Influence of Environmental Sensitivity and Noise Sensitivity on Soundscape Evaluations in Urban Open Public Spaces

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ABSTRACT

In this study, the effects of individuals' environmental sensitivity and noise sensitivity on soundscape evaluations were examined through experiencing the audio-visual environments of various urban public spaces in a laboratory setting. The participants, 19–36-year-old college students and staff with normal hearing (N = 60), experienced 12 common urban open space scenarios (parks, squares, pedestrian streets, and residential public areas) for at least 3 minutes each, and completed the questionnaire, which consisted of two parts: 1) soundscape evaluations, which included the 8-dimensional perceived affective quality, overall quality, appropriateness, and perceived loudness of urban soundscapes; and 2) personal characteristics, including the Highly Sensitive Person Scale (HSPS) and Weinstein's Noise Sensitivity Scale (WNSS) for comparison. The results showed that people with higher environmental sensitivity tended to experience soundscape more pleasant and calm, while no significant effect of noise sensitivity was found for the soundscape evaluations, and a moderate correlation between environmental sensitivity and noise sensitivity was also revealed.

1. INTRODUCTION

Open public spaces are the most commonly utilized outdoor leisure facilities in cities, and the quality of the sound environment in these areas may have a considerable impact on people's psychological and even physiological responses. While previous research has concentrated on the negative effects of noise on people, the soundscape concept had shifted the research focus to the positive effects of the sound environment on people, with an emphasis on the interpretation of the surrounding sound environment from a human perception perspective [1-5].

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Meanwhile, research on individuals' perceptions of outdoor urban sound environments has revealed significant differences, for example, soundscape pleasantness and eventfulness, etc [6,7]. To quantify these differences, researchers frequently use the "noise sensitivity" scale, which was established to assess people's vulnerability to various types of noise [8,9]. However, noise sensitivity does not explain as much variance in population perception as predicted in urban contexts with high acoustic quality [4,10-12].

Environmental psychology research has discovered that individuals also differ in their degree of sensitivity to positive environmental stimuli, a phenomenon termed "vantage sensitivity" [13]. Though researchers had developed environmental sensitivity measures that incorporate this vantage sensitivity named the Highly Sensitive Person Scale (HSPS) [14], few studies have been conducted in the field of soundscape to examine the relationship between this environmental sensitivity and the perception of high-quality acoustic environments. Whether HSPS can explain the differences in the perception of positive soundscape or not is still uncertain, and how environmental sensitivity relates to noise sensitivity is also a question.

The purpose of this study is to determine whether environmental sensitivity and noise sensitivity have an effect on soundscape evaluations in urban open public spaces and to verify the correlation between these two factors.

2. METHODS

In this study, laboratory experiments were conducted in which participants perceived a series of reproduced soundscape contexts and completed subjective evaluations. The experimental exposure settings included both auditory and visual stimuli. After the entire soundscape evaluation process, participants were required to complete a personal characteristics questionnaire.

2.1. Participants

A total of 60 participants (34 males and 26 females) ranging in age from 19 to 36 years (mean: 25.17, SD: 3.36) were recruited, and all participants reported they have normal hearing and eyesight.

