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How soundscapes affect the perceived soundscape restorativeness in green space in residential areas-a perspective from elder people

Xuan Guo¹, Jiang Liu² *

¹ Ruhr University Bochum, Institute of Geography, 44801 Bochum, Germany

² Fuzhou University, School of Architecture and Urban-Rural Planning, 350108 Fuzhou, China

Corresponding author's e-mail address: jiang.liu@fzu.edu.cn

ABSTRACT

As an important place for the elder people to relieve pressure and relax their mood, the green space plays the role of providing a restorative environment, while residential green space is particularly favored by the elderly because of its high accessibility. Taking 33 residential areas in Cangshan District, Fuzhou as examples, the research aims to explore the soundscape perception affecting the perceived soundscape restorativeness (PSR) of the elderly in the background of aging, through a field survey and a questionnaire survey of 438 residents. The results showed that the perceived soundscape restorativeness for elder people can be divided into two main dimensions: inclusiveness and attractiveness. Among the three main sound sources, only mechanical sound had a direct and significant negative impact on inclusiveness, while natural and human sound could affect the perceived soundscape restorativeness indirectly by influencing the perceived soundscape affective quality of elder people. The perceived soundscape affective quality, especially eventfulness had a direct and significant positive impact on the PSR of elder people. In addition, the results of the multi-group analysis indicated that there are differences between male and female elder people in the effects of human and mechanical sounds on the perceived soundscape restorativeness.

Keywords: Soundscape perception, Perceived soundscape restorativeness; Elder people; Green space; Structural equation model

INTRODUCTION

It is widely acknowledged that urban residents face multiple physical and psychological health risks from environmental pollutants, including air, water, and noise pollution, as well

as stress overload in daily life and work [1]. Hence, much attention has been paid to constructing high-quality living spaces to improve people's health conditions[2].

In the field of environmental psychology, researchers have identified that specific environmental characteristics can help individuals improve their physiological and psychological states and promote physical and mental health [3]. The Stress Recovery Theory (SRT) and Attention Restoration Theory (ART) provide important foundations for studying restorative environments [4; 5]. Based on these theories, researchers have widely discussed the characteristics of restorative environments, the way individuals perceive restorative benefits, and the influential factors through on-site investigation or controlled laboratory experiments. While many studies have investigated the restorative benefits of natural environments, particularly the visual dimension, the role of other senses in achieving restorative benefits has been overlooked [6; 7].

In fact, on the auditory dimension, some researchers have been exploring its relationship with restorative environment [8; 9]. The restorative benefits of soundscape have been verified from different perspectives, both in subjective evaluation and physiological measures [10-13]. At the same time, the influential factors on the PSR were identified by researchers from different perspectives such as type of sound sources, landscape factors, individual characteristics, etc.[14-16]. It worth to note that age was one of the most frequently mentioned among individual characteristic that influence the PSR. This is due to the fact that there are significant differences in individuals' social experience and physiological characteristics at different ages. In particular, the restorative potential of the soundscape for children has been investigated from different aspect [17-19]. However, in addition to children, the elderly is also a special group in need of a high-quality restorative environment. The health status of elder people is more vulnerable than that of other age groups, with physical decline leading to increased risk of disease, as well as with social role change after retirement leading to a high prevalence of mental illnesses such as loneliness, anxiety and depression [20]. Both in terms of the deteriorating mental health of elder people in the world today and the exponential increase in the number of elder people, we need to pay more attention to this specific group. Therefore, there is an urgent requirement for approaches and strategies to address the physical and mental health condition of elder people. Although the restorative benefits of positive soundscapes for people have been validated in many studies, the characteristics of PSR of elder people and the influential factors have not yet been explored in depth.

