Soundscape Identification in Noise Annoyance Evaluation

Lei YU[1]; Jian KANG[2]; Liang HONG[3]; Charles XIE[4]
[1,4] Shenzhen Graduate School, Harbin Institute of Technology, China
the Shenzhen Key Laboratory of Urban Planning and Decision Making
[2] School of Architecture, University of Sheffield, UK
[3] Shenzhen Environmental Monitoring Centre, China

ABSTRACT

Living in modern cities is being interfered by ambitious noise more and more seriously. Present controlling approach is to monitor sound pressure level, which only describes one characteristic of a sound environment and ignores its influence on people too. Many studies proved that noise annoyance is not only determined by sound pressure level but also by soundscape that a person identifies. Since a bird singing or water babbling is perceived quieter than a traffic roaring even both having the same sound pressure level, it is considered that soundscape identification plays an important role in subjective evaluation of noise annoyance. Therefore, this study is going to explore how soundscape identification in determining noise annoyance evaluation within a city context. The study investigates four places in an ecological residential area that contains completely nature, nature mixed with man-made, and complete man-made soundscapes. Using recordings of the four study-sites, physical characteristics of a diversity soundscape have been analyzed and relationships of a soundscape's physical characteristics with noise annoyance evaluation have been studied.

Keywords: Soundscape Identification, Noise Annoyance Evaluation,
I-INCE Classification of Subjects Number(s): 56. 3

1. INTRODUCTION

Noise is becoming a serious pollutant in urban lives especially in modern Chinese metropolises. Apparently, Shenzhen is one of them. Amongst numerous residential departments in Shenzhen, Oversea City Town (OCT) is one outstanding ecological residential department, which physical environment is quite comfortable. The OCT presents an excellent mode for ecological living within a big city. For a sound environment, the OCT contains a diverse of soundscapes, namely nature soundscape (mostly noticed by nature sound barely man-made sound), neutral soundscape (noticed by nature and man-made sound), and man-made soundscape (mostly noticed by man-made sound barely nature sound). Although the area is reputed as a wonderfully ecological living environment, it is also found that its sound environment is not much satisfied due to some man-made sounds. Based on previous studies of noise impact, it is well known that unique attenuation on sound level is insufficient to reduce noise annoyance (1-3), whereas a soundscape perspective has been proven more effective and feasible (4, 5). Different from a physical sound environment, a soundscape refers to a subjective sound environment focused on a way that sounds and the containing "scapes" are perceived by surrounding individuals or societies (6). In order to produce a pleasure soundscape to the OCT residential department and to make a good sound environmental model for other places' development, this study is then going to investigate noise annoyance evaluation in terms of soundscape identifications. In the study, different soundscapes and their relations with noise annoyance evaluations are explored.

[1] Leilayu@hitsz.edu.cn
[2] J.Kang@Shef.ac.uk
[3] 376604225@qq.com

2. METHODS

2.1 Field Studies

In order to study noise annoyance evaluations in terms of soundscape identification, an opening space in the Shenzhen OCT residential area namely the OCT Ecological Square, is chosen to undertake field studies. The Square provides various spaces for activities and can be functionally divided into four parts named A, B, C, and D as shown in Figure 1. According to on-site observation, each part decorates with a rather different soundscape. The Part A is near to two roads and featured by hard surfaces to provide dancing or doing exercise except the northeast corner is a small natural part decorated with wetland, wood-platform and trees. It is then found that the Part A is basically formed by man-made sounds namely traffic, commercial activities, and also fountain sound, and can be considered as a man-made soundscape area. The Part B is a very long area ranging from the east side to the inner part of the Square. In the Part B, it contains various sounds including the east traffic noise and the west bird singing. It is a neural soundscape area composition of most man-made sounds mixed some nature ones. The Part C is in the very west part of the Square. A landscape feature of this part is generally nature scattering a few man-made works. A soundscape characteristic of the Part C is rather nature rendering by birds and cicadas singing and water twittering. The Part D is in the southwest part of the Square. A landscape feature of the Part D is basically man-made but embellished some nature factors such as a water pool and wood paths. An apparent soundscape feature of the Part D is man-made mixed nature sounds (See Figure 1).

