Middle-aged women ($n = 597$)	Middle aged men ($n = 455$)	Elderly women ($n = 860$)	Elderly men ($n = 788$)	All young ($n = 706$)	All middle aged ($n = 1052$)	All elderly ($n = 1648$)	All women ($n = 1898$)	All men ($n = 1508$)	Total sample ($n = 3406$)
Percentile												
5	2.5	1.0	3.3	2.1	4.6	3.3	1.7	2.8	4.2	3.7	2.3	2.9
10	5.4	2.5	5.8	3.6	7.5	5.4	4.2	5.0	6.2	6.2	4.2	5.4
25	10.4	6.7	11.7	8.3	13.7	10.8	8.7	10.0	12.1	12.1	9.2	10.8
50	17.9	12.5	20.0	15.8	23.3	18.7	15.4	18.3	21.2	20.8	16.7	19.2
75	27.5	21.7	30.4	26.2	35.4	30.0	25.8	28.7	32.9	32.1	27.9	30.0
90	37.1	30.8	42.9	37.2	48.7	40.8	35.4	40.7	45.0	44.2	38.7	41.7
95	44.2	37.1	47.6	44.7	58.7	51.7	42.5	46.7	56.2	53.7	46.2	51.2
Min–Max	0–66.7	0–74.2	0–70.4	0–95.4	0–83.7	0–74.2	0–74.2	0–95.4	0–83.7	0–83.7	0–95.4	0–95.4
Skewness	0.81	1.50	0.82	1.37	0.79	0.98	1.01	1.03	0.88	0.86	1.16	0.98
Kurtosis	0.47	3.49	0.44	2.87	0.25	0.84	1.18	1.30	0.50	0.52	1.64	0.90
Cronbach α	0.946	0.957	0.955	0.962	0.962	0.964	0.951	0.958	0.963	0.958	0.963	0.960

Young = 18–34 years, middle-aged = 35–54 years, elderly = 55–79 years.