Residential green spaces are the most convenient spaces for elder people to access in their daily lives. Therefore, how the auditory experience in such spaces is related to their perceived soundscape restorativeness (PSR) should be given more attention when constructing high-quality spaces in an aging society. This study focuses on elder people of residential green spaces and explores the impact of soundscape perception on their PSR. Based on field surveys and public survey data from 33 residential areas in Fuzhou, China, this study aims to explore three questions: 1) What is the PSR of olded people in residential green spaces? 2) How does their perception of soundscapes affect the PSR? 3) Are there any differences between genders regarding the impact of soundscape perception on PSR?

MATERIALS AND METHODS

Study area

Green spaces in residential areas are the most accessible and usable places for the elder people. Therefore, green spaces in residential quarters of the Cangshan District, a built-up area located in the southern part of Fuzhou, China were selected as case study sites. During the preliminary study on the sample sites, the investigators recorded the sound

sources that occurred with high-frequency by conducting soundwalks through the green spaces. Eight sound sources were finally identified from three sound categories, i.e., natural sound, human sound and mechanical sound, including birdsong, tree rustling, water sound, surrounding speech, sports and fitness, broadcasting music, traffic sound, construction sound.

Questionnaire design

The questionnaire mainly included four parts. In the first part, the respondents' demographic/social characteristics were investigated, including gender, age, education level, length of residence in the residential quarter, visit frequency and length of stay. The second part of the questionnaire mainly concerned the perception of sound sources in green spaces in the residential areas. Respondents were asked to assess the dominate degree of typical sound sources in green space using a 5-point Likert scale (1 not at all - 5 dominates completely) [21]. The third part addressed the soundscape perception. Four positive indicators of the perceived affective quality of soundscape from ISO 12913-2 were selected for evaluation, respectively pleasant, vibrant, calm, and eventful [21]. The ratings were evaluated using a 5-point Likert scale (1 strongly disagree - 5 strongly agree). The final part of the questionnaire focused on the PSR of the respondents. Based on the Perceived Restorativeness Soundscape Scale (PRSS), the evaluation was adapted to the research objectives of this study [8; 22], with the specific items shown in Table 1. A 5-point Likert scale was used for the evaluation (1 strongly disagree - 5 strongly agree).

Table 1: Dimensions and items applied to evaluate perceived soundscape restorativeness in green spaces in residential area

Dimension	Item
Fascination	The soundscape in the green space awakens my curiosity.
	There is plenty for me to discover in this soundscape.
	Following what is going on in this soundscape really evokes my interest.
Being-away	Spending time in this soundscape gives me a break from my day-to-day routine.
	When I am in this soundscape, I feel free from work and/or responsibilities.
	This soundscape is a refuge for me from unwanted distractions.
Compatibility	There is an accordance between what I like to do and this soundscape.
	I rapidly adapt to this soundscape in the green space.
	Being in this soundscape fits with my personal inclinations.
	When I'm in this soundscape, it's not easy to do what I want to do.
Coherence	The existing sounds belong to this soundscape.
	The sounds fit together to form a coherent soundscape.
	This soundscape in the green space is coherent.
Extent	This soundscape in the green space feels very spacious.
	It seems like the extent of this soundscape is limitless.
	This soundscape is large enough to allow exploration in many

directions.

Data collection

The official survey was carried out between April and May 2022 during good weather conditions, from 8:00 to 18:00. Respondents who lived in the corresponding residential area were randomly selected on-site in the green space. Before starting the survey, respondents were firstly informed of the purpose of the survey and asked about their age. If they met the age requirement and were willing to participate, they were further asked to complete the questionnaire with necessary instruction from the interviewers, especially for respondents who were unable to complete the questionnaire independently due to physical reasons (e.g., inability to read the font or mobility problems). In this study "elder people" are defined as those aged 60 and over. Finally, a total of 450 questionnaires were distributed at the 33 sample sites, and after removing those that were incomplete, 438 questionnaires were finally valid, with an effective rate of 97.3%.

Data analysis

Factor analysis was conducted in SPSS 25.0 to characterize the PSR of elder people in residential green spaces. In addition, a partial least squares structural equation model (PLS-SEM) was used to explore (1) the effect of the dominate degree of sound source and the perceived affective quality of soundscape on the PSR of elder people, and (2) the differences in this effect between the genders. The PLS-SEM procedure was carried out in Smart PLS 3.3.

