

Comparison between the UK and Taiwan on the sound environment in urban residential areas

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ABSTRACT: Environmental noise is one of the main pollutions in urban areas. The general aim of this study is to examine how people perceive sound environment and acoustic quality in urban residential areas, and identify the key components of a comfortable and pleasant acoustic environment. This paper examines the importance of cultural factors through a comparative study between the UK and Taiwan. In particular, using six case study sites, three in Sheffield and three in Taipei, representing typical urban texture as well as social/demographic factors of the residents, the research includes: measurement and simulation of the case study sites using noise-mapping software, in order to better understand the effects of urban texture and sustainable development on the urban acoustic comfort in residential areas; and a series of questionnaire surveys focusing on how people perceive acoustic quality in urban residential areas, with statistics software SPSS used to analyse the results. The comparative study reveals the importance of considering cultural factors as well as urban texture and building types in evaluating urban sound environment.

Keywords: Perception, acoustic quality, urban environment

1. INTRODUCTION

The sound quality in our living environment is becoming more important whilst the noise level is continuously increasing [1,2]. Noise will not disappear but it could be dealt with in a more sustainable manner.

Cultural background plays an important role in the evaluation of urban sound environment. A cross-cultural study on the key factors of evaluating environmental sound quality in Japan, Germany, USA and China, using semantic differential analysis, has demonstrated notable differences between the four countries [1]. Also, for a given noise level inhabitants of small towns seem to be less annoyed than those of large urban communities [2,3].

The evaluation of urban sound environment has been studied for a number of years, for which the method of examining sound quality is relevant, where three main aspects are considered: stimulus-response compatibility, which is the functional aspect of a sound; pleasantness of sounds, which is based on an instantaneous overall impression emerging from various sound attributes as well as individual preferences and experience; and identifiability of sounds or sound sources, so people know what is going on around them [4].

It is also important to consider the physical sound environment. Differences in urban texture, including building density, dimensions and boundaries, could lead to different urban sound fields [2].

The aim of this paper is to examine the existing sound environment in urban residential areas and explore the way that people perceive/evaluate the sound quality, through a comparative study between the UK and Taiwan.

2. METHODOLOGY

Since the urban sound environment and quality is significantly influenced by many factors, including objective ones such as building types, urban elements, building elements, and noise sources; and subjective ones such as social and economic conditions, this study included objective measurements and noise-mapping, as well as subjective surveys.

Six residential areas were selected for the study, three in Sheffield and three in Taipei, as listed in Table 1. The sites were selected to represent typical urban textures as well as residents' social, demographic and cultural backgrounds. Sound pressure level (SPL) measurements were made considering various typical time periods, and noise maps were made using software CADNA [5]. Whilst the traffic data and building heights used in the noise mapping were obtained through on-site observations and measurements, the calculation parameters in the noise maps were calibrated through comparisons between measured and calculated SPL.

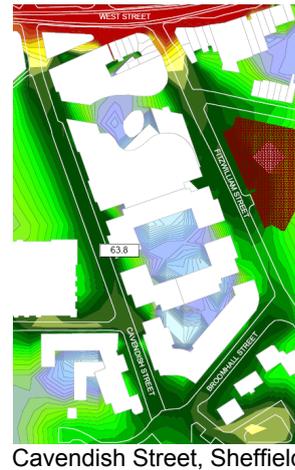
For each site around 30-50 interviews were carried out with an identical questionnaire in English or Chinese. There were a number of structured questions, including demographic data, evaluation and preference of various sound/noise sources, and perception of general living environment. In the questionnaire a five-level linear scale was generally used, for example, from -2, very uncomfortable, to 2, very comfortable. The interviewees were selected at random in the case study sites, and the statistic analysis using software SPSS [6] shows that the distribution of gender, age, occupation, and income was rather representative.

Table 1: Situations of the case study sites.

