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THE EFFECTS OF DIFFERENT CONFIGURATIONS OF NEIGHBORHOOD SCENERIES ON SOUND PERCEPTIONS

J.M. Xu, T.M. LEUNG, C.K. CHAU*, S.K. TANG

Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong

**E-mail: chi-kwan.chau@polyu.edu.hk*

In the past and even now, local governments have often relied on traditional sound control approach to resolve noise problems by lowering sound pressure level. However, this approach may not always be practical and cost effective. Alternative approaches have been explored by properly utilizing neighborhood sceneries or additional sound sources in neighborhood planning and building design to reduce the annoyance induced by road traffic noises. Past evidence suggested that greenery and water space were able to moderate noise annoyance, and water sound could be added to improve the acceptance of neighborhood sound environment. However, few studies investigated how the proportions of different types of environment features would affect sound perceptions. This study aims to reveal the effects of different proportions of environment features on the perception of combined water sounds and road traffic noises. A series of controlled experiments had been performed with a group of human participants in a laboratory setting mimicking a living room setting in Hong Kong. The relationships among neighborhood sceneries, water sound and noise annoyance were also revealed. The results of the study can help formulate a set of building design planning guidelines for effectively utilizing neighborhood sceneries and additional sound sources for providing better acoustic environment and promoting good well-being for modern city dwellers within limited community resources.

Keywords: noise annoyance; combined sound; visual-audio interaction

1. Introduction

Amongst all the environmental stressors, noise is the only agent whose number of related complaints from city communities has been increasing year by year [1], [2]. Substantial efforts and resources have been spent to minimize the impact of noise pollution within compact cities. Besides acoustic factors like sound pressure level of noise source, more and more studies are focusing on the effect of non-acoustic factors such as visual sceneries and personal characteristics on individual's noise reactions.

Certain type of visual sceneries like natural sceneries [3]–[5] have been reported to have the capability of modifying the auditory perceptions of people [6]–[9]. A positively evaluated landscape [9], [10], a simple presence of parks or courtyards, or even better accessibility to nearby green space could lower dissatisfaction with traffic noise [3], [11] or reduce the long-term noise annoyances of dwellers [3], [12]. Views of sea was also found to have noise annoyance moderation capability [13] and also could provide high restorativeness to people [14]. However, noise annoyance moderation capability for different types of natural features may be different. On the contrary, urban visual sceneries tended to exacerbate noise annoyance problem [15]. The aesthetic preference for sceneries also exerted influences

on noise perception [16]. Water features were found to exert positive effect on the preference of combined road traffic noise and water sound could effectively reduce noise annoyance caused by road traffic noises when the traffic sound was 3 dB higher than that of water sound at 55 dBA [17].

Although many studies revealed that visual sceneries affected the perception of sound [18]–[20], few of them successfully quantified the types of sceneries as well as their amounts. Little has been known on whether the effect of visual sceneries on the combined sounds varies with the proportion of its individual landscape components perceived. With this type of knowledge, it is possible to reveal how visual preference, acoustic comfort or noise annoyance responses vary with the type of composite audio and visual sceneries. The findings will also help building designers and urban planners to formulate guidelines for planning the neighborhood sceneries to mitigate the noise annoyance caused by visual settings and sound types. This can provide valuable insights in formulating a more sustainable approach in resolving noise annoyance problems and increasing the preference for the acoustic environment of city dwellers.

2. Methodology

To reveal the effects of different configurations of neighborhood sceneries and combined sounds on individuals' sound perception, a series of experiments were conducted inside an experiment room purposely built inside an anechoic chamber in the Hong Kong Polytechnic University. The settings of the room were to mimic a living room of a dwelling in Hong Kong. Figs. 1-2 show the room configuration and setup, and Fig. 3 shows the layout plan of the room. A panel of windows was located on one wall of the living room was covered by special daylight reflection films. A projector and two 5.1 surround sound speakers were placed at the outside of the room. Videos were projected onto the window panel to simulate the outside sceneries in a way that participants could only perceive the composed outside sceneries and soundscape without realizing there was an experimental setup behind the windows.

