Quantifying Environmental Intolerance: Digital Reports From Daily Life

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Abstract

Environmental intolerance (EI) is a condition characterized by low tolerance to environmental stimuli at levels that would not affect most people. EI is an ill-defined condition from which sufferers experience highly individual multisystem symptoms following exposure from specific environmental sources. Subgroups of EI are typically distinguished by the source that cause negative effects. In this study, intolerance attributed to noise and odors was investigated. Most research on EI is conducted using cross sectional approaches and among the instruments used to quantify EI is the Noise Sensitivity Scale (NSS-11) and the Chemical Sensitivity Scale for Sensory Hyperreactivity (CSS-SHR). To fully understand EI, more longitudinal research is needed. The aim of this study was to establish how a recently developed smartphone app, intended for longitudinal research, compares to the NSS-11 and CSS-SHR with regards to its ability to detect EI. 12 participants (mean age 29 years, SD=10.7 years) filled out the NSS-11/CSS-SHR following a period of two weeks using the app. It was hypothesized that individuals scoring high/low on the NSS-11/CSS-SHR would also express high/low levels of EI as measured by reports in the app on the variables discomfort rating, number of unique symptoms reported and number of reports. Although analyses revealed effects in the direction of the hypothesis for all variables, Independent samples t-test analyses yielded no significant associations. Either there are in fact no differences, but speculatively, the lack of significant associations can also be attributed any the following: (1) the groups were to similar (2) the sample was too small (3) the participants used avoidance as coping strategies.

Abstrakt

Miljöintolerans (MI) är en åkomma som karaktäriseras av låg tolerans mot stimuli från omvärlden vid nivåer som inte påverkar majoriteten av befolkningen. MI är en svårdefinierad åkomma där stimuli från specifika källor i omvärlden efterföljs av högst individuella symtom i flertalet kroppsliga system. Undergrupper av MI kännetecknas vanligtvis av källan som ger upphov till symptomen. I den här studien undersöks intoleranser som tillskrivits buller och lukter. Majoriteten av forskningen inom MI görs genom tvärsnittsstudier och bland instrumenten som används för att kvantifiera MI finns Noise Sensitivity Scale (NSS-11) och Chemical Sensitivity Scale for Sensory Hyperreactivity (CSS-SHR). För att fullt ut förstå MI krävs mer longitudinell forskning. Målet med den här studien var att utröna hur en nyligen utvecklad smartphone-app, avsedd för longitudinell forskning, jämför sig med NSS-11 och CSS-SHR med avseende på dess förmåga att upptäcka MI. 12 deltagare (medelålder 29 år, standardavvikelse=10.7 år) fylde i NSS-11 och CSS-SHR efter att de använt sig av appen under en tvåveckors period. Det hypotiserades att individer som fick höga poäng på NSS-11/CSS-SHR också skulle uttrycka högre grad av MI, mätt genom rapporter i appen på variablerna obehags-skattning, antal unika symptom och antal rapporter. Trots att analyserna som gjordes kunde påvisa effekter i riktningen av hypotesen för alla variabler så visade ett oberoende t-test att dessa skillnader inte var signifikanta. Antingen stämmer det att det inte finns några kopplingar, men det är även möjligt att bristen på signifikanta resultat kan härledas till någon/några av följande saker: (1) för stora likheter mellan grupperna (2) för litet urval (3) deltagarna använde sig av strategier för att undvika exponering.
Quantifying environmental intolerance:
Digital reports from daily life

Background

The environment in which we live can sometimes be experienced as overwhelming, such as when visiting loud and crowded environments with exaggerated sensory input or being exposed to prolonged noise or odor of extreme character. Such sensory pollutions are often accompanied by negative psychological and physiological effects. For most people brief exposures to sensory polluted environments are manageable, and situations in which sensory input are experienced as overwhelming are the exception rather than the normal case. However, there are groups who display sensitivities to environmental sensory input at levels that would not affect most people. Individuals in these groups are collectively referred to as suffering from environmental intolerance (EI). There are different subgroups of EI, typically distinguished by the source that cause negative effects. The sources commonly (but not exclusively) attributed to EI are odors/chemicals, noise, electromagnetic fields and certain buildings (Frías, 2015; Palmquist, Claeson, Neely, Stenberg, & Nordin, 2014).