RESULTS

Factor analysis was conducted to characterize the PSR of elder people in residential green spaces. Two common factors with eigenvalues greater than 1 were extracted, accounting for 58.691% of the total variance. Factor 1 consisted of 11 items, mainly inclusive of three dimensions of compatibility, coherence, and extent, which can be summarized as inclusiveness. Factor 2 contained 5 items, primarily comprising two dimensions of fascination and being-away, which can be summarized as attractiveness. The two common factors explained 36.809% and 21.882% of the variance of the original dataset, respectively. The findings suggest that compared to the five progressive dimensions of PRSS, the PSR of elder people is relatively simple, featuring two main progressive dimensions: being attracted to high-quality soundscapes to detach from an unfavorable environment and further enjoying and immersing oneself in the soundscapes.

Using the two dimensions obtained from factor analysis as dependent variables, and the dominate degree of sound source and the perceived affective quality of soundscape as independent variables, a model for the perceived soundscape restorativeness for elder people in residential green spaces was established through PLS-SEM. The model includes three main hypotheses and 28 specific hypotheses:

Ha: The dominate degree of sound source directly affects the perceived soundscape affective quality;

Hb: The dominate degree of sound source directly affects the PSR of elder people;

Hc: The perceived soundscape affective quality directly affects the PSR of elder people;

Hd: The dominate degree of sound source indirectly affects the PSR of elder people by affecting the perceived affective quality of soundscape.

During the model construction process, except for broadcasting music in human sound

which was removed due to low factor loading compared to standards, all other indicators met requirements. The final model is shown in Figure 1.