Figure 1: An experiment room built inside the anechoic chamber

Figure 2: The living room setting

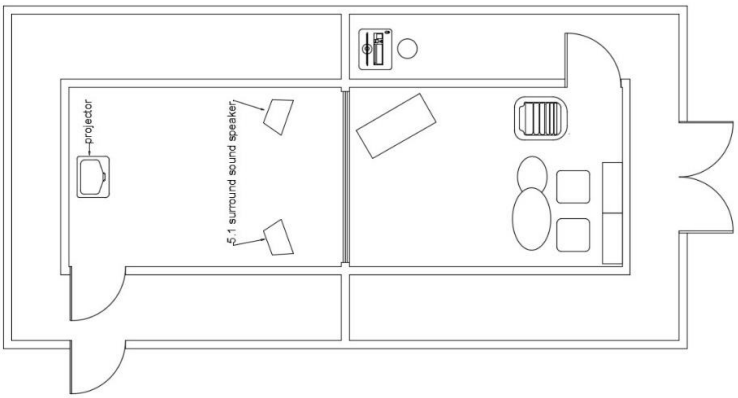

Figure 3: Floor Plan of the living room

2.1. Preparation of Visual and Audio Stimuli

Three types of neighborhood features were simulated in the study, i.e. greenery, sea and traffic road. Each of this feature contributed to a proportion of 0/30%/60% in a composite neighborhood scene. A series of video clips and images were captured in Hong Kong and have been modified using the software "Adobe Photoshop CS6" and "Adobe After Effects". Finally, eleven composite sceneries were generated (See Table 1). 24 sound scripts (including 6 single source sound scripts and 18 combined source sound scripts) have been prepared (See Table 2). For the combined source sound scripts of road traffic were set to one of three levels, i.e. 55dBA, 60dBA or 65dBA, while difference in sound pressure levels between traffic sound and sea sound (i.e. signal-to-noise ratio (SNR)) ranged from -6dB to 9dB at 3dB interval. Keeping all of the combinations of video and sound scripts would result in a total of 18×11=198 composite scenarios. To reduce the total number of scenarios needed to be performed for each participant, an efficiency design was performed with the aid of software "SAS". Finally, 36 composite scenarios were generated for the experiments.

2.2. Experimental setup and questionnaire design

The 36 composite visual and audio scenarios were randomly divided into three groups to minimize the total duration required for each participant. A structured questionnaire form was designed to collect individual responses. The questionnaire was divided into four sections. The first section aims at collecting the personal information from participants (e.g. gender, age, current position). Besides, five-point scales were used for individuals to self-report their noise sensitivity levels and health conditions. The second section aims at revealing individuals' preferences of single sound sources (i.e. road traffic sound and sea sound) at different sound pressure levels. In this section, 6 single sound clips were presented together with a background scenery of blue sky. Participants were required to give a 21-point scale rating for each sound clip (where "-10" denotes "*Extremely annoyed*", "0" denotes "*Neutral*", "10" denotes "*Extremely comfortable*"). The third section aims to reveal the effects of different composite neighborhood sceneries as well as mixed sounds on the noise annoyance responses of individuals. The scenarios were divided into three groups. Each group contains 12 video clips containing different types of sceneries. Only one of the three groups was presented to the participants. After presenting each clip, participants were needed to give an 11-point scale noise annoyance rating for each scenario (where "0" denotes "*Not annoyed at all*", "10"denotes "*Extremely annoyed*"). Also, they were required to rank the dominant sound they perceived from this video clip (where "0" denotes "*Water sound dominant*", "5" denotes "*No dominant sound*", "10" denotes "*Traffic noise dominant*"). The fourth section aims at revealing the visual preference of neighborhood sceneries viewed from dwellings. 11 types of composite

sceneries were projected onto the window panels, and participants were requested to give their preference ratings for each individual scenery (where "0" for "*The least preferred scenery*", "10" for "*The most preferred scenery*", and all scores should fall between 0 and 10).

Table 1: Scenarios of composite greenery, sea and traffic road sceneries

Proportion of Landscape Features		
Greenery	Sea	Road
0%	0%	0%
30%	30%	30%
30%	0%	0%
0%	0%	30%
0%	30%	0%
0%	30%	60%
0%	60%	30%
30%	0%	60%
30%	60%	0%
60%	0%	30%
60%	30%	0%

Table 2: Scenarios containing both road traffic noise and sea sound

Sound Pressure Level of Traffic Noise (dB(A))	SNR of traffic noise and sea sound (dB)					
55	-6	-3	0	3	6	9
60	-6	-3	0	3	6	9
65	-6	-3	0	3	6	9
Note: Positive sign in SNR denotes that level of sea sound is higher than that of traffic noise; negative sign in SNR denotes that the level of sea sound is lower than that of road traffic noise.						

3. Preliminary Results

In total, 186 participants were successfully recruited to the experiments. As a quality assurance procedure, all the received questionnaire responses were checked. 37 responses were discarded due to

conflicting or missing information. The results of bivariate Pearson's correlation tests revealed that noise annoyance ratings statistically significant correlated with types of dominant sound perceived by participants, greenery, SNR, sound pressure level for road traffic ($SPL_{traffic}$). It was in line with earlier findings that noise annoyance ratings would be higher if traffic sound levels were higher [21]. The annoyance rating would be higher with a higher road traffic sound level. On the other hand, it was found that noise annoyance ratings would be higher for a larger greenery proportion, which is in divergence with previous findings.