According to Frías, (2015), EI is estimated to affect between 0.2% and 20.3% of the population, depending on sample and diagnostic criteria. In a review by Witthöft and Hiller, (2010) a prevalence between 15 and 30% for minor EI symptoms was reported for the general population. The same review reported that 1-4% of the population fulfill the more restrictive criteria for EI.

Common to all types of EI is that the condition is often ill-defined and sufferers experience highly individual multisystem symptoms following exposure from specific environmental sources (Frías, 2015). Some of the symptoms frequently reported are attention- and memory deficits, skin and eye irritation, irritation in mucous membranes, nausea, headaches, fatigue, anxiety and sleep disturbances (Frías, 2015; IPCS, 1996; Palmquist et al., 2014; Paulin, Andersson, & Nordin, 2016).

The wide range of symptoms accompanying EI, together with a lack of physiological basis makes detectability and diagnosing difficult. The term multiple chemical sensitivity (MCS) was previously used to describe conditions in which patients lack the ability to adapt to common environmental (chemical) exposures at lower levels than those of the general population. In 1996, an interdisciplinary workshop suggested the term idiopathic environmental intolerance (IEI) to be used, for conditions with symptomatology similar to that of MCS (IPCS, 1996). This terminology was proposed to eschew any suggestions of causation and at the same time it was argued to provide a less categorical description of MCS, as it had been proposed that also non-chemical triggers can be the source of similar illnesses. The term idiopathic in the context of IEI serves to highlight the fact that the condition is of unknown causation. In this paper, the term EI will be used to denote intolerances with known (presumed) causations.

The largely similar symptomatology between different EIs together with the lack of physiological basis for the conditions have raised speculations of some common underlying mechanism. A large (n=3406), survey-based, cross sectional study investigating health patterns in Västerbotten, Sweden, found support for overlaps between all four intolerances with the exception of overlaps between intolerance to sounds and electromagnetic fields (Palmquist et al., 2014). Similarly, Nordin, Ljungberg, Claeson and Neely (2013) found that high scores on the Noise Sensitivity Scale (NSS) (Weinstein, 1978) was a predictor for higher scores on the Perceived Stress Questionnaire (PSQ) (Levenstein et al., 1993) and the Chemical Sensitivity Scale (CSS) (Nordin, Millqvist, Löwhagen, & Bende, 2003). Baliatsas, Van Kamp, Swart, Hooiveld and Yzermans, (2016) investigated the overlap between noise sensitivity and
numerous variables available from questionnaires and medical records and found co-occurrence rates with other intolerances to be between 9 and 50% depending on type of intolerance.

The exact mechanism behind EI is unestablished. However, exposure to environmental stimuli over time seems to evoke increasing reactions for some and decreasing reactions for others (Andersson, Bende, Millqvist, & Nordin, 2009; Pellegrino, Sinding, de Wijk, & Hummel, 2017; Sorg, 1999). This phenomenon has been described as sensitization and habituation of the central nervous system (CNS) in the literature (for review, see Overmier, 2002). Moreover, it has been found that attention bias can affect the way environmental stimuli are perceived in individuals with EI (Andersson et al., 2009). Supporting this notion is the finding that individuals scoring high on varying types of EI also express heightened modern health worries (MHW). According to Bailer, Witthöft and Rist (2008), high levels of MHW leads to increased perception awareness and amplification of bodily sensations, resulting in negative symptoms attributed to environmental causes.