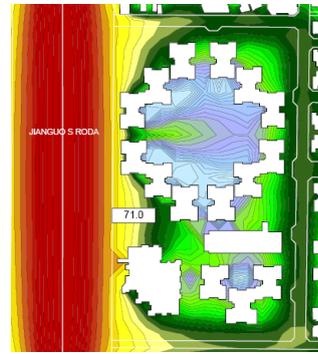
City	Site	Land	House	Traffic /hour
Sheffield	Springvale Road	Sloped 1/12	Detached /terraced	57
	Highton Street	Sloped 1/7	Detached /terraced	54
	Cavendish Street	Sloped 1/20	Flat	84
Taipei	JianGuo S Road	Flat	Flat	8837
	GuoXing Road	Flat	Flat	3861
	ZhangXing E Road	Flat	Flat	7335

3. RESULT OF OBJECTIVE SURVEY

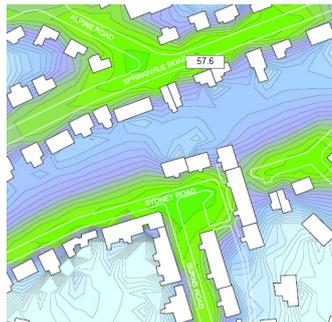
The noise maps of the six case study sites are shown in Figure 1. It can be seen that the SPL in the Taipei sites were about 10dBA higher than those in Sheffield at typical road-side receivers, due to the difference in landform, building types, and more importantly, the traffic density. Between the three sites in Sheffield the SPL varied by about 6dBA, and the variation range in Taipei was similar.



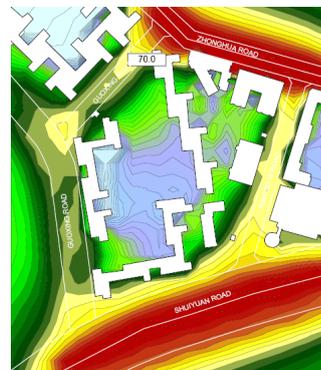
Cavendish Street, Sheffield



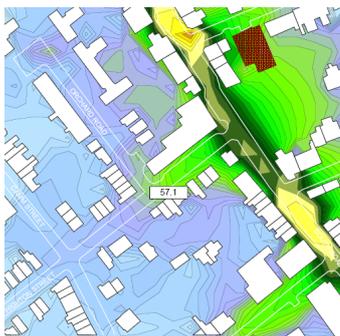
JianGuo S Road, Taipei



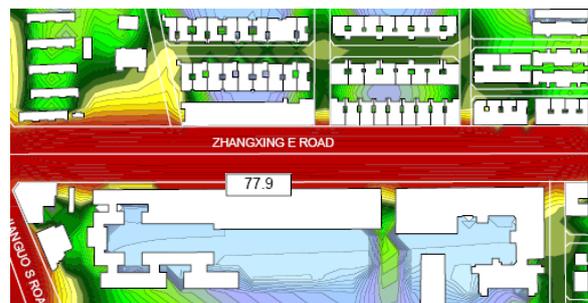
Springvale Road, Sheffield



GuoXing Road, Taipei



Highton Street, Sheffield



ZhangXing E Road, Taipei

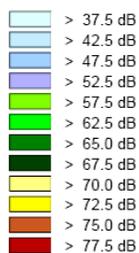


Figure 1: Plan of case study sites and noise-maps.

4. RESULTS OF SUBJECTIVE SURVEY

Previous studies show that regional differences, including cultural heritage, construction methods, lifestyle and weather, may influence the noise annoyance [7-9]. Moreover, the economic effects of community noise have been examined, especially from the viewpoint of compensation payable on depreciation in property value that can be attributed to noise, among other physical factors [10-19]. Consequently, in the subjective survey questions were asked about the importance of various factors when people chose a living environment. A five-level linear scale was used, from -2, do not mind, to 2, very important. The results in Sheffield and Taipei are compared in Table 2. Through the Independent Samples Test, as also shown in Table 2, it can be seen that there were generally significant differences between the two cities. In terms of the order of importance of various factors, there were some similarities between the two cities, for example, safety was on the top of the list.

It is interesting to note that the factor 'quiet' was ranked as the 4th important factor in Sheffield, and 3rd in Taipei, suggesting in both cities sound environment was an important consideration compared to other factors.

Table 2: Importance of various factors when choosing a living environment: comparison between Sheffield and Taipei.