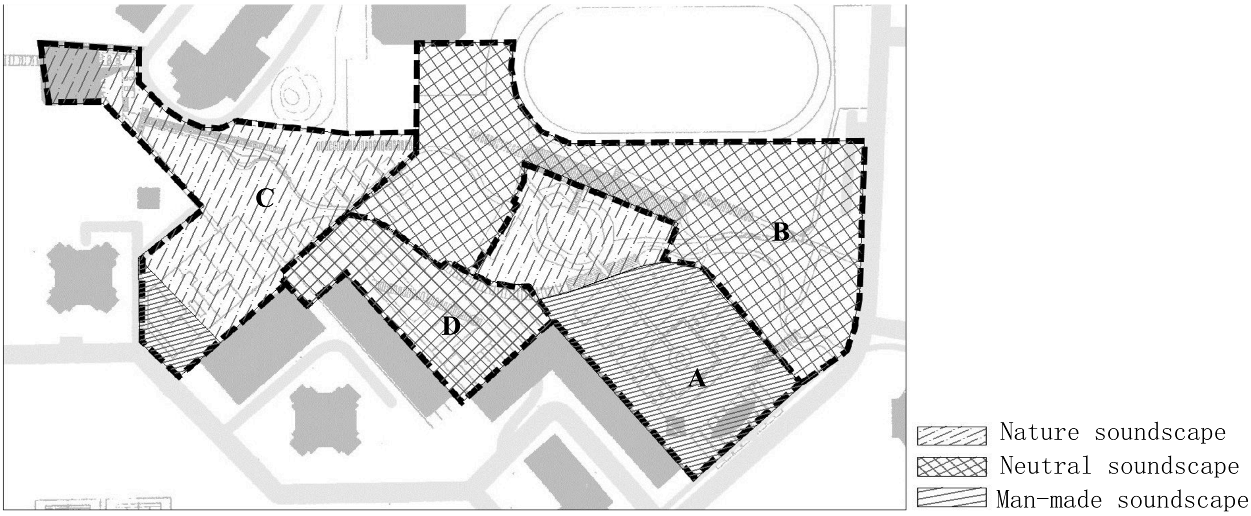

Figure 1 – Soundscape distribution of the OCT Ecological Square

In the field studies, intensive social surveys have been conducted in the four parts. Questions of subjective evaluations of noise annoyance, soundscape comfort, and noticed sound sources have been asked. More questions of subjects' social/demographic backgrounds, activity behaviors and psychological factors have also been elicited. A five-minutes recording has been undertaken when doing interviews. For each study part, fifty interviewees have been chosen. Totally, two hundred interviews have been done in the complete field studies. Using data collected from the field studies, soundscape identification and its relation with noise annoyance evaluation have been studied and will demonstrate in the following sections.

2.2 Nature Soundscape in the Part C

To a nature soundscape, on-site recording data of the Part C have been analyzed using the Head acoustics' ArtemiS to understand physical characteristics of a nature soundscape. Analyzing on-site subjects noticed sounds for the Part C presents that a 60% of noticed sounds are nature. Sound level analyses of the Part C shows that its background sound level (L_{90}) is around 60dB and a foreground sound level is around 67dB (L_{10}) with the highest of 80dB. Psychological acoustic parameter analyses illustrate that roughness of the Part C is rather stable but the loudness and sharpness is bit fluctuation that might be occasionally cicadas singing. As shown in Figure 2, it can be seen that frequency of the Part C covers from 20Hz to 1kHz and concentrating on high frequencies. It is assumed that a rather lower frequency around 200 to 500 Hz is contributed by peoples' activity. The most obvious frequencies around 500 to 1kHz might come from nature sounds noticed as water twittering, insect singing, and wind and rain sound. A mean value of noise annoyance evaluation of the Part C is 3.8.