2.2. Audio-visual Stimuli

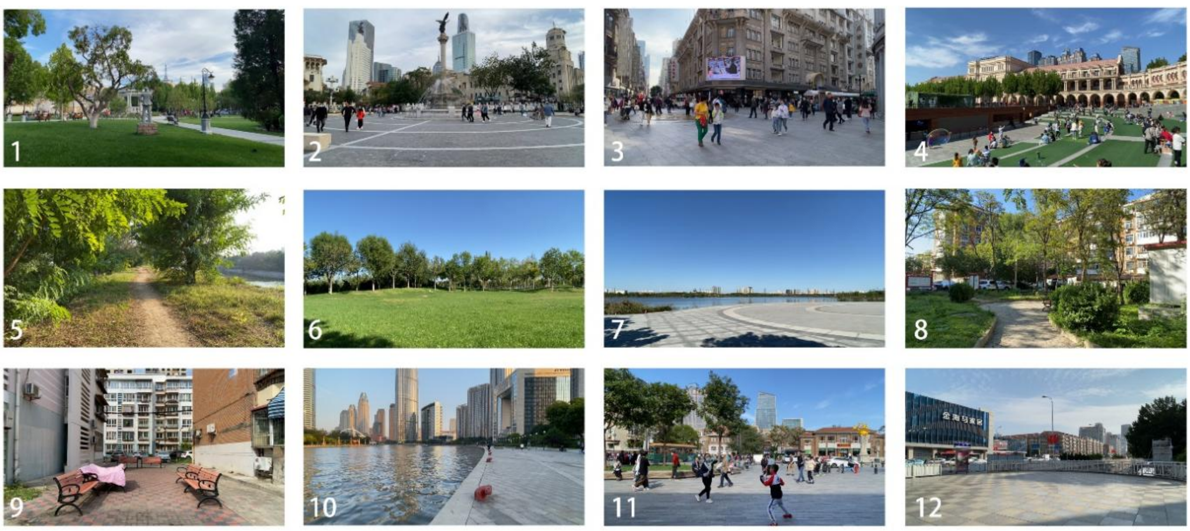

Figure 1: Views of the 12 soundscape contexts

To investigate the different perceptions of soundscapes in urban open public spaces by people with different environmental sensitivity, we chose 12 frequent scenes from the Tianjin urban area that represented a diversity of morphological functions and sound environments (see Figure 1). The scenes included 1) Central Park, 2) Marco Polo Square, 3) Quanyechang Square, 4) Minyuan Square, 5) Canal Park, 6) Shuixi Park, 7) a lakeside square in Shuixi Park, 8) a public garden in a residential area, 9) a pocket square in a residential area, 10) Haihe Park, 11) a commercial street, and 12) a pocket square by the road. The dominant sound sources and sound pressure levels of the background sound in each scenario are shown in Table 1. The classification method of dominant sound sources is based on ISO 12913-2, those are traffic noise (cars, buses, trains, airplanes, etc.), human sounds (conversations, laughter, children playing, footsteps, etc.), natural sounds (birds, water, wind, etc.), and other noises (sirens, construction, industry, etc.).

The visual data was captured using a Canon 5D camera, while the auditory data was recorded using a Sennheiser AMBEO four-channel VR microphone and a ZOOM F6 portable four-channel recorder with a panoramic sound a-format first-order format. Additionally, 3 minutes A-weighted equivalent sound pressure level were measured for calibration in laboratory reproduction using a Norsonic 140 sound level meter.

Table 1 Descriptions of 12 experimental audio-visual stimuli

ID	**Site**	**Dominant sound sources**	**$L_{Aeq, 3min}$ (dB)**
1	Central Park	Human, Traffic	59.7
2	Marco Polo Square	Human, Natural	67.5
3	Quanyechang Square	Human	78.0
4	Minyuan Square	Human	72.8
5	Canal Park	Natural, Traffic	63.4
6	Shuixi Park	Natural	49.3
7	A lakeside square in Shuixi Park	Natural, Human	47.3
8	A public garden in a residential area	Natural, Other	53.5
9	A pocket square in a residential area	Other	50.6
10	Haihe Park	Natural, Traffic	57.4
11	A commercial street	Human, Traffic	63.4
12	A pocket square by the road	Traffic	63.3

2.3. Questionnaire

The subjective evaluation questionnaire is divided into several sections: Section 1 consisted of eight-dimensional items on the perceived affective quality of the acoustic environment as recommended by ISO 12913-3. Sections 2, 3, and 4 were comprised of the overall acoustic environment assessment, the evaluation of audiovisual appropriateness of scenes, and the loudness of the overall environment. Section 5: The Environmental Sensitivity Scale was developed by Aron et al. based on the 27-item Highly Sensitive Person Scale [14]. The scale contains the more comprehensive measurement dimensions of environmental sensitivity, such as vantage environmental sensitivity, and is thus commonly used in environmental psychology research [13]. Section 6 is the simplified Chinese version of Weinstein's Noise Sensitivity Scale with 15 items [15].

2.4. Procedure

Participants were required to experience twelve audiovisual stimulus scenes in a random order, and each scene was presented for three minutes. The videos were shown in high definition using a JIMI projector, and the ambient sound was reproduced using four loudspeakers (Genelec 8030C) in a semi-anechoic chamber. After each scene began to play, they were asked to experience the scene fully first, and then they were asked to complete Sections 1 through 4 of the questionnaire with no time limit. The audiovisual stimuli were repeated until the end of this current set of evaluations. When each scene evaluation was completed, participants took a one-minute break and then started the next set of evaluations. After evaluating the soundscapes of all scenarios, participants were given a 5-minute pause before being asked to complete Sections 5 and 6 of the survey, which focused on personal characteristics and included the HSP and WNS scales. The whole experimentation process took around 45 minutes.

3. RESULTS AND DISCUSSIONS

3.1. Effects of Environmental Sensitivity on Soundscape Evaluations

Individuals were classified into high- and low-environmental sensitivity groups based on the median of HSPS scores. Then a series of independent sample t-tests were conducted to assess whether there were statistically significant differences in soundscape evaluations between the low and high sensitivity population groups.