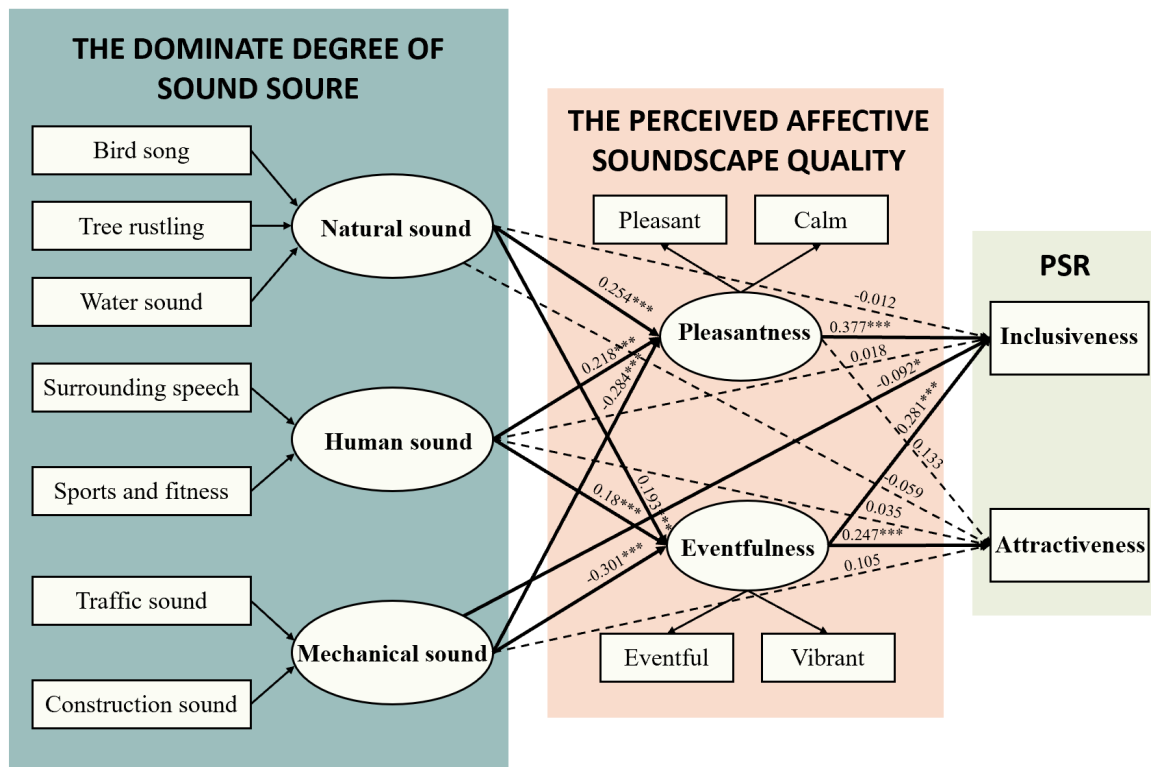


Figure 1: The structural equation model of the perceived soundscape restorativeness of elder people in resident green space (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; non-significant paths are marked with dashed lines and are not annotated)

The results of the path analysis showed that all three types of sound source had a significant effect on the perceived soundscape affective quality of elder people in the test of the H_a hypothesis. In particular, mechanical sound had the greatest and negative effect on both the soundscape pleasantness and eventfulness of the three types of sound source. It is worth noting that, in addition to the significant positive effect of natural sound on both the soundscape pleasantness and eventfulness, human sound also had a significant positive effect. Regarding H_b , of the three types of sound source, only mechanical sound had a direct and significant negative effect on inclusiveness. In H_c , the two aspects of perceived soundscape affective quality all had a significant effect on the PSR of elder people, except for soundscape pleasantness, which had no significant effect on attractiveness. Moreover, inclusiveness was more influenced by soundscape pleasantness and attractiveness by eventfulness.

Further mediation analysis revealed that among the 12 (9) mediating paths, the effect of mechanical sound on inclusiveness by affecting soundscape pleasantness was the strongest. Additionally, under the mediation of the perceived soundscape affective quality, mechanical sound had the largest indirect impact on the PSR of elder people compared to other types of sound source. However, in terms of overall effect value, mechanical sound contributed most to inclusiveness while human sound contributed most to attractiveness.

In order to further explore the impact of individual factors on the model, we analyzed the differences between males and females through multi-group analysis. The results are shown in Figure 2 and Table 2. The results showed that natural sound and human sound had significantly different direct effects on soundscape eventfulness in different genders. Regardless of gender, the perception of soundscape eventfulness was significantly

positively influenced by the dominate degree of natural sound, but this effect is smaller in melas than in females. In addition, human sound had a greater and more significant impact on the perception of soundscape eventfulness among females. Furthermore, there were also different direct effects of human sound and mechanical sound on inclusiveness, which showed significant differences between genders. Specifically, both human sound and mechanical sound had a significant direct impact on inclusiveness among females; however, this is not true for males.

