Effects of sound preference on acoustic comfort evaluation of open commercial space

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ABSTRACT

The effects of sound preference on acoustic comfort evaluation of open commercial space were investigated through social surveys held in Tianjin, China. Altogether 200 effective questionnaires were collected from 10 different investigation spots. The result shows that 12 sound sources are recognized, which can be divided into 3 groups, including artificial sounds, natural sounds and human activity sounds. Among all sounds, background music and natural sounds are preferred by the interviewees, and acoustic comfort evaluation is considerably affected by sound preference. Acoustic comfort of open commercial space is evaluated to be improved by introducing a pleasant sound such as natural sounds. However, the result also shows people's background knowledge will affect the sound source perception. Some unpleasant sounds will be ignored and have no negative effect, even though the sound level is quiet high. No significant positive effect is found for background music on acoustic comfort evaluation as expected though it is preferred by 84% of the interviewees. It reveals that more detailed factors about background music such as harmony between music and general environment, music type and sound level should be taken into consideration in soundscape design in order to improve acoustic comfort in open commercial space.

1 INTRODUCTION:

A series of researches on acoustic comfort have been carried out in urban open spaces. Early researches were mostly focused on the annoyance caused by the noise (Moreira N M & Bryan M E 1972; Shaw E A G 1996; Fields J M et al, 1997;) and noise propagation (Kang J 2001; De Ruiter E, 2000), and established a series of noise regulations. Recent researches turned to human-centered, focusing on sound field perception and treatments to improve acoustic comfort (Ismail M R & Oldham D J 2003; Schulte-Fortkamp B 2001; Zimmer K & Ellermeier W 1999; Yang W & Kang J 2005; Yu L & Kang J 2009), and sound source preference was thought to be one of the important elements in sound field perception. However, urban commercial space has many characters which are very different from other urban spaces, including various sound sources, semi-enclosed space and so on.

In this paper, the result of a primary analysis on acoustic comfort in urban pedestrian streets is presented, which is based on a series of field surveys in Tianjin, China. Effect of individual sound source is analyzed to offer an approach of improving acoustic comfort.

2 METHOD:

Tianjin, a city with one of the biggest amount of commercial real estate all over the world in 2012 is selected as the case study city. Two most famous pedestrian shopping streets are sampled to represent typical urban open commercial space, which are (A) Binjiang Road shopping street and (B) Xinyi Street, as shown in Fig.1.

Binjiang Road shopping street is a typical pedestrian street with high shopping

centers on both sides of the street, while Xinyi Street is a commercial district made up by a series of small streets and low buildings.

Fig.1: Plan of the sample areas and the positions of questionnaire surveys.

A questionnaire was designed by a number of structural questions, covering the follow aspects: the acoustic comfort evaluation, individual sound sources, and the sound sources preference (pleasant/unpleasant). For acoustic comfort evaluation, five-point verbal scales (1-very comfortable, 2-comfortable, 3-neither comfortable nor uncomfortable, 4-uncomfortable, 5-very uncomfortable) were used.

The interviewees were selected at random. In each survey location 20 valid questionnaires were obtained, and the total number of valid questionnaires in this study was 200. The analysis was based on all 200 samples. In terms of gender, the percentage of males and females was 45.5% and 54.5%. In terms of age, the majority of the interviewees, 71%, were aged 20-30, as shown in Fig.2.

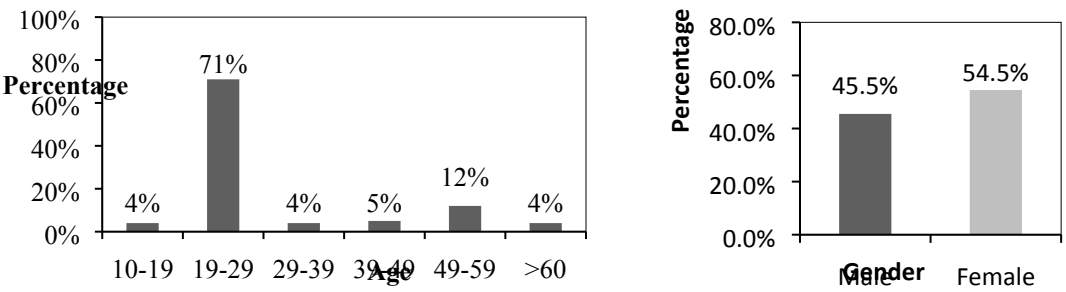


Fig.2: Age and gender proportion of the interviewees.