In the group analysis of the HSPS scores, the mean value of the pleasant dimension for the high environmental sensitivity group ($M = 3.35$, $SD = 0.42$) was significantly greater ($p < 0.05$) than the mean value for the low environmental sensitivity group ($M = 3.11$, $SD = 0.44$); and the mean value of the calm dimension was 2.78 ($SD = 0.27$) for the high environmental sensitivity group and 2.60 ($SD = 0.33$) for the low environmental sensitivity group, there were also significant differences between the two groups in the evaluations of calm dimension ($p < 0.05$) (see Figure 2). For the other perceived affective dimensions, overall quality, appropriateness, and perceived loudness, no statistically significant differences ($p > 0.05$) were observed between the two groups. For a comparison of mean values, see Figures 2 and 3.

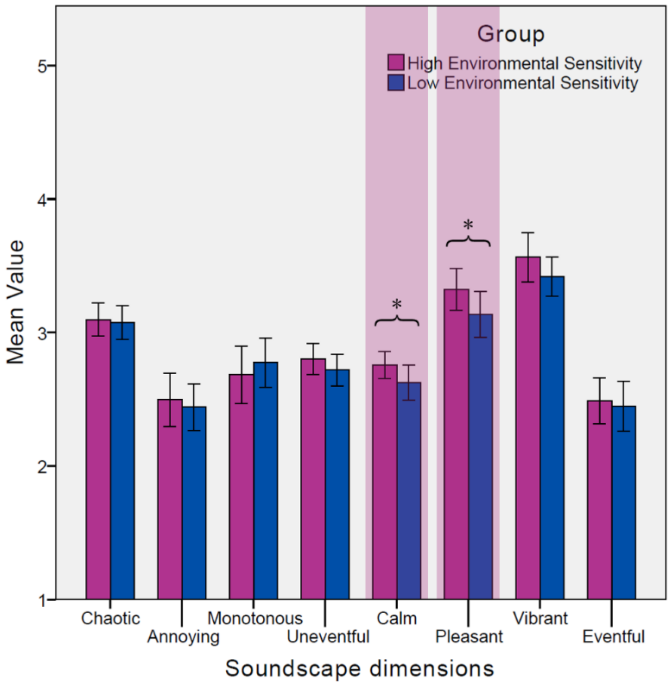

Figure 2: Mean scores of the soundscape dimensions by environmental sensitivity group (* *p*-value < 0.05 for independent sample *t*-test, error bars: 95% CI)

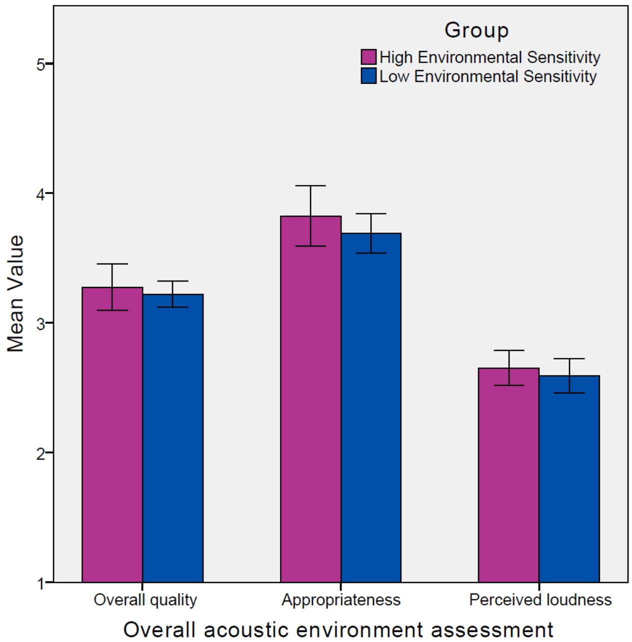

Figure 3: Mean scores of the overall acoustic environment assessment by environmental sensitivity group (error bars: 95% CI)

3.2. Effects of Noise Sensitivity on Soundscape Evaluations

Similarly, on the basis of the median of WNSS scores, individuals were divided into high- and low-noise sensitivity groups. Independent sample t-test for the mean value of each evaluation item for both groups showed there were no significant variations in any of the evaluations reported ($p > 0.05$). The mean values are shown in Figures 4 and 5.