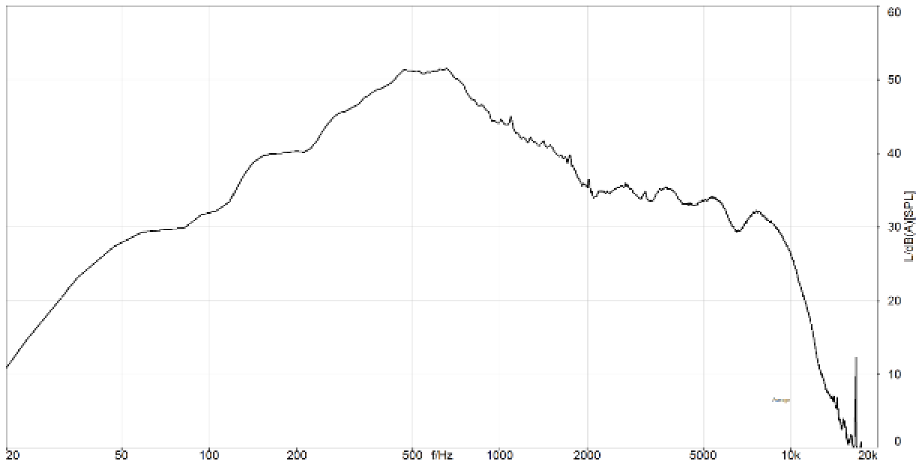

Figure 2 – Frequency of the Part C area

2.3 Man-made Soundscape in the Part A

As the Part A is mostly decorated by man-made sounds with only a few nature sounds, it has been taken as a man-made soundscape in this study. For the Part A, a background sound level is around 68dB and a foreground sound level is about 73dB with occasionally reached 85dB high. Analyses of psychoacoustic parameters illustrate that loudness, sharpness and roughness varies rather stable except occasional loud sounds outbreak in some moments, which might be sounds from a tape recorder for dancing. Figure 3 shows frequency analyses of the Part A, it can be seen that its frequency basically covers from 20Hz to 5000Hz; the frequency value is growing up from 20Hz to 500Hz and then dropping dramatically from 500Hz to 1kHz. It also shows an obvious man-made sound characteristic of talking and playing although this might be mixed with a few nature sounds, however, the highest sound level must come from sometimes square dancing. A mean value of noise annoyance evaluation of the Part A is 3.46, which is lower than the Part C indicating people feeling more annoyed in the Part A as 1 stands for very noise and 5 stands for very quietness.