Since EI is highly defined by the individual’s subjective experience, reports from questionnaires and self-reports from controlled exposures largely dictates both clinical diagnosis and research. A self-report instrument frequently used by both researchers and clinicians to quantify degree of EI in patients is the NSS (Weinstein, 1978) and the CSS (Nordin et al., 2003). These were designed to quantify negative affective reactions and behavioral disruptions from noise and chemicals/odors. The scales include 21 items each. Each item is formulated as a claim, to which an answer on a scale (0-5 or 0-4 depending on item) is required. For convenience and quicker recognition of EI, these instruments have also been translated into 11-item short-versions (NSS-11 and CSS-SHR respectively) (Nordin, Millqvist, Löwhagen, & Bende, 2004; Nordin, Palmquist, & Claeson, 2013).

Self-reports through questionnaire instruments and experimental approaches such as controlled exposures are highly useful and have contributed to major findings in the study of EI. However, research covering the individual experience of subjective, negatively laden sensory experience, at the time of the exposure in environments with high ecological validity are scarce. One reason for this may be the lack of instruments with which the nature of the subjective experience can be captured together with an objective measure of intolerance. At issue here is the risk of neglecting findings from longitudinal research by conducting research with primarily cross-sectional methods.

Therefore, this study aimed to investigate how data collected using a smartphone app in participant’s everyday life, compares to data collected from two well established questionnaire instruments that are widely used to recognize EI (NSS-11 and CSS-SHR). This comparison was made on data from individuals with varying degrees of intolerance (including non-intolerant) with the overarching goal of evaluating the detective properties of current methods against already existing measures of EI.

Considering that the two most frequently reported EIs are those attributed to noise and chemicals/odors and considering the high rates of overlap between these two intolerances (see Baliatsas et al., 2016; Palmquist et al., 2014), it makes sense to investigate them together. Therefore, the scope of this study was to investigate intolerances in which symptoms are attributed to noise and chemicals/odors.

By collecting data of various variables of negatively laden sensory experiences, the present study aimed at capturing and quantifying negative sensory events at the time of the exposure. It was hypothesized that individuals scoring high/low on the NSS-11 and CSS-SHR, widely used for quantifying EI, would also express high/low levels of EI as measured by reports in the smartphone app on the variables discomfort rating, number of symptoms reported and number of reports.
Methods

Participants and recruitment

To ensure that the study included an evenly distributed number of intolerant/non-intolerant participants, the recruitment process was carried out in two phases. In the first phase, 8 participants were recruited through social media and using flyers in various public advertisement boards around Umeå. One participant was recruited using an email list of individuals with self-reported noise intolerance, who had previously participated in a study investigating physiological and cognitive reactions to noise exposure. The advertisement asked specifically for individuals between 18 and 64 years of age who experienced themselves to be bothered by noise and odors to a larger extent than other people. The advertisement also stated that participants would receive 100 SEK for their participation.

The second phase yielded 5 participants through people-to-people interaction on the campus area of Umeå university. These participants received the same information as those in the first phase, with the exception of the explicit requirement of EI to participate.

Due to application malfunction and discontinuation, 2 participants were excluded from the dataset. The study included a total of 12 participants, 4 males, 7 females and one person who identified as neither (mean age 29 years, SD=10.7 years).

Ethical considerations

Prior to participation, participants were informed about the voluntary nature of the study and their option to cancel without explanations at any time. It was also communicated that present study was not considered to be associated to any risks, nor apparent benefits and that their data might come to be published in scientific contexts. The study was evaluated and approved by the regional ethics committee in Umeå.

Design

The study was designed to gather data from participants as they operated in their daily life. For a period of two weeks, participants used an application in their smartphones to report exposures to noise and/or odors that affected them negatively. The application required the participants to report five aspects of the event: Time and date of exposure, type of exposure (noise or odor), subjective rating of discomfort associated to the event, symptoms following the event and place of exposure. Duration of symptoms could be reported any time post-exposure using a follow-up feature incorporated in the application.

The NSS-11 (Nordin, Palmquist, & Claeson, 2013) and CSS-SHR (Nordin et al., 2004) were completed by all participants in order to have a standardized measure of their intolerance. Optimal cut-off scores for the NSS-11 and CSS-SHR have previously been developed to classify individuals as intolerant and non-intolerant (Nordin, Karvala, Nyback, & Sainio, 2018), but for the purpose of this study, a relative cut-off score was calculated to divide participants into either high- or low intolerance.