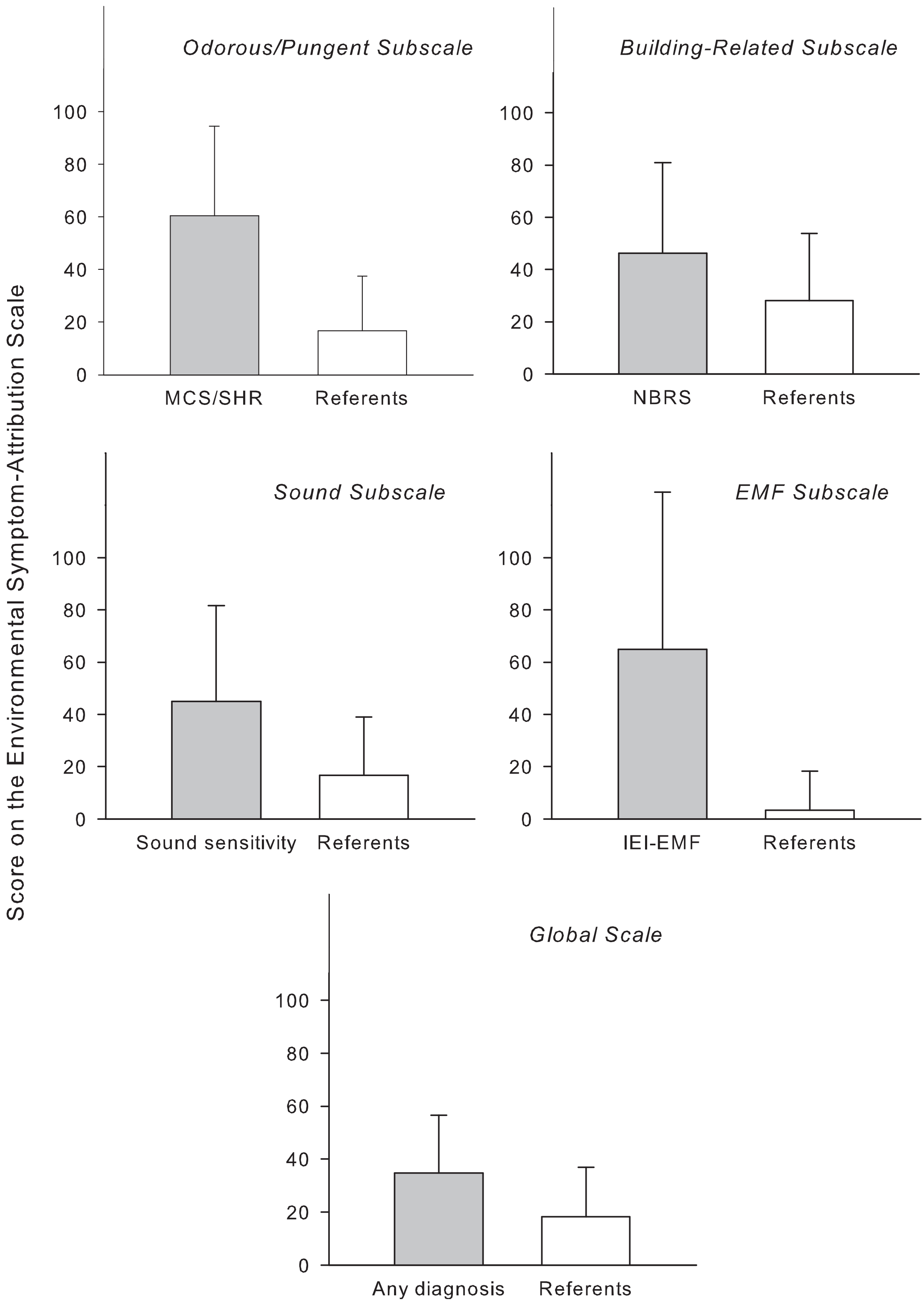

Fig. 2. Median (+interquartile range) scores on the four subscales and the Global Scale of the ESAS for respondents with a diagnosis and without a diagnosis (referents) of relevance for the specific scale. MCS = Multiple chemical sensitivity, SHR = sensory hyperreactivity, NBRS = nonspecific building-related symptoms, and IEI-EMF = idiopathic environmental intolerance attributed to electromagnetic fields.