3.1. Effects of visual stimuli

In addition, the effect of preferences of sceneries on the noise annoyance responses has been studied. As expected, people's preferences for the eleven visual sceneries varied. Views containing greenery and road were the least preferred (with an average preference rating ≤ 3). Views containing sea were highly preferred (with an average preference rating ≥ 7), in particular the view containing 30% sea was most preferred (with an average preference rating =9). Type of views were found to be weakly correlated with noise annoyance ratings. People who preferred the scenery containing 30% greenery and 30% road tended to give high noise annoyance ratings (with a preference rating score ≥8) ($p < 0.01$). People who preferred the scenery containing 30% sea tended to give lower noise annoyance ratings ($p < 0.01$). ANOVA results indicated that mean annoyance rating of sceneries containing 30% greenery was higher than that without any greenery (mean difference: 4.755, $p < 0.05$), but lower than that of 60% greenery (mean difference: -2.731, $p < 0.05$). No significant differences in noise annoyance ratings were found between sceneries containing different proportions of sea. However, significant statistical differences in noise annoyance ratings were found between views containing 30% road and those without any road (mean difference: 4.132, $p < 0.05$) and between views containing 30% and 60% road (mean difference: 3.734, $p < 0.01$).

3.2. Effects of audio stimuli

Based on the analysis of the results from the single sound tests in Part A, participants tended to give lower noise annoyance ratings if they considered sea sound to be comfortable (i.e. comfort ratings for all the single sound scripts of sea were larger than 3). In contrast, participants tended to give higher annoyance ratings if they considered sea sound or road traffic sound to be annoying (i.e. comfort ratings for all the single sound scripts of sea or road traffic were smaller than -3).

3.3. Effects of combined visual and audio stimuli

Further data analysis revealed that sound perception varies with the nature of visual scenery. For instance, noise annoyance rating would be higher if participants perceived views of road traffic at home and conceived that road traffic noise was the dominant sound ($p<0.05$). On the contrary, noise annoyance rating would be lower if participants perceived views of sea at home and conceived that the sea sound was the dominant sound ($p < 0.01$). Meanwhile, proportions of views of sea might have an influence on the noise annoyance ratings when individuals perceived both sea and road traffic sound. Views containing 60% of sea would invoke a lower noise annoyance rating compared with views containing 30% sea view (See Fig. 4). At the $SPL_{traffic}$ of 65dBA, the average noise annoyance ratings given by participants perceiving views containing 60% sea were 23% lower than those perceiving views containing 30% sea.

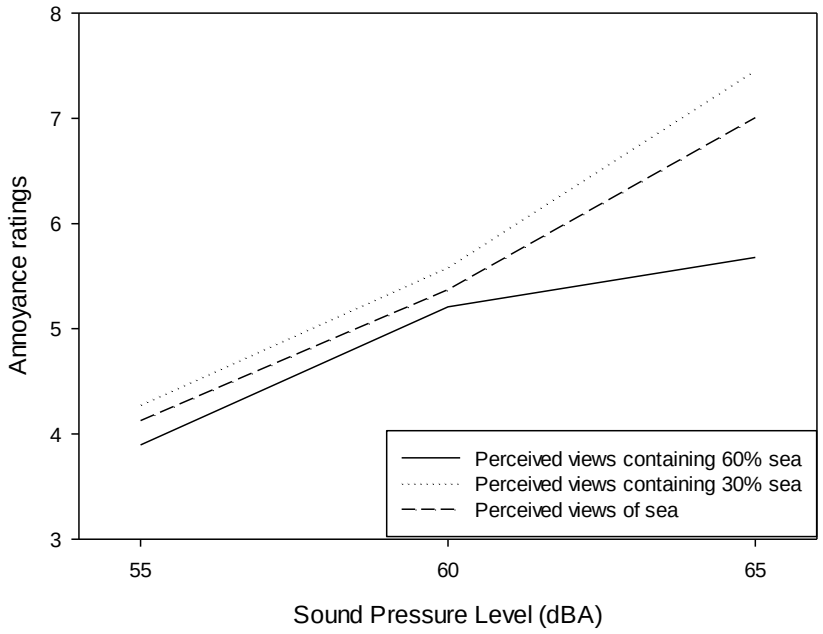

Figure 4: Annoyance ratings of individuals perceiving different proportions of sea at different $SPL_{traffic}$

4. Discussions and Conclusion

Preliminary data analysis showed that individuals' visual preference and acoustic comfort would affect noise annoyance responses differently. People would become more tolerant of the sound environment if the views perceived were more preferred, and they become more annoyed if the views perceived were less preferred. Besides, the issue on whether the visual environment match with the types of sound also plays a role in the annoyance responses. Perceiving different proportions of landscape features seems to have different impact on sound perception. Perceiving views containing 60% sea at home provided a higher annoyance moderation capability to individuals exposed to a high level of traffic noise. In this experiment, views of greenery were found not to be preferred by participants, especially when it was perceived together with road traffic. This is in divergence with the earlier findings that the annoyance moderation capability increased with the proportion of greenery [22]. The divergence is probably because people dislike oppressiveness effect caused by the greenery setting in this experiment i.e. greenery hills were located close to the windows. Further studies will be performed to verify this.

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