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MEASURING HUMAN NOISE-SENSITIVITY: PSYCHOMETRIC EVALUATION IN AN ONLINE SURVEY

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ABSTRACT

Human noise-sensitivity has been measured by various instruments. These have rarely been compared, and, if so, with limited sample sizes. Therefore, the present study administered all major noise-sensitivity instruments simultaneously and in the same participant sample. An online survey was conducted and distributed via Prolific, recruiting 311 British participants (sample representative with respect to age, sex and ethnicity). The 21-item Weinstein Noise-Sensitivity Scale (WNSS), the 52-item Individual Noise-Sensitivity Questionnaire (LEF), and the 35-item Noise-Sensitivity Questionnaire (NoiSeQ) were presented in random order along with two types of single-item ratings of noise sensitivity. Additionally, retrospective annoyance ratings with respect to six specific noise-sources, the Hyperacusis Impact Questionnaire (HIQ), and the Severity of Symptoms of Sound Sensitivity Questionnaire (SSSQ) were included. Results show high internal consistency (all Cronbach's alpha > .90) for the three noise-sensitivity questionnaires and strong inter-correlations (all r > .83) of their overall scores. As expected, correlations with annoyance are lower, showing remarkable differences depending on the noise source in question. In all, the present findings provide support for the excellent psychometric quality of the established noise-sensitivity questionnaires, and confirm noise sensitivity as a characteristic separate from other constructs measured in this study.

Keywords: *noise sensitivity, questionnaire, psychometric properties, online survey*

1. INTRODUCTION

Over the past four decades, questionnaires designed to assess human noise-sensitivity have evolved in various ways: from focusing solely on specific groups, such as students [1], to including versions in various languages [2-3]. Types of questionnaires range from short versions [4-6], including a sub-set of items in an established questionnaire, to variant forms that combine existing questionnaires with new items [7]. Among these, three major full-length questionnaires were shown to be psychometrically evaluated to some extent in a recent systematic review [8]. These were: the Weinstein Noise-Sensitivity Scale (WNSS) [1], the Individual Noise-Sensitivity Questionnaire (LEF) [2], and the Noise-Sensitivity Questionnaire (NoiSeQ) [9], derived from the first two.

Our recent systematic review of the psychometric quality of existing noise-sensitivity questionnaires [8] revealed severe gaps in that research literature, namely with respect to (1) reliability, (2) structural validity and (3) cross-language validity. Specifically, (regarding 1) retest reliability has rarely been investigated, (regarding 2) the components of what the questionnaire measures are often unclear or unstable, and (regarding 3) while translations of these questionnaires have been produced, their psychometric properties have been insufficiently assessed in other languages.

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Extending the earlier work on the questionnaires available at the time [10], the aim of the present study is to systematically assess the psychometric properties of all major instruments to assess noise sensitivity by administering them to demographically representative samples of participants in four languages: English (UK, US), French, German, and Korean. The present, initial report will focus on the results of the UK sample.

2. METHOD

2.1 Participants

A sample representative by age, sex, and ethnicity of 311 participants who live in the United Kingdom, and are fluent in English, was recruited and paid via the online-survey platform Prolific [11]. After excluding careless responders [12], 305 participants remained for analysis. The participants' age ranged from 18 to 80 years (M = 46.4, SD = 15.7). 158 participants were female (52%), one reported their gender as 'other'.

2.2 Online survey implementation

The survey was administered online using SoSci Survey [13]. Participants were invited to participate in a survey on 'Noise in Everyday Life'.