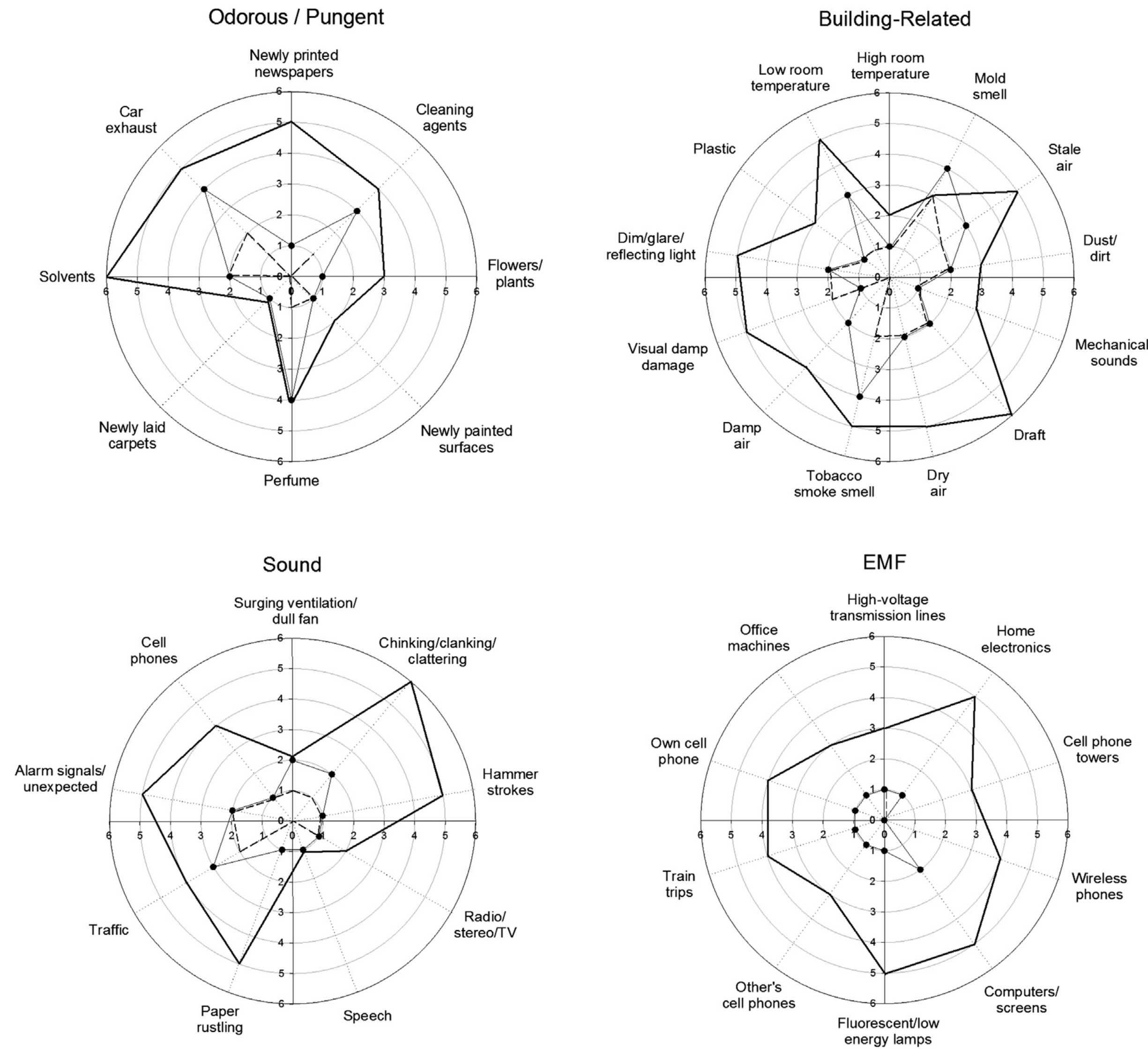

Fig. 3. Examples of application of the ESAS on two individuals (see text for further information), Subjects A (thin line with filled circles) and Subject B (bold line) with outcome on the four subscales. Dashed lines represent normative data that are median scores for the population-based sample.

intervention. Thus, regarding Subject A it appears that it predominantly is the activities of persons in certain buildings, more than the buildings per se, that are underlying the intolerance to certain buildings. Regarding Subject B it appears that an intervention approach focusing on individual factors (e.g., stress and environmental health worry) may be an alternative to attempting to remove single odorous/pungent chemicals, sound sources, and EMF sources.

The study population has an age and gender distribution that is very similar to that of Sweden in general (Statistics Sweden, 2012). This enhances generalization of the findings for use of the ESAS on the general Swedish population and similar populations. However, among the randomly selected individuals only 40% volunteered. This is a somewhat low percentage, with consequences for the representativeness. Research ethical regulations for conducting research in Sweden do not allow asking the selected individuals why they chose not to participate or about certain characteristics they may possess (Proposition 2007/08:44). However, information on age and gender was available for those who declined participation, and the largest proportion of non-responders was found among young men. Assuming that young men to a relatively low degree are bothered by environmental exposures (Sears, 2007), the normative data for young men, all men, and the total sample may have somewhat higher scores than otherwise would have been the case.

It is possible that individuals who are sensitive to environmental exposures, compared to those who are not sensitive, are more likely to agree to participate, since they may be more inclined to find this type of study to be important. If so, this may also have contributed to slightly higher mean scores. When using the normative data from this study one should therefore bear in mind that the comparison of the obtained ESAS scores with the normative data may be a slight underrepresentation of the individual's attribution of symptoms to environmental exposures. With this in mind, the ESAS can be recommended for reliable and valid quantification of self-reported health effects attributed to specific forms of environmental exposures.

In conclusion, the results from the present study suggest that the ESAS with its four subscales and global scale has good reliability and validity for quantifying to what extent health symptoms are attributed to odorous/pungent chemicals, buildings, sounds, and EMF sources. The fact that the ESAS is fast to administer (≤5 min) makes it appropriate for use in clinical and epidemiological settings.

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