3 RESULT AND ANALYSIS:

In the questionnaire survey, the interviewees were also asked to evaluate the sound environment by five-point verbal scales: 1-very comfortable, 2-comfortable, 3-neither comfortable nor uncomfortable, 4-uncomfortable, 5-very uncomfortable. As shown in Fig.3, the evaluation result shows that location 1-4 are thought to be uncomfortable (mean evaluation >3), location 5-10 are thought to be comfortable (mean evaluation <3), as shown in Fig.3. Location 1-5 are in area A, and location 6-10 are in area B. So Area A is more noisy than Area B (mean evaluation of area A >area B) in the questionnaire survey.

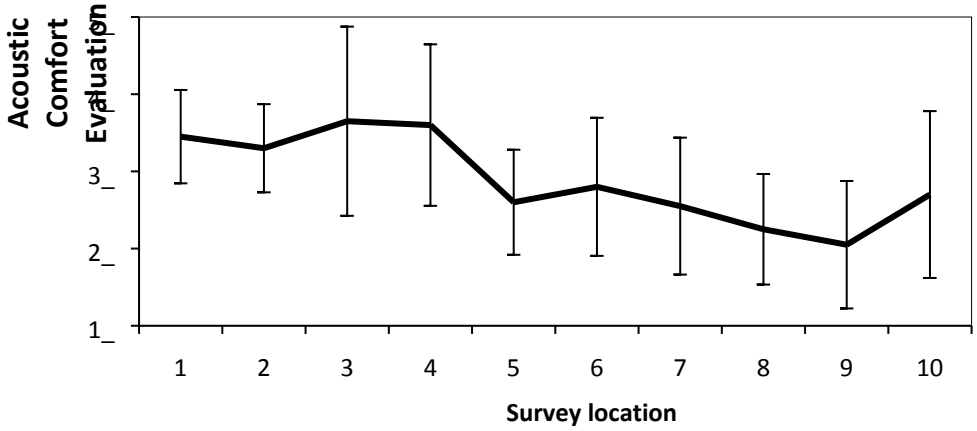
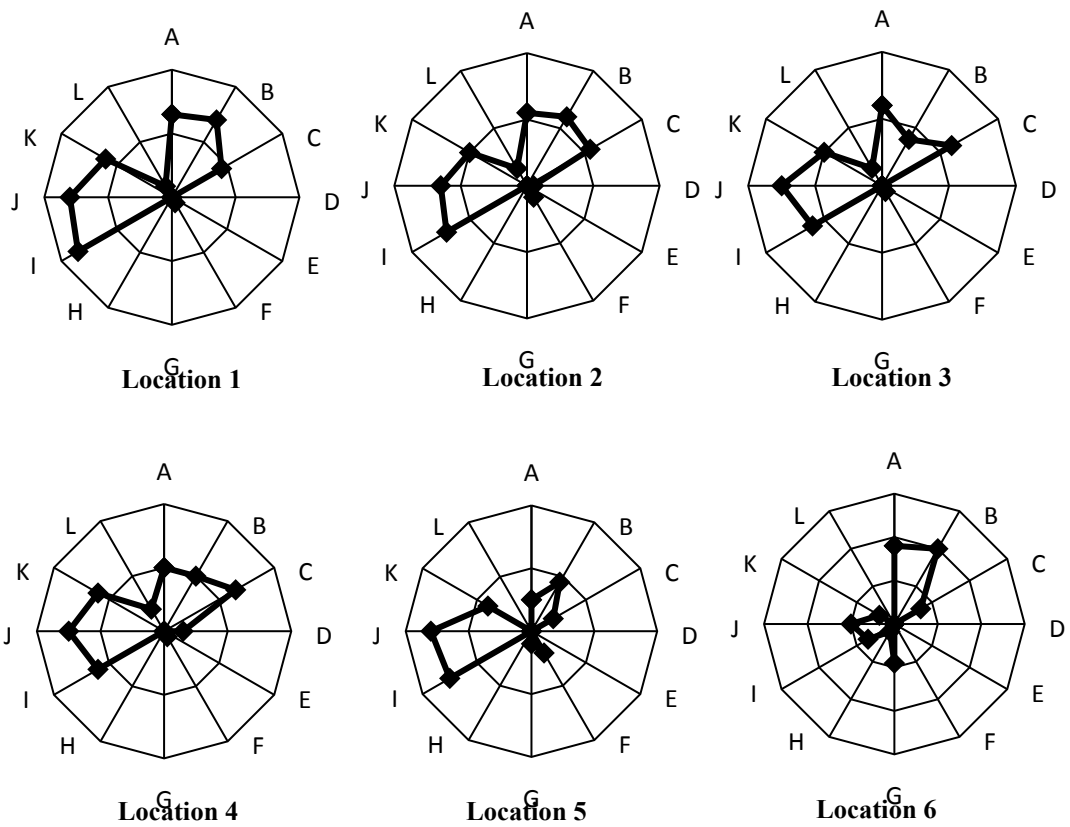