Three questionnaires, and two types of single-item ratings measuring noise sensitivity were administered, as well as a source-specific retrospective assessment of long-term noise annoyance based on an ISO standard [14]. In addition, demographic information was collected regarding the type of residential area, the noise conditions of the living environment, and hearing-related issues. The three major noise-sensitivity questionnaires were the Weinstein Noise-Sensitivity Scale (WNSS) [1], which consists of 21 items and uses a 6-point Likert scale (ranging from 1 = agree strongly to 6 = disagree strongly); the Individual Noise-Sensitivity Questionnaire (LEF) [2] , which consists of 52 items and uses a 4-point Likert scale (ranging from 0 = strongly agree to 3 = strongly disagree), and the Noise-Sensitivity Questionnaire (NoiSeQ) [9], which consists of 35 items and uses the same scaling as the LEF. For the single-item ratings (1-item NS), participants responded to the question, *"Are you sensitive to noise?"*, using a continuous rating scale [15], marked from 0 to 10, with endpoints labeled *Not sensitive at all* and *Extremely sensitive*. Additionally, a single question (1-item SOCIAL) assessing *"Compared to people around you, do you think that you are ... to noise?"* [16, 17] was presented on a 5-point verbal scale, ranging from *Much less sensitive* to *Much more sensitive*. To assess perceived annoyance from everyday environmental noises, participants retrospectively rated their annoyance over the past 12 months for six specific noise sources: road traffic, railway, aircraft, neighborhood, industrial, and construction noise. Using the standardized 11-point scale commonly applied in noise surveys [14], participants were asked: *"Thinking about the last 12 months, how much did noise from [source] bother, disturb or annoy you?"*.

All instruments were presented in counterbalanced order based on a balanced Latin square design. The online survey was launched in July 2024 and the overall survey results and analyses for psychometric properties were conducted using R version 4.2.1 [18].

3. RESULTS & DISCUSSION

3.1 Descriptive statistics

Initially, the shape of the overall-score distributions of all noise-sensitivity questionnaires were evaluated: Shapiro-Wilk normality tests indicated that, except for slight departures from normality for the WNSS ($W = 0.987$, $p < .006$), the other two major questionnaires followed a normal distribution.

3.2 Reliability

To assess the internal consistency of the noise-sensitivity instruments, Cronbach's alpha was examined. All three major questionnaires demonstrated high reliability, with Cronbach's alpha values exceeding 0.9 (NoiSeQ: $\alpha = 0.932$; WNSS: $\alpha = 0.928$; and LEF: $\alpha = 0.916$).

3.3 Structural validity

Confirmatory factor analysis (CFA) was conducted to examine whether the data fit the previously proposed factor structures [1,2,9]. According to prior research, the three major questionnaires (WNSS, LEF, NoiSeQ) were originally developed based on single- [19], four- [2], and five-factor models [9], respectively. CFA was performed using the Maximum Likelihood extraction method. Model fit was evaluated using several indices: The Comparative Fit Index (CFI), Tucker & Lewis index (TLI), the Root Mean Square Error of Approximation index (RMSEA), Standardized Root Mean Square Residual (SRMR), the chi-square to degrees of freedom ratio (χ^2/df), and Goodness of Fit Index (GFI). The recommended ideal values for each index, along with the fit indices for each questionnaire, are presented in Tab. 1. The CFA results indicated an acceptable fit for all three questionnaires on the chi-square

statistic (χ^2/df), and for NoiSeQ and WNSS, also on the SRMR statistic. For the other indices of fit, the three questionnaires show comparable performance somewhat below the established norms.

Table 1. CFA Model Fit Indices for Three Major Noise-Sensitivity Questionnaires

	Good fit	WNSS	LEF	NoiSeQ
Number of Factor		1	4	5
CFI	>.90	0.863	0.716	0.854
TLI	>.90	0.848	0.703	0.842
RMSEA	≈ 0.06 or lower	0.077	0.071	0.066
SRMR	≈ 0.08 or lower	0.058	0.097	0.065
χ^2/df	< 3	2.820	2.552	2.330
GFI	≈ 0.9 or higher	0.804	0.608	0.771

Instruments: WNSS: Weinstein Noise Sensitivity Scale [1], LEF: The Individual Noise Sensitivity Questionnaire [2], NoiSeQ: Noise Sensitivity Questionnaire [9], Model fit indices: comparative fit index (CFI), Tucker & Lewis index (TLI), the root mean square error of approximation index (RMSEA), Standardized root mean square residual (SRMR), the chi-square to degrees of freedom ratio (χ^2/df), and Goodness of Fit Index (GFI).