Statistical analyses were carried out for variables discomfort rating, number of symptoms reported, number of reports and NSS-11/CSS-SHR-scores to establish how the smartphone app used in this study compared to the NSS-11 and CSS-11 with regards to its ability to detect EI.
Material

Web-based application. The application was originally created by Greg Neely at the Department of Psychology at Umeå University in collaboration with one external programmer (Lind & Neely, 2017) to support the data collection of a longitudinal study investigating EI. The application system is accessed through the browser of any smartphone. However, participants were encouraged to add the webpage as a shortcut on the desktop of their smartphone, as a means of making the app more accessible as well as enhancing the experience of using a normal app.

The app has a down-scaled, easy to use interface. Each report requires the user to go through three pages with a total of seven questions. The total amount of time required for one report is approximately 45-60 seconds. The first page of the app includes three questions (Figure 1, A), time of event, type of exposure and rating of discomfort associated to the exposure on a scale 1-10. The second page asks the user for symptoms associated to the exposure. The list of prespecified symptoms include those used in the Environmental Hypersensitivity Symptom Inventory (EHSI) (Nordin, Palmquist, Claeson, & Stenberg, 2013). Symptoms are presented in six categories which, upon action, reveals further symptoms belonging to each category (see Figure 1, B, C). On the third and final page (Figure 1, D), users are asked to report where the event took place. They were also encouraged to write down notes associated to the event in a free-text field. This option was included to ensure that details of events were remembered until the report had been followed up. To follow up an event, participants were required to log in to their account on the app using a computer. Once logged in, each report that had not yet been followed up appeared as “available for follow-up” (Figure 2, A). The purpose of the follow-up feature was for participants to report the duration of the event (Figure 2, B).

Questionnaires. The 11-item NSS-11 (Nordin, Palmquist, & Claeson, 2013) and the 11-item CSS-SHR (Nordin et al., 2004) were designed to capture negative affective reactions and behavioral disruptions to noise and chemicals/odors. Each item is formulated as a claim, to which an answer on a scale (0-5 or 0-4 depending on item) is required (table 1). Despite the few items, the psychometric properties of both instruments have proven to be satisfactory with high test-retest reliability and high internal consistency (Nordin et al., 2004; Nordin, Palmquist, & Claeson, 2013).
Figure 1. Interface of the Sensorik app for each page. First page (A) let the user chose date and time, type of exposure and rate discomfort. The second page shows categories (B) and symptoms associated to sensory events (C). The third page allows the user to chose where the event took place. It also includes the option for notes associated to event (D).

Figure 2. Interface of the follow-up feature that is accessible through the browser of a computer. The webpage let you know that you have reports that have not yet been followed up (A). Clicking a report allow the user to view details of the report and describe the event in detail in a free-text field. The user is also asked to approximate the duration of the symptoms on a three-grade scale (less than one hour, 1-8 hours, more than eight hours).
Table 1. Items and rating scales for the NSS-11 and the CSS-SHR

