Community annoyance from road traffic noise and construction noise in urban spaces

Jin Yong Jeon*, Pyoung Jik Lee, Jin You

Department of Architectural Engineering, Hanyang University, Seoul, 133-791, Korea

* corresponding author: e-mail: jyjeon@hanyang.ac.kr

ABSTRACT

This paper provides an overview of the exposure-response relationship between environmental noise and community annoyance and sound masking technique for noise abatement in urban spaces. Most previous studies focused on the community response in residential areas not urban spaces and evaluated the indoor environmental quality. However, many residents spent their daytime in outdoor such as open public space. Outdoor environmental quality is also important, and it is necessary to investigate the reaction to environmental noise in urban spaces. Social survey for evaluating the outdoor envinromental quality was introduced, and application of sound masking technique was suggested to improve the outdoor soundscape.

INTRODUCTION

Many researchers have investigated sound level or sound quality of noises in urban public area. This is because acoustical characteristics are one of the important aspects indicating the amenity of the place. However, most of the open public areas are necessarily accompanied with heavy flux of transportation and complicated activities so that excessive noise evokes annoyance to community. Among the various noises, road traffic noises are reported as one of the most dominant factors affecting community annoyance (Miedema & Vos 1998) so that many studies were concentrated on finding the method of transportation noise reduction. Several methods such as tree-planting or advanced pavements can be applied to the urban spaces. However, effects of the methods are limited in actual environments with various noises especially intermittent or impulsive noises such as construction noise are present. Therefore, sound masking technologies should be introduced to the urban public spaces in order to improve the soundscape more effectively. Also, more advanced measurement methods of soundwalking system should be applied for the realistic analyses and evaluations.

In the present study, community annoyance in urban spaces was obtained by social survey and construction noise as well as road traffic noise was dealt with as noise source. Standardized questions to obtain the noise annoyance were applied and synthesis curves for the relationship between noise exposure and annoyance were derived. Also, noise level and sound quality characteristics of the road traffic and construction site noises were defined by using physical analyses and subjective evaluations.

NOISE MEASUREMENTS

Methods

A total of sixteen urban areas around Seoul were chosen considering road traffic and construction sites. The dominant noise source of the four sites was the road traffic noise, and twelve sites were exposed to the construction noise as well as the road traffic noise. The sites can be categorized into two groups, residential area and open public space according to the usage. The sites selected in this study are listed in Table 1.

Table 1: Categorization of sites

Noise source	Number of site	
	Residential area	Open public space
Road traffic noise	2	2
Road traffic noise with construction noise	6	6
Total	8	8

The sound pressure levels were measured using a binaural ear microphone (B&K Type 4101) while one subject walked around each site. In addition, visual data was captured using a camcorder (Sony DCR-HC90) to investigate the effect of visual information in the auditory test. Also, Head and Torso Simulator (HATS, B&K Type 4100) was positioned considering the walking path of pedestrians in public spaces. Height of microphone was determined as 1.5 m from the ground.

SUBJECTIVE EVALUATIONS

Field survey

ICBEN team 6 (Fields et al. 2001) recommends that each survey use two questions to measure annoyance reactions for the purpose of making comparisons between social surveys. Therefore, the questions with 5-point verbal scale question and 11-point numerical answer scale were used in the present study. Annoyance responses from two questions were translated into a scale from 0 to 100 to assess the %HA (percentage of highly annoyed). The %HA is the percentage of annoyance responses exceeding a certain cutoff point. Schultz (1978) used a cutoff at 72 in his influential synthesis to define %HA, and same cutoff point was chosen in this study.

Construction type and progress of the selected sites were various. Some sites with construction noise were in the progress of excavation and rock removal work, and others were exposed to noise from hammering, drilling and grinding. Field survey was conducted in the afternoon (13:00-18:00) on the basis of the assumption that the outdoor activities are most frequent at that period. A total of 15 subjects (7 females, 8 males) between 20 and 30 years age participated in the survey. The soundwalk was conducted in silence and participants were asked to concentrate on what they could hear as they walked and to look at the urban environments in order to make connections between what they could see and what they could hear. After soundwalking for 30 minute at each site, participants were asked to evaluate the annoyance from the noise sources.