3.4 Associations between Noise-Sensitivity measures and Long-term Annoyance

As shown in Fig. 1, correlations among the noise-sensitivity instruments were examined. All of these intercorrelations were statistically significant at $p < .001$. The results showed high correlations among the three major questionnaires, ranging from 0.83 to 0.93. The observed inter-correlations among the major instruments are in line with those reported in earlier studies [10]. Correlations between the 1-item NS, 1-item SOCIAL, and the major questionnaires ranged from 0.59 to 0.64, consistent with prior studies [10] using an 11-point scale. One recent study that had found a much lower, and statistically insignificant correlation ($r = .32$) between the NoiSeQ and a 3-category, 1-item noise-sensitivity scale appears to be an exception [20]. In addition, full forms and short versions of the questionnaires (WNSS, LEF, NoiSeQ) correlated strongly among each other (Fig. 1) with coefficients ranging from 0.74 to 0.94. The correlation between the WNSS and the WNSS-SF-5 was consistent with a previous study [4]. Similarly, the relationship between the LEF and the LEF-K-9 showed a comparable pattern to earlier findings [5]. However, prior studies did not examine the associations between the full forms and short versions, respectively, of all the major noise-sensitivity questionnaires. The present study is more comprehensive, in this respect.

Furthermore, since noise sensitivity is conceptualized as being related to the annoyance produced by various noise sources, correlations between the retrospectively rated long-term annoyance due to six specific noise sources and the noise sensitivity measures were inspected. All noise-sensitivity instruments showed positive, weak to medium-strength correlations (between 0.11 and 0.43) with the annoyance measures (Fig. 1), except for railway noise annoyance and industrial noise annoyance, for which no significant correlations were observed. However, compared to previous findings on the correlation between long-term noise annoyance from road traffic, railway, and aircraft noise and general noise-sensitivity [21] (measured by a single item), the present study showed somewhat lower correlations. This may be due to the retrospective nature of the annoyance questions, without reference to actual noise exposure, as the data were collected via an online survey only.

Method: Spearman, p-value: p<0.001, Instruments: WNSS: Weinstein Noise Sensitivity Scale [1], LEF: the Individual Noise Sensitivity Questionnaire [2], NoiSeQ: Noise Sensitivity Questionnaire [9], 1-item NS: a single-item rating about general noise sensitivity [15], 1-item SOCIAL: a single-item rating of social comparison [16.17], WNSS-SF: a short version of the WNSS [4], LEF-K: a short version of the LEF [5], NoiSeQ- R: a short version of NoiSeQ [6], ANN- variables indicate annoyance ratings for six specific noise sources: road-traffic, railway, neighborhood, aircraft, industry, and construction [14], Symbol ('X'): not significant ($p > 0.05$)

Figure 1. Correlation between noise sensitivity instruments and long-term noise annoyance ratings

4. OUTLOOK

To complement the results from the UK sample initially recruited for this study, additional data were collected through an online survey with English-speaking participants from the United States. Furthermore, equivalent surveys were administered under the same conditions to participants from French-, German-, and Korean-speaking populations. These multilingual datasets will be used in future comparative analyses to examine cross-language differences in the way noise sensitivity is construed and how it interacts with related concepts like noise annoyance.

5. CONCLUSION

The present large-scale (N>300) online survey provides a first comparative psychometric assessment of the three major noise sensitivity questionnaires—WNSS, LEF, and NoiSeQ— based on a demographically representative UK sample. The results show excellent internal consistency for all three major questionnaires, with Cronbach's alpha coefficients ranging from 0.92 to 0.93. The CFA results suggest that all three questionnaires demonstrated acceptable model fit based on the chi-square statistic, with NoiSeQ and WNSS also meeting the SRMR criterion. Other fit indices indicated slightly weaker but comparable performance across the three instruments. Intercorrelations revealed that the three major questionnaires were highly correlated with one another (r > .83, p < .001). Good correlations were found between major questionnaires and two single-items (r = .59-.64, p < .001), and high correlations were observed with the short versions (r = .88-.94, p < .001). Additionally, the three questionnaires showed weak to moderate positive correlations with long-term noise annoyance ratings. To further examine how well the concept of noise sensitivity transfers to other languages, further cross-linguistic comparisons are in the process of being made, involving a representative sample from the United States, as well as French-, German-, and Korean-speaking samples.

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