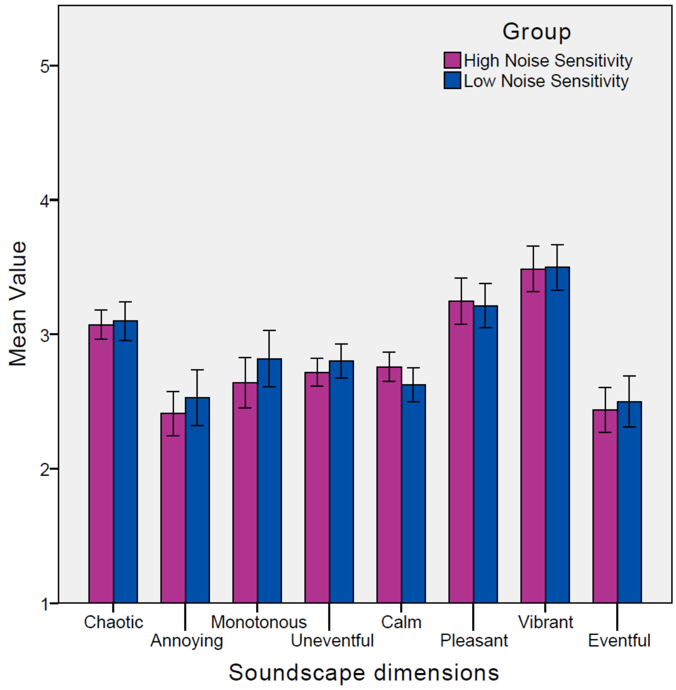

Figure 4: Mean scores of the soundscape dimensions by noise sensitivity group (error bars: 95% CI)

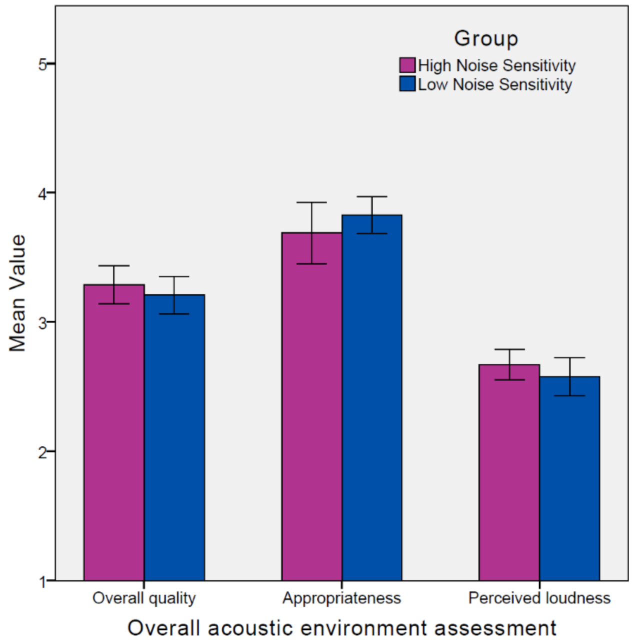

Figure 5: Mean scores of the overall acoustic environment assessment by noise sensitivity group (error bars: 95% CI)

3.3. Relationship Between Environmental sensitivity and Noise Sensitivity

The chi-square test of independence was conducted between the environmental sensitivity and noise sensitivity groups, $\chi^2(1) = 3.223$, $p = 0.073$. A moderate association was presented between these two factors, Cramer's V = 0.232, indicating that the two components have some similarity in their assessment content.

When the evaluation results of different environmental and noise sensitivity populations were compared, it appeared that environmental sensitivity had a higher predictive value in the experimental results. The noise sensitivity, on the other hand, had no significance in explaining the differences in soundscape evaluations, which was different from the findings of previous studies[8].One explanation might be that noise sensitivity is a measure of people's sensitivity to negative environmental stimuli. Literature has reported better predictive significance of noise sensitivity only when responses to environmental noise are involved [16]. However, due to the fact that the 12 experiment scenarios in this study were more oriented toward outdoor spaces conducive to relaxing and that the acoustic environment was of a comparatively high quality, environmental sensitivity measurement would be more appropriate for such scenarios because it included a measure for sensitivity to the positive, vantage environmental stimuli.

4. CONCLUSIONS

This study determined the effect of environmental sensitivity and noise sensitivity on the soundscape evaluations in urban open public spaces. It was found that people with higher environmental sensitivity tended to rate the pleasant dimension and the calm dimension higher, while no significant differences were found between the groups with different noise sensitivity for any soundscape evaluations. Additionally, a moderate correlation was revealed between environmental sensitivity and noise sensitivity. These findings might be used when consideration needs to be given to the diverse requirements of various communities in urban planning.

5. ACKNOWLEDGEMENTS

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