<table>
<thead>
<tr>
<th>CSS-SHR</th>
<th>NSS-11</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I would not mind living on a street with odorous/pungent car exhausts if the apartment I had was nice.</td>
<td>1. I would not mind living on a street with odorous/pungent car exhausts if the apartment I had was nice.</td>
</tr>
<tr>
<td>2. I am more aware of odorous/pungent substances than I used to be.</td>
<td>2. I am more aware of odorous/pungent substances than I used to be.</td>
</tr>
<tr>
<td>3. At movies, other persons’ perfume and aftershave disturb me.</td>
<td>3. At movies, other persons’ perfume and aftershave disturb me.</td>
</tr>
<tr>
<td>4. I am easily alerted by odorous/pungent substances.</td>
<td>4. I am easily alerted by odorous/pungent substances.</td>
</tr>
<tr>
<td>5. I get used to most odorous/pungent substances without much difficulty.</td>
<td>5. I get used to most odorous/pungent substances without much difficulty.</td>
</tr>
<tr>
<td>6. How much would it matter to you if an apartment you were interested in renting was located close to a factory that emitted odorous/pungent substances?</td>
<td>6. How much would it matter to you if an apartment you were interested in renting was located close to a factory that emitted odorous/pungent substances?</td>
</tr>
<tr>
<td>8. There are often times when I want a complete odor-free environment.</td>
<td>8. There are often times when I want a complete odor-free environment.</td>
</tr>
<tr>
<td>9. I find it hard to relax in a place that evokes odor/pungent sensations.</td>
<td>9. I find it hard to relax in a place that evokes odor/pungent sensations.</td>
</tr>
<tr>
<td>10. I would not mind living in an apartment that has a slight smell.</td>
<td>10. I would not mind living in an apartment that has a slight smell.</td>
</tr>
<tr>
<td>11. I am sensitive to odorous/pungent substances.</td>
<td>11. I am sensitive to odorous/pungent substances.</td>
</tr>
</tbody>
</table>

a Scale: agree strongly (0), agree (1), agree mildly (2), disagree mildly (3), disagree (4), disagree strongly (5). The numbers in parentheses refer to the score given for that response
b Item scored in opposite direction before responses are summed
c Scale: completely deter me (0), very important (1), important (2), slightly important (3), not at all important (4)
d Scale: always (0), very often (1), often (2), occasionally (3), seldom (4), never (5)

Procedure

Introduction to the study could either be attended with an instructor at Umeå University or by telephone. The introduction included a short description of the purpose of the study and a step-by-step tutorial to the app. Participants were encouraged to ask questions during the introduction. In order to make sure that there were no uncertainties, each meeting was also ended with the instructor asking if the participant had understood their role and if they had any further questions. Informed consent was signed either during the introduction meeting or as soon as the participant received the necessary documents by post.

Participants who had their introduction at Umeå University were told to start with their participation immediately and that they would be contacted by their instructor two weeks later to fill out the NSS-11 and the CSS-SHR. Those who did their introduction by phone, were told to start reporting as soon as they had received and signed their informed consent by post. Two weeks after the introduction, participants received an email explaining that two weeks had past and that in order to complete their participation they had to fill out a 22-item questionnaire online (NSS-11 and CSS-SHR combined).

Statistical analysis and grouping

All statistical analyses were carried out using IBM SPSS Statistics. Participants were divided into a high- or low intolerance group for noise and odors/chemicals, respectively, based on a split-half of the median of their scores on the NSS-11 and CSS-SHR. The two groups for
each modality (noise/odors) were compared on the variables *mean discomfort rating, number of unique symptoms reported* and *number of reports*. The comparison yielded six separate independent samples t-test analyses with group (high/low intolerance) as independent variables and *discomfort rating, number of symptoms* and *number of reports* as dependent variables.

**Results**

**Grouping**

Participants were grouped into a high or low intolerance group based on their scores on the NSS-11 and CSS-SHR conditions, respectively (NSS low n=6, NSS high, n=6, CSS low n=6, CSS high n=6). Norm data for the general population have a mean score of 29.7 ($SD=8.73$) on the CSS-SHR with approximately normal distribution (Nordin, Palmquist, Bende, & Millqvist, 2013). The same number for the NSS-11 is 27.2 ($SD=7.97$) (Nordin, Palmquist, & Claeson, 2013). A comparison between the sample in present study and norm data revealed that the low intolerance group corresponded to the $59^{th}$ percentile of the population for the NSS-11 ($mean score=29, SD=5.33$) and the $30^{th}$ percentile for the CSS-SHR ($mean score=25.17, SD=4$). The high intolerance group corresponded to the $88^{th}$ and the $97^{th}$ percentile of the population for the NSS-11 ($mean score=42.67, SD=3.38$) and CSS-SHR ($mean score=40.17, SD=7.16$) respectively.