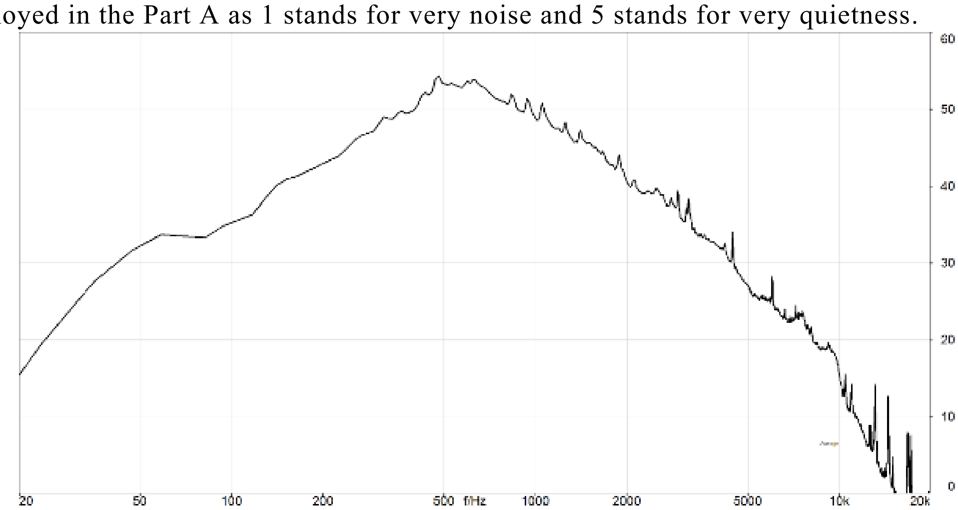

Figure 3 – Frequency of the Part A area

2.4 Neutral Soundscape in the Part B&D

As there are 41% nature sound versus 59% man-made sound in the Part B and 38% nature sound versus 62% man-made sound in the Part D, these two Parts have been taken as a neutral soundscape in this study. A background sound level of the Part B and as well as the Part D is around 60dB, whereas a foreground sound level of the Part B is about 69dB but 70dB of the Part D, while the highest sound level approximately reaches 76dB. Acoustic psychological analyses for the Part B and

Part D show that loudness, sharpness and roughness of both part are more stable compared to those of the Part A & C although loudness and roughness varies a bit more than sharpness for the both part while a variation of the Part B is bigger. Figure 4 & 5 show frequency analyses of the Part B and Part D. It can be seen that the frequency of the two part are rather similar, which both has a range of 20Hz to 1kHz except the Part D drops quickly to 1kHz. Making a comparison of the frequency of the Part B & D to the Part A, it is interesting to note that all three have a similar trend of frequency with only a slightly different in the high frequency part, which might be of nature sound variation. A mean value of noise annoyance evaluation of the Part B and D is 3.62 and 3.42 respectively, indicating that people feeling the most annoyed in the Part D and the most quieter in the Part C.