			Sheffield		Taipei		Sig.
				Ranking		Ranking	
Convenient	to work	Mean Std.	0.83 1.08	3	1.54 0.76	2	0.002
	transport	Mean Std.	0.65 1.17	5	1.54 0.76	2	0.003
	school, shopping	Mean Std.	0.83 1.19	3	1.39 0.74	5	0.003
Recreational space		Mean Std.	0.61 1.16	6	1.08 0.87	7	0.002
Social with neighborhoods		Mean Std.	0.60 1.16	7	0.54 0.95	9	0.048
Safety		Mean Std.	1.24 0.85	1	1.66 0.65	1	0.013
Property price		Mean Std.	1.00 1.09	2	1.46 0.75	4	0.072
Quiet		Mean Std.	0.71 0.97	4	1.49 0.71	3	0.006
Views		Mean Std.	0.15 1.23	8	1.08 0.94	7	0.058
House size		Mean Std.	0.83 0.99	3	1.15 0.80	6	0.035
Interior decoration		Mean Std.	-0.06 1.02	9	1.05 1.01	8	0.389

Social and demographic factors are important considerations when studying the subjective evaluation, although results of previous studies varied [2,20-26]. In Table 3 the differences between various occupations, education levels and age groups are examined, through the significance test of correlations. It is seen there was generally no significant difference in terms of these social and demographic factors when choosing a living environment.

Table 3: Effect of occupation, education, and age when choosing a living environment.

Sig. (2-tailed)		Occupation		Education		Age	
		Shef	TP	Shef	TP	Shef	TP
Convenient	to work	0.12	0.10	0.80	0.98	0.39	0.19
	to transport	0.05	0.10	0.10	0.98	0.07	0.19
	to school, shop	0.91	0.14	0.04	0.67	0.43	0.50
Recreational		0.00	0.02	0.00	0.38	0.01	0.09
Social		0.03	0.46	0.00	0.01	0.09	0.47
Safety		0.71	0.54	0.94	0.67	0.30	0.83
Property price		0.10	0.11	0.13	0.71	0.00	0.43
Quiet		0.02	0.55	0.13	0.91	0.00	0.52
Views		0.02	0.93	0.44	0.17	0.00	0.67
House size		0.24	0.95	1.00	0.06	0.00	0.17
Interior decoration		0.37	0.62	0.31	0.06	0.76	0.74

Table 4 compares the perception of interviewees in Sheffield and Taipei on their general living environment, sound quality of their living area, and sound quality at home, where a five-level linear scale was again used, from 1, comfortable, to 5, very uncomfortable. It is interesting to note that the scores in Taipei were all significantly higher than those in Sheffield, by about 0.5, which corresponded to the noise level difference between the two cities, as shown in Figure 1. Although the interviewees in Sheffield and Taipei were all urban residents, most interviewees in Taipei lived within or close to the central areas, whereas the Sheffield interviewees were in the outer areas of the Sheffield city centre.

In Table 4 the evaluation of general health level is also shown. Corresponding to the evaluation of their living environment and sound quality, Taipei residents also found their health condition less satisfactory compared to that in Sheffield.

Table 4: Evaluations of living environment and sound quality, as well as health status.

		Shef	TP	Sig.
General living environment	Mean	1.81	2.43	0.000
	Std.	0.53	0.90	
Sound quality of living area	Mean	2.16	2.44	0.000
	Std.	0.65	0.93	
Sound quality of home	Mean	1.95	2.59	0.000
	Std.	0.53	0.88	
Health	Mean	1.75	2.54	0.852
	Std.	0.83	0.75	

While in Table 4 it is shown that the evaluation of general living environment corresponds to the evaluation of sound quality; the evaluation of noise pollution was compared with other pollutions. In the questionnaire the interviewees were asked to rank various pollutions, and in Table 5 are shown the mean ranking order and standard deviation. It is important to note that in both Sheffield and Taipei noise was perceived as the second serious pollutant, with a slightly lower score than air pollution. The importance of noise pollution in the overall sustainable urban environment has also been demonstrated by other researchers [27,28].

Table 5: Ranking of various environmental pollutions.

		Sheffield	Taipei	Sig.
Water pollution	Mean	3.26	2.81	0.123
	Std.	0.96	1.30	
Air pollution	Mean	2.09	2.29	0.957
	Std.	0.90	1.01	
Noise pollution	Mean	2.12	2.33	0.491
	Std.	1.20	1.12	
Waste pollution	Mean	2.53	2.94	0.010
	Std.	1.02	1.34	

Since noise may be more disturbing for certain activities, such as oral communication, listening to radio and intellectual tasks, than for other activities, the main activities of the interviewees when they stay at home were asked and the results are shown in Table 6. It can be seen that there was a high percentage of activities which could potentially be disturbed by noise.

