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COMPATIBILITY OF DATA COLLECTION PROTOCOL IN ISO 12913-2 FOR URBAN SOUNDSCAPE ASSESSMENT

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ABSTRACT

This study investigates the compatibility of soundscape evaluation results based on the data-collection protocols proposed in ISO 12913-2—Method A, Method B, and Method C—and proposes protocol usage guidelines for evaluating urban soundscapes. We assessed soundscapes of 10 multi-functional sites in an urban environment through the responses of 50 participants (laboratory) and 10 participants (soundwalk) to questions on sound source identification, perceived affective quality, and overall quality. The responses pertaining to sound source identification were similar. Regarding perceived affective quality, the pleasantness-eventfulness model derived from Method A was also found in the text-mining results of Methods B and C, and additional emotional responses, such as spatial impression and restoration were discovered. Regarding overall quality, the preference for each assessment site was similar. Method C, which entailed social network analysis, revealed the influence of non-acoustical factors on soundscape perception. It is expected that this study's findings can be used as baseline data for selecting a methodology to assess urban soundscapes as well as for informing urban planning.

1. INTRODUCTION

As urban noise raises concern over possible negative impacts on citizens' health and quality of life, much research has been conducted on measures to mitigate noise. However, simply reducing noise does not guarantee improved life satisfaction [1]. Unlike the conventional approach of handling noise as waste, soundscape perceives sound as a resource and addresses acoustic environment problems by utilizing preferred sounds. ISO 12913-1 [2] defines a soundscape as the "acoustic environment as perceived or experienced and/or understood by a person or people, in context," thus interpreting the sound environment from the perspective of human perception rather than from the physical properties of sound. The concept of soundscape began drawing attention in the environmental acoustics field, and various soundscape studies were conducted [3-5].

Soundscape data collection can be conducted either quantitatively or qualitatively. According to the recently released ISO 12913-2 [6], soundscape data-collection methods include questionnaires, interviews, rating scales, observation, and some combinations of these, allowing assessments in-situ or in laboratory settings. ISO 12913-2 provides three protocols for soundscape data collection.

Methods A and B are questionnaire-based and can be utilized for soundwalk assessment, while Method C can be used as a narrative interview for off-site assessment. ISO 12913-3 [7] provides guidelines on analyzing each assessment. Although much progress has been made since the soundscape evaluation standards were released, research on ensuring soundscape data-collection method compatibility is lacking [8]. This study demonstrates the compatibility of ISO 12913-2 data-collection protocols and provides assessment guidelines for interpreting urban soundscapes.

2. METHODS

2.1 Experiment 1: Laboratory experiment

2.1.1 Audio-visual data collection

Ten evaluation sites were selected in Seoul—they were used for various functions such as green space (a, b), public space (c, d), urban street (e, f), open square (g, h), and open space (i, j) (See Figure 1). Audio data were recorded using a four-channel ambisonic microphone (Soundfield SPS 200). Visual data were collected using a 360 camera with six channels (Insta360 pro).

2.1.2 VR reproduction for laboratory experiment

Based on the collected data, we created a Virtual reality (VR) simulation in a laboratory. Audio data were provided through open-type headphones (HD-650, Sennheiser) with a binaural track. The videos recorded on six channels were edited using stitching software (Insta360 Pro Stitcher) and provided through a head-mounted display (VIVE Pro).

2.1.3 Procedure

This study included 50 subjects (male = 25, female = 25). The subjects had normal hearing and were aged 21 – 41 (mean age = 23.82, standard deviation = 3.06). Subjects participated in three experiments on three different days using the same assessment set-up in the same order: Methods A, B, and C in the first, second, and third experiments, respectively.

2.2 Experiment 2: Soundwalk in in-situ environments

2.2.1 Soundwalk

For the purpose of verifying the evaluation results in the VR environment in the in-situ environment, the soundwalk was conducted at the same evaluation site with the laboratory VR environment (Figure 1). The evaluation was

conducted from 10 p.m. to 2 p.m. in October 2020, and at the time of the soundwalk evaluation, a stereo sound was recorded with binaural microphone (Type 4101-A, Brüel & Kjær).