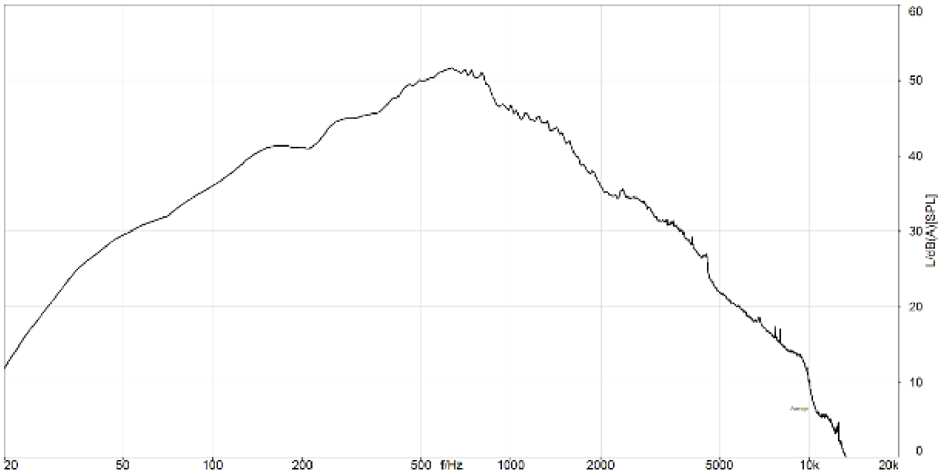

Figure 4 – Frequency of the Part B area

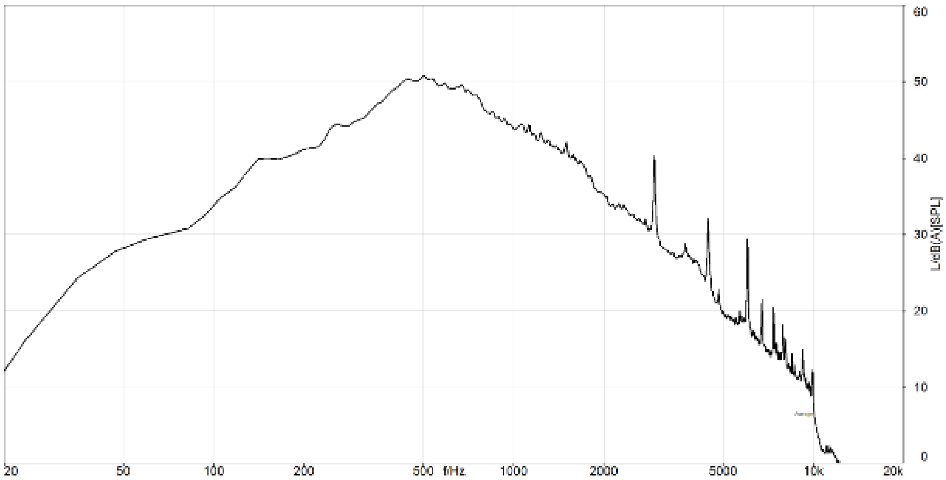

Figure 5 – Frequency of the Part D area

3. RESULTS

Following analyses of the above section, this section is going to study noise annoyance evaluation in terms of soundscape differences. Firstly, noise annoyance evaluation to the nature soundscape is studied, and then to the man-made soundscape, and eventually to the neutral (man-made and nature mixed) soundscape.

3.1 Noise Annoyance Evaluation to Nature Soundscape

Using relationship analysis modular of SPSS, sound levels influencing noise annoyance evaluation to a nature soundscape have been made based on the Part C data. Results are made in Table 1. It can be seen that there is no significant relations between noise annoyance evaluation and L_{Aeq}, L_{10}, L_{50}, or L_{90} although a negative relation is found indicating people feeling quieter when sound level is lower. Amongst all sound levels, the most influencing parameter is L_{50} that has the highest correlation value. Analyses of psychoacoustic parameters influencing noise annoyance evaluation present that only loudness has a significant correlation with noise annoyance evaluation (also shown in Table 1). It is found that all psychoacoustic parameters have a negative relationship with noise annoyance evaluation. This indicates that to a nature soundscape when it is perceived louder, sharper, or rougher, subjects would feel more annoyed. Based on studies of the Part C, it is then concluded that for a rather nature soundscape area, when a sound level is higher and a soundscape is perceived louder or sharper or rougher, individuals probably feel more annoyed. However, such a result is obtained on a situation of a background sound level is higher than 60dB.

3.2 Noise Annoyance Evaluation to Man-made Soundscape

Analyses of noise annoyance evaluation to man-made soundscape are studied using data from the Part A, and the results are shown in the Table 1 too. It can be seen there is no significant influence of sound levels as well as psychoacoustic parameters on noise annoyance evaluation although all have a negative relationship except L_{90} but with a very small correlation value, indicating that with L_{Aeq}, L_{10}, L_{50} is going higher or loudness, sharpness, roughness is going up, the subjects felt more annoyed. This might be of a rather stable variation of sound levels and psychoacoustic parameters to a man-made soundscape. As sound levels of a man-made soundscape as the Part A has is usually not fluctuation much and also its psychoacoustic parameters (see the Section 2.3), their influence on noise annoyance might be rather limited.

3.3 Noise Annoyance Evaluation to Neutral Soundscape

In this study, two sites, the Part B and D can be considered as a neutral soundscape place, which is mixed nature and man-made sounds as illustrated in the Section 2.4. The Part B has been noticed with more nature sounds than the Part D. As shown in Table 1, it can be seen that sound levels and psychoacoustic parameters on noise annoyance evaluation to the Part B & D are barely significant to noise annoyance evaluation except the Part D's L_{10}. A difference of the Part B and D is a negative relationship has been found to all factors of the Part B except sharpness but a positive relationship is found to all of the Part D. Although a barely significant relationship is found to the Part B and the Part D, a closer relationship of the sound levels on noise annoyance evaluation to the Part D can be seen and L_{10} even reaches significance. A possible reason is that a sound source difference since both parts have the similar sound levels but a rather different roughness. Through studies of the Part B and Part D, it is found that noise annoyance evaluation to a neutral soundscape is rather complicated. A possible key factor to influence noise annoyance evaluation to a neutral soundscape might be much determined by a sound source difference while psychoacoustic parameters play an important role.