Fig.3: Acoustic comfort evaluation. A five-point verbal scale was used: 1-very comfortable, 2-comfortable, 3-neither comfortable nor uncomfortable, 4-uncomfortable, 5-very uncomfortable. Location 1-5 was in area A, and location 6-10 was in area B.

During the field survey, 12 sound sources were recognized by interviewees. All sound sources heard are divided into 3 groups:1-artificial sound(including A-background music, B-the noise of the vehicle, C-the advertisement of the shop, D-construction noise), 2-natural sound (including E-water sound, F-sound of the wind, G-bird sing, H-sound of rustling leaves,), 3-human activity sound (including I-sound of people talking, J-the noise of the crowd, K-sound of footsteps, L-vendor shouts). Fig.4 shows the distribution of sound sources in different survey location.



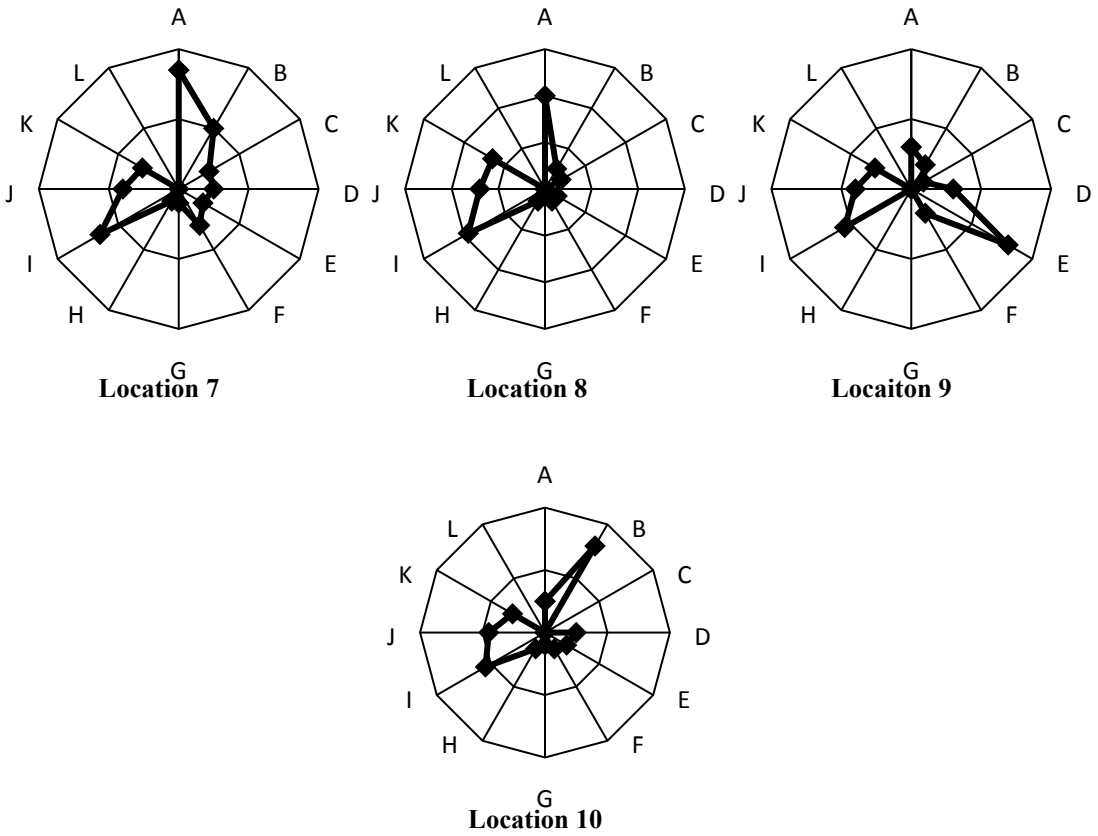


Fig.4: the distribution of sound sources in different survey location. Location 1-5 are in area A, while location 6-10 are in area B. A-L represent the sound sources heard during the survey: A-background music, B-the noise of the vehicle, C-the advertisement of the shop, D- construction noise; E-water sound, F-sound of the wind, G-bird sing, H-sound of rustling leaves; I-sound of people talking, J-the noise of the crowd, K-sound of footsteps, L- vendor shouts.