2.2.2 Procedure

A total of 10 subjects (male 8, female 2) participated in Soundwalk. The subjects were aged between 20 and 27 years old (mean age = 24.70, Standard deviation = 2.31), and all had normal hearing levels. The same questionnaire used for the laboratory VR evaluation was used. Subjects responded to Method A and B while performing the soundwalk, and responded to Method C after the soundwalk was over. When examining the intraclass correlation coefficient, the degree of correspondence of the subjects' responses was very high as 0.93 ($p < 0.01$).

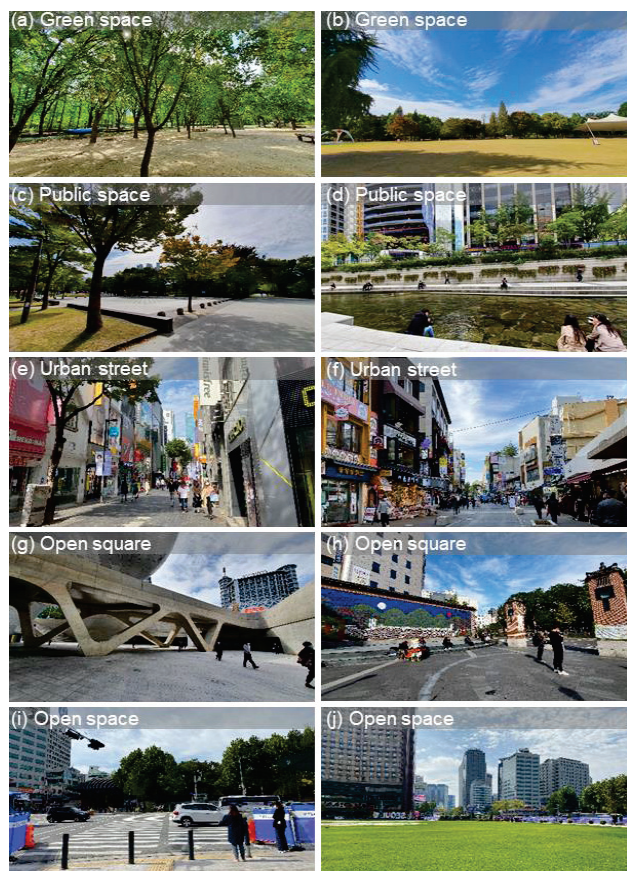


Figure 1. View of the 10 assessment sites.

2.3 Data collection protocols

We composed a questionnaire on urban soundscape to compare the following ISO 12913-2-recommended protocols: Method A, Method B, and Method C. Method A has three parts: A1) sound source identification, A2) perceived affective quality, and A3) overall quality. Each question was assessed on a five-point Likert scale. Method B has three parts: B1) sound environment assessment, B2) sound source recognition and ranking, and B3) subsequent comment. The questions in B1 are assessed on a five-point Likert scale. B2, however, asks open-ended questions with responses collected in ascending order of saliency

identified sound sources. For Method C, we revised the questionnaire to suit this study's urban sites, as ISO 12913-2 allows question modification according to site functions. To compare Methods A and B, we composed C1: questions concerning sound sources. To elicit responses regarding subjects' understanding of the acoustic environment, we composed C2. The participants could give free responses to all questions.

2.4 Data analysis

2.4.1 Determination of the response tendencies

For the analysis of the collected soundscape evaluation data, the scale value in the range of 1–5 is assigned to the 5-point Likert-scale result of methods A (A1–A3) and B (B1) [7]. The B2 and C1 received an ascending answer with an open answer instead of a Likert scale; therefore, a 3-point scale value was applied with reference to a previous study [8].

2.4.2 Text-mining and social network analysis

To extract keywords that can represent each response for the corpus obtained through pre-processing, 1) simple frequency analysis and 2) TF-IDF (term frequency-inverse document frequency) weighted according to the relative importance of frequency were calculated. To analyze the characteristics of the entities, social network analysis is used. The centrality scale is used as a method to identify the word (node) located in the center of the network.

3. RESULTS

3.1 Sound source identification

It was found that, while evaluating sound source identification, most of the response tendencies can be obtained regardless of the data collection protocol method, except for sounds not specified in the questionnaire such as music sound. The trend of sound source identification in laboratory environment was similar to the perception result in the VR evaluation environment. Similar response trends were found for traffic noise, natural sound, and human-being sound as in the VR evaluation environment, but there were some differences in other noise.