Laboratory experiments

Laboratory experiments were composed of three experiments in order to determine characteristics of masker. First, masker sound among various natural sounds was selected by preference tests. Second, signal to noise ratio between masker and maskee sounds was determined and finally, sound quality characteristics of the masker sound was manipulated in order to enhance the effectiveness of masking.

For all of the three experiments, paired comparison method was used. All of the subjects were asked to choose the preferred one between two sound stimuli in each pair. Duration of each pair was 17.5 second because an interval sound of 3.5 second duration was set between the 7.0 second stimulus and another 7.0 second stimulus. All of the stimuli pairs were randomly presented to the subjects. Visual image of the actual sites was presented to subjects before the auditory tests began. Twelve subjects between 20 and 30 years age evaluated the sounds via headphone system in a semi-anechoic chamber. Presentation level of the sound stimuli was set to 58 and 60 dBA for road traffic and construction noise, respectively, by considering the actual sound level of the noise at the real sound fields.

RESULTS

Exposure-response relationship

Exposure-response relationships were obtained as a function of L_{Aeq} from 5-point verbal scale and 11-point numerical scale respectively. And the curves for %A and %HA are given in Figure 1. %HA from 5-point verbal scale question was slightly higher than that from 11-point verbal scale at same noise exposure level. The difference between %HA curves from two different annoyance scales was statistically significant (p<0.01). However, %A curves from 5-point verbal scale and 11-point numerical scale were almost same in contrast to the results of %HA.

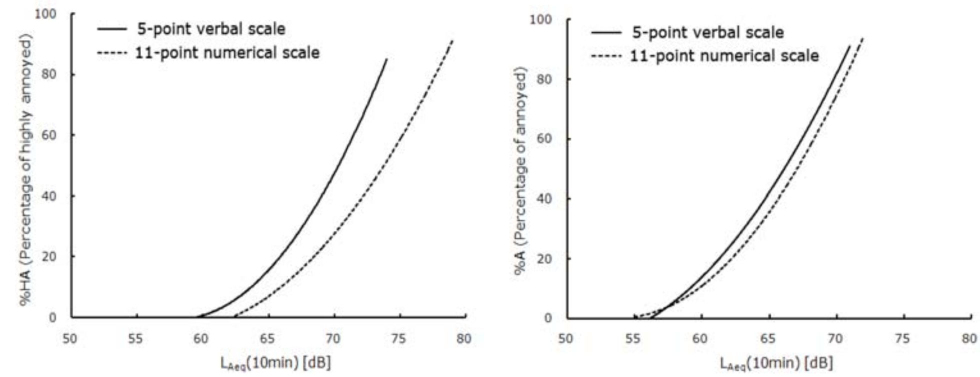

Figure 1: The percentages highly annoyed (%HA) and annoyed (%A) as a function of L_{Aeq}

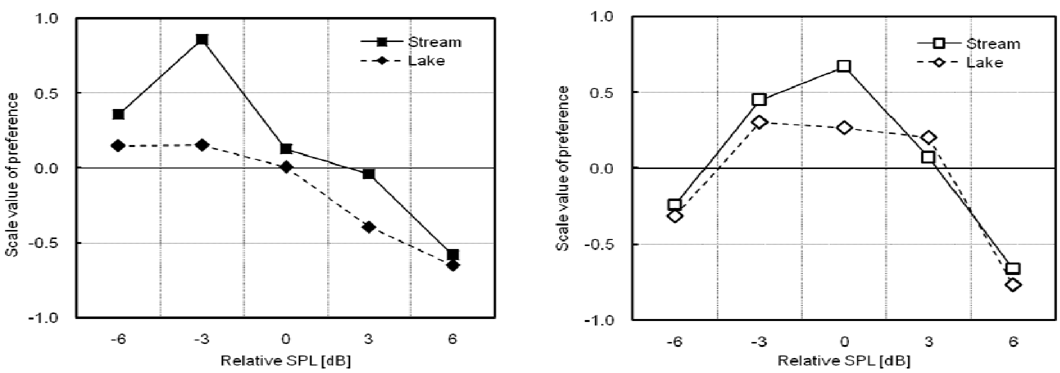

Figure 2: Scale value of preference according to relative presentation level: Left, Construction noise; Right, Road traffic noise