It can be found that the sound source distribution is quiet different between area A (location 1-5) and area B (location 6-10). For area A, artificial sounds (sound A-D) and human activity sounds (sound I-L) are very strong, while natural sounds (sound E-H) are hardly heard. For area B, though artificial sounds and human activity sounds are still strong, however, there are more natural sounds and the sound source distribution is more balanced. This may offer a reasonable explanation to the difference of acoustic comfort evaluation: the distribution of sound sources will significantly affect acoustic comfort in urban commercial spaces. Natural sounds seem to have positive effect while artificial sounds and human activity sounds are negative.

For analyzing the sound source preference, interviewees were asked to point out the pleasant and unpleasant sound sources from the sound sources which they heard during the interviews. The result is shown in Fig.5. Generally speaking, natural sounds are mostly preferred in urban open commercial spaces (preferred over 50%), while artificial sound and human activity sound are thought to be unpleasant (preferred below 50%). However, there are some exceptions. For (F) wind sound, (I) talking sound, and (K) footsteps sound, they are all preferred by around 50% of the interviewees, and can be thought to be neutral. For (A) background music, it is preferred by 84% of the interviewees, as expected.

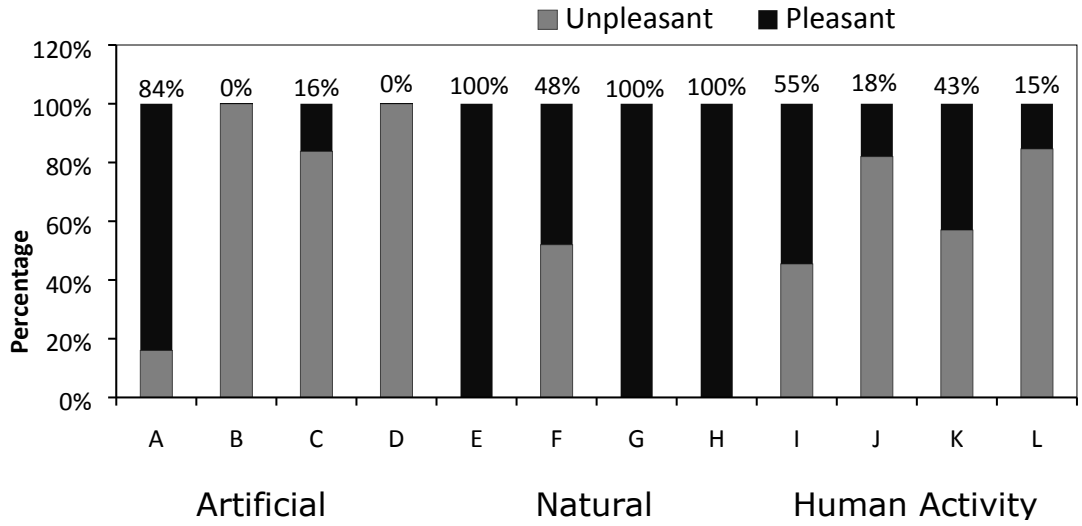


Fig.5: Sound preference analysis. The percentage of pointed out as pleasant sound for each sound source in the questionnaire is listed above the histogram.