Table 6: Main activities at home (%).

Activities	Sheffield	Taipei
Reading	61	35
TV	54	85
Music	55	9
Others	41	29

Various sources in an urban soundscape could have rather different impact on people, and this could differ with different cultural environments. In the questionnaire the noticeability, annoyance level and sleep disturbance of typical sound sources in residential areas were examined. The comparison of noticeability between Sheffield and Taipei is shown in Table 7, where a five-level linear scale was again used, from -2, none, to 2, very significant. It can be seen that there were generally significant differences between Sheffield and Taipei. It is interesting to note that people living in Sheffield had a higher noticeability on traffic noise, especially heavy vehicles, although their SPL was actually much lower than that in Taipei. In Taipei the noise sources on the top list were two wheelers, as well as talking, music and TV, both from neighbours and from their own home. This strongly demonstrates the importance of considering cultural factors as well as urban structure and building types when evaluating noise.

Table 7: Noticeability of various noise sources.

Noise sources			Sheffield		Taipei	
			Mean	Ranking	Mean	Ranking
Traffic	Light vehicle	Mean	-0.45	3	0.34	4
		Std.	1.11		1.71	
	Medium vehicle	Mean	-0.26	2	0.24	5
		Std.	1.21		1.26	
Heavy vehicle	Mean	-0.09	1	0.18	6	
	Std.	1.36		1.33		
Two wheelers	Mean	-1.29	10	0.56	1	
	Std.	0.93		1.26		
Nearby	School	Mean	-1.46	11	0.13	7
		Std.	0.95		1.36	
	Shops	Mean	-1.28	9	0.11	8
		Std.	1.07		1.36	
	Recreation, leisure facilities	Mean	-1.03	7	-0.11	12
		Std.	1.41		1.37	
Transportation stations	Mean	-1.26	8	-0.30	13	
	Std.	1.09		1.31		
Events	Mean	-0.96	6	0.05	10	
	Std.	1.28		1.37		
Neighbors	Talking, music, TV	Mean	-0.93	5	0.35	3
		Std.	1.26		1.24	
Air-conditioning	Mean	-1.76	13	0.10	9	
	Std.	0.82		1.11		
Own home	Talking, music, TV	Mean	-0.76	4	0.43	2
		Std.	1.22		1.18	
	Air-conditioning	Mean	-1.75	12	-0.01	11
		Std.	0.74		1.17	

In Table 8 the annoyance level of various noise sources are compared, with a five-level linear scale, from -2, not annoyed, to 2, very annoyed. Generally speaking, the annoyance level corresponded to the noticeability as shown in Table 7. Traffic noise was again on the top list in Sheffield, whereas in Taipei two wheelers and talking/music/TV were mostly annoyed. Noise sources from nearby facilities and activities were generally not annoyed, mostly with negative values.

Whilst the results in Table 7 and 8 do not fully correspond to the SPL of the noise sources, according to Guski [29], the noise annoyance by inhabitants only depends on approximately 33% of the acoustic parameters such as acoustic energy, number of sound events, and length of moments of calm between intermittent noises. Moreover, annoyance may increase if a neighbourhood is perceived in a negative way, and it is also influenced by the life-style chosen by certain people, for whom a certain quantity of noise is part of their life. Moreover, people may get used to certain noises and thus become less annoyed [2].

It is particularly interesting to note that the values in Table 8 are generally systematically lower than those in Table 7, showing people's tolerance, which is similar to the case in urban open public spaces [2].

Table 8: Annoyance of various noise sources.

