



Soundscape characterization in outdoor public spaces in urban high-rise residential blocks

Guofeng Zhu¹

School of Architecture, Tianjin University

School of Architecture, Tianjin University, No.92 Weijin Road, Nankai District, Tianjin 300072, China

Jian Kang²

School of Architecture, Tianjin University

Institute for Environmental Design and Engineering, University College London

Central House, 14 Upper Woburn Place, London WC1H 0NN, United Kingdom

Hui Ma*³

School of Architecture, Tianjin University

School of Architecture, Tianjin University, No.92 Weijin Road, Nankai District, Tianjin 300072, China

Chao Wang⁴

School of Architecture, Tianjin University

School of Architecture, Tianjin University, No.92 Weijin Road, Nankai District, Tianjin 300072, China

ABSTRACT

Outdoor public spaces in high-rise residential districts are essential components in modern high-density cities, and acoustic comfort in those spaces are important for enhancing personal relaxation and community communications. However, while considerable previous works were carried out from the viewpoint of noise control, their overall sound environment perception has not been paid sufficient attention. Therefore, this study aims to characterize the soundscape dimensions of outdoor public spaces in urban high-rise residential districts, and to explore the effect of soundscape dimensions on the overall soundscape satisfaction. A detailed soundscape survey was conducted in the outdoor public space of a typical residential

¹ zhuguofeng_tj@tongji.edu.cn

² j.kang@ucl.ac.uk

³ mahui@tju.edu.cn

⁴ pdwangchao@tju.edu.cn

block. The semantic differential analysis of soundscape dimensions shows that while the soundscape in outdoor public spaces of high-rise residential districts is rather complicated, five major dimensions are identified, including pleasantness, familiarity, strength, stability, and spatiality. Consequently, effect of the dimensions on the overall soundscape satisfaction was briefly discussed.

1. INTRODUCTION

High-rise residential buildings are becoming more widespread as modern cities are increasingly dense. The outdoor public spaces in residential districts as places of daily play, relaxing and social activities, are becoming even more important. As compared to other urban public spaces, those spaces are more frequently visited by local residents. Therefore, the acoustic environment is an important factor affecting their living quality.

Plenty of previous work have been carried out from the viewpoint of noise in the outdoor public spaces of residential areas, including traffic noise distribution [1][2], relationships between noise exposure and annoyance [3][4][5], and noise-related physiological effects [6][7]. However, reducing noise level does not necessarily lead to better auditory experience [8]. The overall sound environment perception is affected by many factors and the soundscape approach offers a new perspective. Whilst most existing investigations on soundscape have mainly dealt with urban public spaces, such as urban squares and urban parks, research on the outdoor public spaces is limited. This kind of space differs from other urban public spaces in two ways: firstly, the outdoor public space is mainly visited by residents living nearby, and it serves a relatively fixed small group of citizens; secondly, these spaces are much more frequently visited, and residents may have stronger daily impression and expectations, which may affect their evaluation on soundscape.

Therefore, the main objectives of this study are as follows: (1) to identify soundscape dimensions in outdoor public spaces in high-rise residential districts and how they differ from other type of urban public spaces; (2) effect of soundscape dimensions on the overall soundscape satisfaction.

2. METHODOLOGY

2.1. Survey Site Selection

Baolongwan residential block located in Tianjin, China, was selected as the survey site for its typical layout as an urban high-rise residential block. The block built in 2008 consists of 15 high-rise buildings, including 1643 local households. A center square is enclosed in the middle by buildings situated all around (Figure 1). The Floor Space Index (FSI, the ratio of the total floor area in the block to the total block area) of the block is 3.2, and the vegetation coverage ratio is 41%. As the community is semi-closed to outsiders, most of the square visitors are residents living within the block.



Figure 1: Layout of the selected residential block

2.2. Questionnaire

Considering the context difference between semi-public space and other urban public spaces (for example urban parks), a semantic differential method was applied to investigate the perceived soundscape dimensions. The questionnaire used in the study consists of 2 main themes, with each containing several items:

(1) Soundscape evaluation based on semantic descriptors. Soundscape perception dimensions were found to be different in different kind of spaces [9][10][11]. In this study, a series of semantic differential descriptors were suggested by previous research on urban soundscapes, To ascertain the unique features of outdoor public spaces in residential districts, a pre-survey on-site interview on soundscape evaluation was performed to extract more relevant descriptors. Finally 18 semantic descriptors were summarized from previous studies and pre-survey interview, which covered various aspects of a soundscape in this type of space. A seven-point bipolar rating scale was used in this part.