A comparison between the total sample for the CSS-SHR and norm data revealed that present sample was within the $63^{rd}$ percentile of the population ($mean score=32.67, SD=9.60$). Corresponding analysis for the NSS-11 showed that the sample was within the $86^{th}$ percentile of the general population ($mean score=35.83, SD=8.31$).

**Internal consistency**

To test the internal consistency of the NSS-11 and the CSS-SHR, Cronbach’s $\alpha$ coefficients were calculated. Similar to previous studies (Nordin, Palmquist, Bende, et al., 2013; Nordin, Palmquist, & Claeson, 2013) the results indicated satisfactory to levels of internal consistency for both the NSS-11 ($\alpha=0.808$) and the CSS-SHR ($\alpha=0.874$).

**Discomfort ratings**

All participant reports included a rating of subjective discomfort following a negative sensory experience. For every participant, a mean discomfort rating was calculated separately for noise and odors/chemicals. The mean of all participant’s mean rating was used to compare level of discomfort for each condition. The results are shown in Figure 3. An independent samples t-test yielded no significant differences between the high ($M=4.83, SD=2.56$) and low ($M=3.83, SD=3.13$) group for the NSS-11 condition $t(9)=-0.606, p=.56$.

For the CSS-SHR, scores for the low intolerance group ($M=3.17, SD=2.56$) were not statistically different from the high group ($M=5.17, SD=2.64$) $t(10)=-1.33, p=.21$. 
Number of reports

The number of app reports for each participant was summed to acquire a total score for participants in each condition (Figure 3). At first glance, there appeared to be a difference between the low intolerance group (\(M=3.83, SD=2.48\)) and the high intolerance group (\(M=10.17, SD=8.09\)) for the NSS-11 condition. However, an independent samples t-test revealed that this difference was not statistically significant \(t(10)=-1.83, p = .097\).

The same analysis for the CSS-SHR condition indicated no significant differences between the high (\(M=13.8, SD=12.61\)) and low (\(M=1.5, SD=1.52\)) intolerance group, \(t(5.15)=-2.38, p = .06\).

Number of unique symptoms

The symptoms variable was treated as the number of unique symptoms that each participant had reported throughout their participation, regardless of them having reported a symptom multiple times. The total number of unique symptoms for each participant was summed for each condition, and the mean of all participant scores for high and low intolerance was used for comparison (Figure 3). Participants with low intolerance in the NSS-11 condition reported 4.5 unique symptoms (\(M=4.5, SD=3.62\)) compared to 6.67 symptoms for the high intolerance group (\(M=6.67, SD=5.89\)). An independent samples t-test showed that this difference was not statistically significant \(t(10)=-0.77, p = .46\).

For the CSS-SHR condition, no significant difference was found between the high (\(M=10.33, SD=10.07\)) and the low (\(M=3.67, SD=3.93\)) intolerance group \(t(9)=-1.51, p = .18\).

![Graphs](image-url)

**Figure 3.** Graphs representing mean difference between high- and low intolerance groups for NSS and CSS conditions, for variables discomfort ratings, number of reports, number of unique symptoms.
Discussion

Compared to already existing instruments, the sensorik.se web app is able to collect several aspects of subjective nature, from negatively laden sensory experiences. Moreover, the app enables research on data with high ecological validity, collected at the time of the sensory exposure. Considering that those instruments available for research on EI are used for cross sectional purposes, the development of an instrument that can be used for longitudinal purposes, with both qualitative and quantitative measures of EI is of great importance.

The aim of this study was to establish how the sensorik.se web app compares to the short versions of the noise sensitivity scale and the chemical sensitivity scale. Important to note is that this study did not investigate the nature of the subjective experience per se, but rather, the comparison intended to investigate how similar these instruments are with regards to their ability to detect EI.

It was hypothesized that individuals with relatively high intolerance, as measured by the CSS-SHR and NSS-11, would have more numerous reports overall, express higher discomfort ratings, and report a higher number of unique symptoms.