Noise sources			Sheffield		Taipei	
			Mean	Ranking	Mean	Ranking
Traffic	Light vehicle	Mean	-0.68	2	-0.18	5
		Std.	1.20		1.33	
	Medium vehicle	Mean	-0.68	2	-0.16	4
		Std.	1.36		1.22	
Heavy vehicle	Mean	-0.28	1	-0.19	6	
	Std.	1.58		1.29		
Two wheelers	Mean	-1.26	6	-0.05	2	
	Std.	1.13		1.30		
Nearby	School	Mean	-1.74	10	-0.38	9
		Std.	0.57		1.37	
	Shops	Mean	-1.60	9	-0.41	10
		Std.	0.81		1.32	
	Recreation, leisure facilities	Mean	-1.20	5	-0.51	11
Std.		1.28		1.32		
Transportation stations	Mean	-1.38	7	-0.73	12	
Std.	1.02		1.24			
Neighbors	Talking, music, TV	Mean	-0.98	3	0.09	1
		Std.	1.29		1.33	
Air-conditioning	Mean	-1.78	11	-0.31	8	
	Std.	0.76		1.16		
Own home	Talking, music, TV	Mean	-1.44	8	-0.08	3
		Std.	0.87		1.20	
Air-conditioning	Mean	-1.78	11	-0.38	9	
	Std.	0.75		1.18		

Table 9: Sleep disturbance of various noise sources.

Noise sources			Sheffield		Taipei	
			Mean	ranking	Mean	ranking
Traffic	Light vehicle	Mean	-1.36	3	-0.30	4
		Std.	1.06		1.44	
	Medium vehicle	Mean	-1.23	2	-0.30	4
		Std.	1.23		1.33	
Heavy vehicle	Mean	-0.94	1	-0.33	5	
	Std.	1.32		1.34		
Two wheelers	Mean	-1.44	7	-0.29	2	
	Std.	0.97		1.34		
Nearby	School	Mean	-1.75	10	-0.60	9
		Std.	0.61		1.33	
	Shops	Mean	-1.74	9	-0.70	10
		Std.	0.69		1.24	
	Recreation, leisure facilities	Mean	-1.54	6	-0.68	11
Std.		0.94		1.25		
Transportation stations	Mean	-1.65	8	-0.84	12	
Std.	0.86		1.20			
Neighbors	Talking, music, TV	Mean	-1.28	4	-0.20	1
		Std.	1.19		1.38	
Air-conditioning	Mean	-1.81	11	-0.40	7	
	Std.	0.73		1.31		
Self house	Talking, music, TV	Mean	-1.74	9	-0.18	3
		Std.	0.65		1.34	
Air-conditioning	Mean	-1.84	12	-0.46	8	
	Std.	0.54		1.28		

The evaluation of sleep disturbance is shown in Table 9, where the five linear scales are from -2, not disturbing, to 2, very disturbing. Generally speaking, the results correspond to Table 7 and 8.

Urban soundscape includes not only negative, but also positive sounds. Sound preference was therefore also studied through the questionnaire survey, where the interviewees were asked to select the sounds they prefer from a list. Table 10 shows the results, where if a sound was selected, value 1 is assigned, otherwise value 2 is given. It can be seen that there were significant differences in sound preference between Sheffield and Taipei. The preference level of bird sounds and water sounds was much higher in Sheffield than in Taipei, by 0.38 and 0.2, respectively. In other words, the percentage of people who preferred those two sounds in Sheffield was 38% and 20% higher than that in Taipei. On the other hand, in Sheffield insect sounds and music from outside were almost not selected, with a mean score of 1.96, whereas this score was about 0.2 lower in Taipei. There were also a higher percentage of people in Sheffield who suggested other preferred sounds.

Table 10: Sound preference. 1=yes (selected); 2=no.

		Shef	TP	Sig.
Bird songs	Mean	1.30	1.68	0.795
	Std.	0.46	0.48	
Insect sounds	Mean	1.96	1.79	0.000
	Std.	0.19	0.42	
Water	Mean	1.69	1.89	0.000
	Std.	0.47	0.32	
Music from outside	Mean	1.96	1.74	0.000
	Std.	0.19	0.45	
Other sounds	Mean	1.71	1.89	0.606
	Std.	0.46	0.57	

5. CONCLUSIONS

The comparative study in the UK and Taiwan reveals the importance of considering cultural factors as well as urban texture and building types in evaluating urban sound environment. This is reflected in a number of aspects, from noise noticeability,

annoyance and sleep disturbance, to sound preference. On the other hand, it has been demonstrated that both in the UK and Taiwan, sound environment is an important consideration of overall urban environment.

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