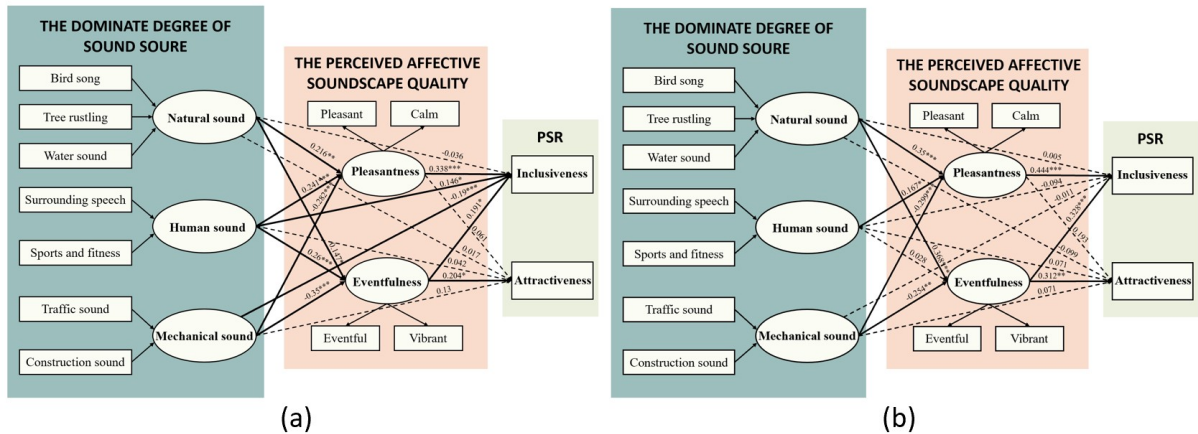


Figure 2: The structural equation model of the perceived soundscape restorativeness of elder people in resident green spaces between different genders (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; non-significant paths are marked with dashed lines and are not annotated), (a) Females, (b) Males

Table 1: The coefficient difference between the same path in different genders

Hypothesis Path	Path Coefficient-Difference	P Value
Natural sound → Pleasantness	0.135	0.145
Natural sound → Eventfulness	0.221	0.02
Natural sound → Inclusiveness	0.067	0.489
Natural sound → Attractiveness	-0.116	0.362
Human sound → Pleasantness	-0.074	0.374
Human sound → Eventfulness	-0.232	0.007
Human sound → Inclusiveness	-0.24	0.008
Human sound → Attractiveness	0.029	0.761
Mechanical sound → Pleasantness	-0.017	0.846
Mechanical sound → Eventfulness	0.096	0.296
Mechanical sound → Inclusiveness	0.18	0.026
Mechanical sound → Attractiveness	-0.059	0.578
Pleasantness → Inclusiveness	0.105	0.297
Pleasantness → Attractiveness	0.132	0.38
Eventfulness → Inclusiveness	0.137	0.168
Eventfulness → Attractiveness	0.109	0.391

DISCUSSION

Although attention has been paid to the health-promoting effects of soundscapes on urban residents, there is still a lack of focus on specific populations, especially the elderly. In this study, we found that the PSR characteristics of elder people were divided into two main dimensions: inclusiveness and attractiveness, which are simpler than the PRSS [8]. This may be attributed to the cognitive status of the elderly, where a decrease in physiological and psychological functioning results in reduced emotional and cognitive processing abilities.

In addition, in previous studies, much emphasis has been placed on the impact of different types of sound sources on restoration [10; 23]. However, regarding elder people, this direct impact is not too obvious overall and mainly manifests as the direct negative effects of noise. The greater influence is mainly generated through the overall soundscape perception, while different types of sound sources affect the PSR of elder people by influencing the overall soundscape perception. This emphasizes the importance of creating a good overall soundscape atmosphere when constructing a soundscape for elder people, rather than just adjusting one type of sound source[15].

In terms of the specific characteristics of elder people, there were also differences in the impact of soundscapes on restoration. This is a departure from the findings of previous studies. In past studies exploring the factors influencing the restorative benefits of soundscape, age has been the most frequently verified of the innate factors [15; 24]. In this study, on the other hand, we found differences between genders in the same case of elder people. In particular, human sound and mechanical sound, the two types of sound sources, can directly influence the PSR obtained by female elder people.

CONCLUSION

Based on the results of 438 questionnaires from 33 green spaces of residential area, this study explores the impact of soundscape on PSR from the perspective of elder people. The results showed that characteristics of the PSR of elder people were divided into two main dimensions: attractiveness and inclusiveness. Among the three types of sound sources, only mechanical sound had a direct and significant negative effect on inclusiveness, while natural sound and human sound mainly influenced the PSR of elder people by affecting the perceived soundscape affective quality. And the perceived soundscape affective quality, especially eventfulness had a direct and significant positive impact on the PSR of elder people. Finally, it was also found that among elder people, there were significant differences in the impact of soundscapes on the PSR between different genders. Specifically, the inclusiveness perceived by females' elder people was directly affected by natural sound and mechanical sound, while males' elder people were not affected. The results of this study reveal the specificity of the PSR of the elderly group, which can provide a theoretical basis for the subsequent restorative landscape design of ageing-friendly residential areas.

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