Table 1 – Relations of soundscape characteristics with noise annoyance evaluation.

Area	Soundscape characteristics		Noise annoyance evaluation	
			Correlation	Significance (2-tailed)
Part A	Sound levels	L_{Aeq}	-0.022	0.879
		L_{10}	-0.037	0.800
		L_{50}	-0.044	0.763
		L_{90}	0.007	0.963
	Psychoacoustic parameters	Loudness	-0.098	0.499
		Sharpness	-0.057	0.692
		Roughness	-0.108	0.455
Part B	Sound levels	L_{Aeq}	-0.043	0.766
		L_{10}	-0.088	0.546
		L_{50}	-0.092	0.524
		L_{90}	-0.110	0.446
	Psychoacoustic parameters	Loudness	-0.112	0.439

		Sharpness	0.028	0.846
		Roughness	-0.056	0.698
Part C	Sound levels	L_{Aeq}	-0.295^{*}	0.037
		L_{10}	-0.292^{*}	0.039
		L_{50}	-0.308^{*}	0.030
		L_{90}	-0.291^{*}	0.040
	Psychoacoustic parameters	Loudness	-0.292^{*}	0.040
		Sharpness	-0.136	0.348
		Roughness	-0.188	0.191
Part D	Sound levels	L_{Aeq}	0.264	0.064
		L_{10}	0.300^{*}	0.035
		L_{50}	0.268	0.060
		L_{90}	0.130	0.367
	Psychoacoustic parameters	Loudness	0.180	0.210
		Sharpness	0.040	0.781
		Roughness	0.138	0.340

4. CONCLUSIONS

Noise annoyance evaluation to various soundscapes is studied in this paper using data collected from the Shenzhen OCT Ecological Square. It is found that sound levels of a nature soundscape are lower than a neutral one, and neutral ones are lower than those of a man-made one. Sound frequency to the man-made and neutral soundscape is similar but rather different to the nature soundscape that includes more high frequency sounds. Analyses of psychoacoustic parameters present that sharpness and roughness fluctuating bigger to the nature soundscape than the neutral or man-made soundscape. A mean value of noise annoyance evaluation to each study part shows that the nature soundscape is perceived the quietest than the neutral and man-made soundscapes. It is also interesting to find that a significant relation exists of sound level and psychoacoustic parameters on noise annoyance evaluation to the nature soundscape but not to the neutral or man-made soundscape.

ACKNOWLEDGEMENTS

Works of this research are supported by the Shenzhen Key Laboratory of Urban Planning and Decision Making, and partly funded by the China National Science Foundation (71371060) as well as the Humanities and Social Sciences of Education Ministry (12YJA880130). The authors are indebted to all research members in this project.

REFERENCES

1. Schulte-Fortkamp B. The meaning of annoyance in relation to the quality of acoustic environments. Noise and Health 2002; 4:13-18.
2. Berglund B, Lindvall T, Schwela DH. Guidelines for community noise. World Health Organization Report, Geneva, OMS 1999, 94.
3. Kang J. Urban sound environment. London: Taylor & Francis incorporating Spon; 2006.
4. Brown AL, Muhar A. An approach to the acoustic design of outdoor space. Journal of Environmental Planning and Management 2004; 47: 827-842.
5. Truax B. Models and strategies for acoustic design：the Hey Listen. Conference of the Royal Swedish Academy of Music, Stockholm, Sweden; 1998.
6. Schafer RM. The tuning of the world. Toronto: McClelland & Stewart; 1977.