Individual sample t-tests were used to compare mean scores on the NSS-11 and CSS-SHR, for a high and a low intolerance group on three variables collected in the sensorik.se web app. The first variable to be tested was mean rating of discomfort following sensory stimulus. Neither the NSS condition or the CSS condition yielded any significant differences between the high and low intolerance group. The second variable that was tested was number of reports. Although seemingly high discrepancy between the low and high intolerance group for both the NSS and CSS condition, no significant difference could be established. The third and last variable that was compared to group score from the established questionnaires was number of unique symptoms. The operationalization of a unique symptom was to count the occurrence of a symptom for an individual only once, regardless of occurrence of that symptom in any of their subsequent reports. As with the other statistical analyses, this analysis did not yield any statistically significant results.

These results can be interpreted in many ways. It is possible that the sensorik.se app cannot reflect the diversity in scores seen in the NSS-11 and CSS-SHR. However, if one were to draw this conclusion, it is important to reflect on three things. (1) the sample size in this study was relatively small. This may be reflected in the results as a high uncertainty of using the sample’s standard deviation, ultimately leading to a low t-value and a high p-value, regardless of mean difference (Bangdiwala, 2016). This is likely a correct interpretation, at least for both conditions in the number of reports analysis, where a difference can be seen between the groups but the t-value as well as the p-value is suppressed.

(2) the total sample produced a total score corresponding to the 63rd and 86th percentile for the CSS and NSS condition respectively, meaning that participants in this study were in the upper bound of the intolerance spectrum for both conditions. Moreover, the mean score for the low intolerance group for the NSS was only 3 points under the optimal cut off score of 32 (Nordin et al., 2004) with two (out of 6) participants scoring above this threshold. For the CSS condition, the opposite could be seen. Namely that 2 out of 6 participants in the high intolerance group scored below the optimal cut off score of 35. Although this study was indeed investigating the relative score on the NSS and CSS, it is plausible that behavior (reports) does not change as a linear function with increased NSS/CSS score. That is, two individuals with scores below the optimal cut off point (say 21 and 26) behave more similar to each other than
two individuals that score on each side of the cut off score (say 28 and 32). Speculatively, data from participants that were incorrectly classified as either low or high intolerant, may have smoothed out group differences. With this in mind, a replication of this study could possibly benefit from a larger sample, enabling the use of the optimal cut-off scores that have been developed for the NSS and CSS.

(3) As with many other conditions, there are strategies that can be used by individuals suffering from EI, to cope with their condition. Three frequently reported coping strategies for odor intolerance are avoidance, asking others to limit their use of perfume/washing detergent and spending time alone (M. Nordin, Andersson, & S. Nordin, 2010). For noise intolerance, (hyperacusis) withdrawal from social interaction and isolation is among the most common coping strategies (Trulsson, Johansson, Jansson, Wiberg, & Hallberg, 2003). These strategies make it inherently problematic to quantify EI using measures such as number of reports, as results may be skewed by the fact that highly intolerant individuals have found ways to limit everyday exposures with negatively laden sensory stimuli. Further development of the sensorik.se app (or similar instruments for that matter), could be helped by integrating a feature that can quantify the use of coping strategies.

To summarize, although the mean differences between groups were in the hypothesized direction, no support for the hypothesis was found in this study. Possible explanations for this outcome may be (1) The population sample used in present study was too small. (2) the relatively high- and low intolerance groups created for this study does not correctly reflect individuals with de facto high and low intolerance. (3) Individuals with high intolerance use coping strategies, such as avoidance and isolation, which may have interfered with data collection and skewed results. (4) The variables that were measured in the sensorik.se web app are not reliable and/or valid measures of environmental intolerance, at least when using the NSS-11 and CSS-SHR as references.

All of the aforementioned explanations are possible. It is possible that only one of them is separately true, but it is also possible that the results obtained in this study are the consequence of several of these explanations. More research is needed on this subject to draw any conclusions with certainty. A future study could be helped by a larger $n$, preferably in combination with the use of the optimal cut-off points developed for the NSS-11 and CSS-SHR.
References