3.2 Perceived affective quality

To compare the perceived affective quality results for urban soundscape perception, the response results of method A-A2, method B-B3, and method C-C2 were analyzed. Method A allows multiple dimensions of perception to be interpreted within a simple two-dimensional framework (Pleasantness – Eventfulness). Table 1 lists the example results of text mining for methods B and C through laboratory experiment. Here, the results for only site (a) are presented. For comparison of these results with those of method A, only adjectives were extracted. Overall, the open-ended answers from Methods B and C elicited emotional responses that were not present in A2.

| Tool | Method B | | | |
|------|-------------|-----------|--------|------------|
| Rank | Attributes | Frequency | TF-IDF | Centrality |
| 1 | Peaceful | 7 | 0.678 | 0.069 |
| 2 | Tranquil | 4 | 0.388 | 0.049 |
| 3 | Disturbing | 3 | 3.000 | 0.028 |
| 4 | Relaxing | 3 | 0.903 | 0.035 |
| 5 | Stationary | 3 | 2.097 | 0.028 |
| 6 | Restful | 2 | 2.000 | 0.021 |
| 7 | Calm | 2 | 0.796 | 0.021 |
| 8 | Open | 1 | 0.301 | 0.007 |
| 9 | Comfortable | 1 | 0.097 | 0.014 |
| 10 | Healing | 1 | 0.699 | 0.014 |
| Tool | Method C | | | |
| Rank | Attributes | Frequency | TF-IDF | Centrality |
| 1 | Comfortable | 20 | 0.000 | 0.110 |
| 2 | Peaceful | 17 | 1.647 | 0.091 |
| 3 | Relaxing | 9 | 0.872 | 0.057 |
| 4 | Comfortable | 9 | 0.000 | 0.046 |
| 5 | Disturbing | 7 | 4.893 | 0.038 |
| 6 | Unsettling | 5 | 3.495 | 0.027 |
| 7 | Restful | 5 | 3.495 | 0.027 |
| 8 | Stationary | 4 | 1.592 | 0.030 |
| 9 | Healing | 4 | 2.092 | 0.030 |
| 10 | Harmonious | 3 | 0.666 | 0.019 |

Table 1. Example of text-mining results for site (a) with subjective interview based on method B and method C protocols through laboratory experiment (Jo & Jeon [13]).

3.3 Overall quality

To examine the difference in the overall soundscape quality according to the data collection protocol in urban environment, the response results of method A-A3, method B-B1, and method C-C2 were analyzed. As a results, methods A and B confirmed the similar tendency for positive / negative evaluation of soundscapes at each evaluation site. The SNA results show that when evaluating soundscape, human and activity are considered as important factors, centering on sound and space, and non-acoustic factors such as mood, weather, and expectation are considered complex.

4. DISCUSSIONS

4.1 Comparison of data-collection protocols

While using method A, it is effective to draw general conclusions while structurally simplifying and perceiving the perception of soundscape. It is considered that method C can be used very effectively for understanding the sound environment of a specific space by not only the research group of experts through powerful visualization tools but also stakeholders. It can be said that the closer a method is to method A, the easier it is to derive a generalized model through quantitative research, and the closer it is to method C, the more detailed and in-depth understanding of the recognition system becomes possible through qualitative

research. However, through the results of this study, similar tendencies were confirmed in the evaluation results of the same items between the three protocols; therefore, it can be considered that a certain level of compatibility was secured.

4.2 Ecological validity of VR environment

It was possible to confirm the similar response compatibility between Methods A, B, and C in in-situ soundwalk with laboratory experiment. That is, it can be said that the VR environment used in this study has sufficient ecological validity to replace the soundscape perception in the in-situ environment in terms of subjective response.

5. CONCLUSIONS

This study examined compatibility of data-collection protocols proposed in ISO 12913-2 for urban soundscape evaluation and compared their assessment results. Overall, the urban soundscape evaluation results based on each assessment protocol were similar regarding preference. Combining quantitative and qualitative data-collection methods depending on researchers' objectives is ideal because each assessment protocol has pros and cons. This study's findings are expected to serve as baseline data for selecting assessment methodologies and for researchers seeking to interpret urban soundscapes.

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