(2) Evaluation on overall soundscape satisfaction and perceived loudness. Respondents were asked to evaluate the holistic soundscape and how loud the sound environment is, both on five scales.

2.3. Procedure

Soundscape data can be collected either through soundwalks with a certain group of subjects or through on-site survey with the real space users. As outdoor public spaces are normally restricted to residents only, data collected from residents may be more authentic. Therefore, residents living inside the block were selected as survey subjects. Questionnaires in paper form were distributed among those who stayed in the square or passers-by. Respondents were asked to complete the questionnaire according to their personal feelings of the sonic environment at that time. Completing the questionnaire normally took 10 minutes for each participant.

The on-site survey was conducted in October and February, 2019, in both weekdays and weekends, between 9:00am and 05:00pm. Finally 41 questionnaires were obtained.

2.4. Statistic analysis

SPSS software was adopted to perform the data analysis. Factor analysis was employed and reliability test shows that the Kaiser-Meyer-Olkin(KMO) measure of sampling adequacy=0.744,

and the corresponding Bartlett's spherical test results ($p < 0.01$) satisfy the validity of the questionnaire.

3. RESULTS AND DISCUSSION

3.1. General soundscape evaluation

The subjective evaluations of the overall soundscape satisfaction as well as perceived loudness were examined. Generally there is a negative correlation between loudness and soundscape satisfaction, meaning that lower loudness corresponds to higher soundscape satisfaction. Therefore the loudness scale 1-5 was inversed to check their correspondence, as shown in Figure 2. For soundscape satisfaction: 2, bad; 3, neither good nor bad; 4, good; 5, very good; and for perceived loudness: 2, very; 3, moderately; 4, slightly; 5, not at all. Rating scale '1' is omitted since there were no such responses. The average score is 3.49 (SD=0.55) for soundscape satisfaction and 3.02 (SD=0.82) for loudness. It is noted that variation on evaluation of soundscape satisfaction among participants is significantly smaller than that of perceived loudness (< 0.05), based on Paired Samples T-tests, indicating that quieter environment does not necessarily lead to more satisfying auditory experience. This is perhaps because unlike the judgement of loudness, evaluation of the overall soundscape satisfaction is a more complicated process.

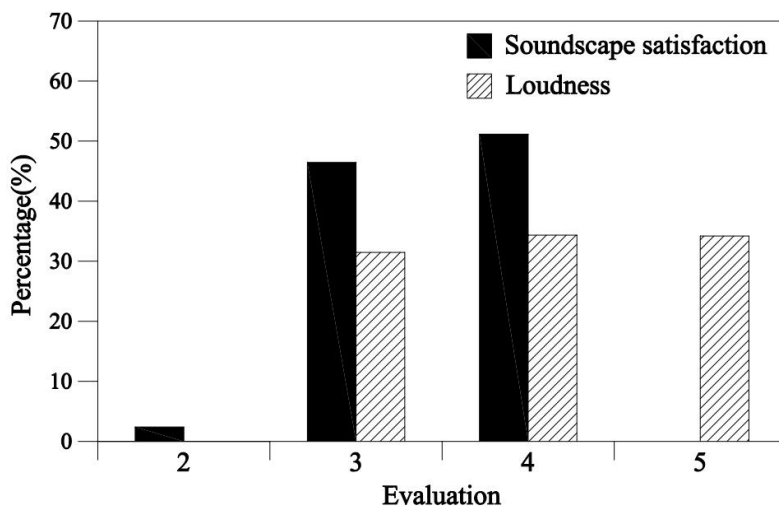


Figure 2: Comparison between the evaluation of overall soundscape satisfaction and perceived loudness. Soundscape satisfaction: 2, bad; 3, neither good nor bad; 4, good; 5, very good. Loudness: 2, very; 3, moderately; 4, slightly; 5, not at all. Rating scale '1' is omitted.