Preferred sound characteristics of noise masker

Sound characteristics of noise masker were determined. Among 9 natural sounds of ‘Waterfall’, ‘Rainfall’, ‘Stream’, ‘Lake’, ‘Birds in forest, ‘Seagulls in port’, ‘Insects’, ‘Church bell’, and ‘Wind sound’, the sounds of ‘Stream’ and ‘Lake’ were preferred the most as the noise masker. Therefore, sounds of ‘Stream’ and ‘Lake’ were applied to investigate the appropriate signal to noise ratio between the masker and maskee. As shown in Figure 2, in the case of construction noise, the scale value of preference showed high value when the sound masker was presented with 3 dBA lower sound pressure level than that of the noise. In the case of road traffic noise, the scale value of preference showed high level when the sounds of 'Stream' and 'Lake' were presented 0 dBA and 3 dBA lower than the noise, respectively. The scale value was decreased when the level of sound masker was increased over the level of site noise.

SUMMARY AND FURTHER STUDIES

Community annoyance was investigated in urban spaces on the basis of sound measurements and field survey. Soundwalking methodology was introduced to calculate the sound levels of urban public spaces more accurately. Standardized annoyance question and procedure to obtain the annoyance measure such as %HA (highly annoyed) and %A (annoyed) were applied.

In case of %HA, questions with 11-point numerical scale caused less annoyance than 5-point verbal scale, as the subjects rarely chose '8', '9' and '10' in the 11-point scale even though they were exposed to higher noise levels. However, it was found that the %A curves from 5-point scale and 11-point scale were almost same. It appears that most subjects chose '3' in the 5-point scale when they were exposed to a wide range of noise levels.

Also, sound characteristics for noise masker were investigated as a preceding research for the application of sound masking system to reduce the annoyance from road traffic or construction site noises. Results which were taken both in laboratory and actual conditions, show that sound maskers such as 'Stream' and 'Lake' are effective for both road traffic and construction noises. When the presentation level of the sound masker is up to 3 dB lower than that of the combined noise sources, the scale values of preferences actually increase.

REFERENCES

Ahn DS (2002). Analyses on the cognitive effects of masking traffic noise by sounds of water. J Korean Inst Forest Recreat 6(4): 9-19.

Anderson LM, Mulligan BE, Goodman LS, Regen HZ (1983). Effects of sounds on preferences for outdoor settings. Environ Behav 15: 539–566.

Berglund B, Nilsson ME (2006). On a tool for measuring soundscape quality in urban residential areas. Acta Acust Acust 92: 938-944.

Fields JM, De Jong JM, Gjestland T, Flindell IH, Job RFS, Kurra S, Lercher P, Vallet M, Yano T, Guski R, Felscher-Suhr U, Schumer R (2001). Standardized general-purpose noise reaction questions for community noise surveys: research and a recommendation. J Sound Vibr 242: 641-679.

Guastavino C, Katz BFG, Polack JD, Levitin DJ, Dubois D (2005). Ecological validity of soundscape reproduction. Acta Acust 91: 333–341.

ISO 15666 (2003). Acoustics - Assessment of noise annoyance by means of social and socio-acoustic surveys.

Jeon JY, Kim KH, Yano T (2003). Standardized noise annoyance modifiers in Korean according to the ICBEN method. J Acoust Soc Kr 22: 56-61.

Miedema HME, Vos H (1998). Exposure-response relationships for transportation noise. J Acoust Soc Am 104: 3432-3445.

Schafer RM (1977). The tuning of the world. New York: Alfred Knopf, Inc.

Schultz THJ (1978). Synthesis of social surveys on noise annoyance. J Acoust Soc Am 64: 377–405.

Semidor C (2006). Listening to a city with the soundwalk method. Acta Acust Acust 92: 959-964.

Skanberg A, Ohrstrom E (2002). Adverse health effects in relation to urban residential soundscapes. J Sound Vibr 250: 151–155.