The mean acoustic comfort evaluations with and without individual sound source are counted, as shown in Fig.6. Generally speaking, evaluations with artificial sound are higher than that without artificial sound, which meant more uncomfortable. On the contrary, natural sounds significantly reduce mean evaluation which meant more comfortable. For human activity sound, the differences between mean evaluations with and without human activity sound are quiet small. However, further variance analysis shows that the differences caused by (B) vehicle noise, (C)shop advertisement, (E)water sound, (G)bird sing, (H)sound of rustling leaves could be considered as significant, and not significant for other sounds, as shown in Table.1.

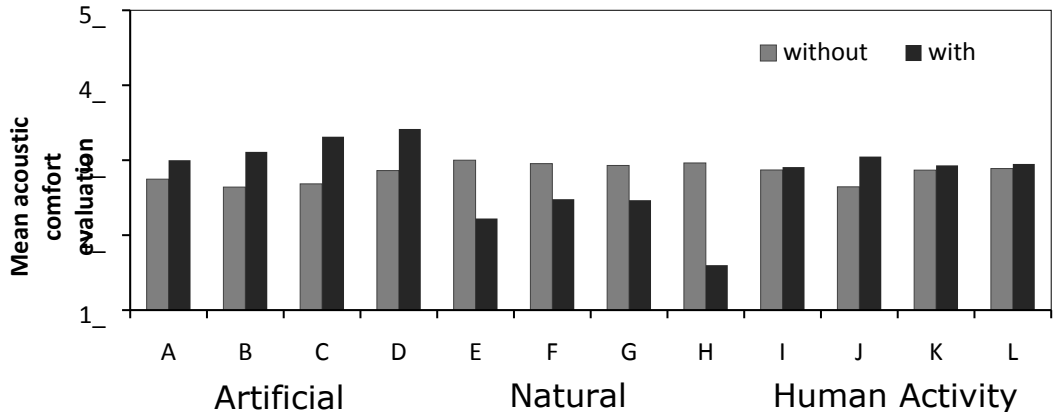


Fig.6: Mean acoustic comfort evaluation with/without individual sound source.

Table.1: Variance analysis of individual sound sources on acoustic comfort evaluation, where the bold entries are those at a significant level, * representing p<0.05.

variance analysis	sound sources											
	A	B	C	D	E	F	G	H	I	J	K	L
p	0.12	**0.00***	**0.02***	0.80	**0.08***	0.66	**0.00***	**0.00***	0.70	0.05	0.57	0.73

* represent significant at 0.05

Comparing the result of sound preference survey in Fig.5 and the effect of individual sound source on acoustic comfort in Fig.6, a good match can be found between sound sources preference and effects on acoustic comfort: natural sounds are preferred and have positive effect on the overall acoustic comfort. While artificial sounds are thought to be unpleasant and have negative influences.

However, the result also shows people's background knowledge will affect the sound source perception. Human activity sounds are the most common sounds in urban open commercial space, so in most cases, people do not focus on human activity sounds though the sound level is quiet high. Therefore, though they are thought to be unpleasant, there were no considerable negative influences with human activity sound in the field. The situation for (D) construction sound is very similar. In urban open commercial spaces, construction sound is usually temporary. Though the attitude towards it is totally negative, 100% unpleasant, no significant negative effect has been found on acoustic comfort.

It is interesting to note an exception that (A)background music do not improve the acoustic comfort significantly with 84% preferred. Even the mean evaluation is worse when there is background music during the survey. In former researches, the introduction of music was mostly thought to be positive. This result indicates that, in urban open commercial spaces, more detail factors (music type, sound level of the music, space function, sound environment and so on) might be important and should take into consideration. Simply introducing music into a sound field may not work.

Conclusion;

In summary, our exploration of acoustic comfort in urban pedestrian streets has produces following observations based on field survey and statistical analysis:

The result shows acoustic comfort is considerably affected by sound source preference in urban open commercial spaces. The introduction of pleasant sounds and the reduction of unpleasant sounds may likely improve the acoustic comfort.

However, the result also shows people's background knowledge will affect the sound source perception. Some unpleasant sounds will be ignored and have no negative effect, even though the sound level is quiet high.

The result also reveals that simply introducing music into a sound field may not lead to better acoustic comfort. The harmony between music and the entire space, not only for sound level but also for music type might be very important and should be taken into consideration in soundscape design.

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