3.2. Perceptual dimensions of soundscape in outdoor public space of urban residential districts

Factor analysis was employed and varimax rotated principal component analysis was employed to extract the orthogonal factors underlying the 18 adjective indices. Five soundscape perception dimensions were determined (Table 1). It can be seen that factor 1 (25.5%) is generally associated with pleasantness, including unclear-clear, disordered-ordered, monotonous-abundant, unpleasant-pleasant, disharmonious-harmonious, tense-relaxing, uncomfortable-comfortable, meaningless-meaningful. Factor 2 (18.6%) is mainly associated with familiarity, including familiar-unfamiliar, safe-unsafe, friendly-unfriendly, and deadly-echoed. Factor 3 (11.8%) is mostly associated with strength, including weak-strong, flat-sharp, and noisy-quiet. Factor 4 (9.7%) is principally related to stability, including varied-stable. The composition of Factor 5 (8.2%) is odd and is perhaps due to the small sample size, temporarily it is summarized as related to spatiality, including natural-artificial, and directional-everywhere.

Table 1: Rotated component matrix of factor analysis

	Component				
	1	2	3	4	5
unclear-clear	.889				
disordered-ordered	.872				
monotonous-abundant	.778				
unpleasant-pleasant	.764				
disharmonious-harmonious	.683				
tense-relaxing	.670				
uncomfortable-comfortable	.617				
meaningless-meaningful	.461				
familiar-unfamiliar		-.915			
safe-unsafe		-.868			
friendly-unfriendly		-.747			
deadly-echoed		.593			
weak-strong			.790		
flat-sharp			.700		
noisy-quiet			-.557		
varied-stable				.885	
natural-artificial					.701
directional-everywhere					.564

The result of the semantic differential analysis shows that there are some similarities and differences between outdoor public spaces in residential blocks and other urban public spaces (Table 2). Compared with previous studies on other urban spaces [9][10][11][12], the major perceptual dimensions that were extracted are very similar and cover the most basic aspects of an acoustic environment including pleasantness, sound strength and stability. However, the analysis also reveals some characteristics of outdoor public spaces in residential blocks. All the five dimensions explained 73.7% of the total variance, which is higher than most results in other urban spaces, indicating a stronger consistency within the residents on soundscape evaluation. Moreover, familiarity has been proved to be the second important perceptual dimension in those spaces. This is perhaps because the outdoor spaces are more frequently used and more ‘private’ to the residents, compared to other urban public spaces, so there is a stronger underlying sense of belonging and expectation of safety towards their surrounding living environment [13][14].

Table 2: Comparison of results from this study and previous studies

Researcher	Space type	Dimensions	Method
This study	outdoor public space in high-rise residential blocks	Pleasantness(25.5%) Familiarity(18.6%) Strength(11.8%) Stability(9.7%) Spatiality(8.2%)	on-site survey
Yu [11]	urban	Preference(17%)	on-site survey

	shopping street	Communication(13%) Loudness(12%) Playfulness(12%) Richness(10%)	
Kang [12]	urban open public space	Relaxation(30%) Communication(13%) Spatiality(7%) Dynamics(3%)	on-site survey
Axelsson [14]	multiple types	Pleasantness(50%) Eventfulness(18%) Familiarity(6%)	laboratory experiment

3.3. Correlations between perceptual dimensions and the overall soundscape satisfaction

The correlations between overall soundscape satisfaction and perceptual dimensions were examined via Spearman correlation test (Table 3). Overall soundscape satisfaction was found to be positively correlated with perceived pleasantness($p < 0.01$), familiarity($p < 0.05$), and negatively correlated with perceived strength($p < 0.05$). This indicates that residents favor sonic environments that are ‘pleasant’, ‘familiar’, and ‘quiet’. In addition, as important perceptual dimensions, the perceived stability and spatiality were found to have no significant relationships with overall soundscape satisfaction.

Table 3. Correlations between perceptual dimensions and overall soundscape satisfaction

	Pleasantness	Familiarity	Strength	Stability	Spatiality
overall soundscape satisfaction	.533**	.332*	-.366*	.129	.105

4. CONCLUSIONS

In this study, a survey on soundscape perception was performed in an outdoor public square inside a typical high-rise residential block. The analysis highlights that for this case study:

(1) Evaluation of soundscape satisfaction in outdoor public spaces in high-rise residential districts is significantly different from evaluation of loudness, indicating a complicated process of soundscape perception. Consequently, five soundscape perceptual dimension were identified, including pleasantness, familiarity, strength, stability, and spatiality, explaining 73.7% of the total variance.

(2) The overall soundscape satisfaction was positively correlated with pleasantness($p < 0.01$) and familiarity($p < 0.05$), and negatively correlated with strength($p < 0.05$), but not significantly related to stability or spatiality.

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