APPLICATION OF SOUNDSCAPE DESIGN ELEMENTS IN URBAN STRRETSCAPE DESIGN

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Abstract

Due to complicate interaction between sounds and human noise perception, many approaches to evaluate sound environment have been investigated as a concept of soundscape. Recently, considerable efforts have been made on standardization of perceptual soundscape evaluation in ISO/TC 43/SC 1/WG 54 for practical application. In this study, urban streetscapes based on soundscape design elements were evaluated through laboratory experiments. Road traffic noise has been chosen as a negative sound source in urban spaces and natural sounds (water and birds sounds connected to water features and trees, respectively) have been selected as positive elements to enhance urban sound environments. The experiments consisted of three parts: 1) a visual-only condition, 2) an audio-only condition, and 3) a combined audio-visual condition. Streetscapes with soundscape design elements were evaluated by 11 point numerical scale and 12 pairs of semantic adjectives. As results, the effects of the soundscape design elements have been examined.

1. Introduction

Sound environment in urban spaces is one of the critical factors in overall comfort. In fact urban acoustic and visual experience is closely related each other (Southworth, 1969). However, in the field of landscape and architecture, visual aspects in terms of urban planning were mainly discussed. Therefore, it is necessary to examine acoustical aspects to improve urban environment. Recently, many researchers have studied soundscape qualities in urban space. Influence of natural sounds including water sounds and bird sounds on soundscape perception were investigated (Coensel et al., 2010; Coensel et al., 2011; Jeon et al., 2012). However, practical approaches of soundscape in urban spaces are essential. In the present study, soundscape design elements for enhancement of urban environment were investigated through laboratory experiments.

2. Method

2.1 Stimuli

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Individual soundwalks were performed in Seoul to assess urban soundscapes (Jeon et al., 2011). Among the evaluation locations through the soundwalk route, the site where its visual and acoustical environment was negatively evaluated by subjects was selected as a reference street view in order to investigate the effect of design elements for enhancement of streetscape. Based on the previous studies (Jeon et al., 2011; Coensel et al., 2011; Jeon et al., 2012) road traffic noise was chosen as a negative sound source in urban spaces and natural sounds (water and birds sounds) was selected as positive soundscape elements.

Audio recording of road traffic noise from the site was conducted, using a binaural microphone (Type 4101, B&K) and a digital recorder (Fostex, FR-2). For laboratory experiments, 6 sec audio road traffic noise sample was excerpted from the 3 min recordings. Two water sounds (drop and stream water sounds) were recorded from water features using binaural microphone and bird sounds (sparrow) were obtained from CD (Sony Pictures Sound). As shown in Figure 1(a), the spectral characteristics of road traffic noise and water sounds were similar presenting constant level at all frequency ranges while the bird sound was dominant at high frequency. In terms of time variability of sounds, road traffic noise and two water sounds were stationary and bird sounds were non-stationary and impulsive.

For visual stimuli, a reference street view was created using Rhino and Adobe Photoshop CS4 software. Two water features, drop (W1) water and stream (W2) water structures which are assumed to generate two water sounds respectively were constructed and an image of still water (W3) feature was created. Small (V1) and large (V2) trees connected to bird sounds were made. The image of low vegetated barriers (V3) was also constructed. A view point was fixed in order to avoid influence of different view angles. In total 16 photomontages of street views were used in the laboratory experiments as illustrated in Figure 2.

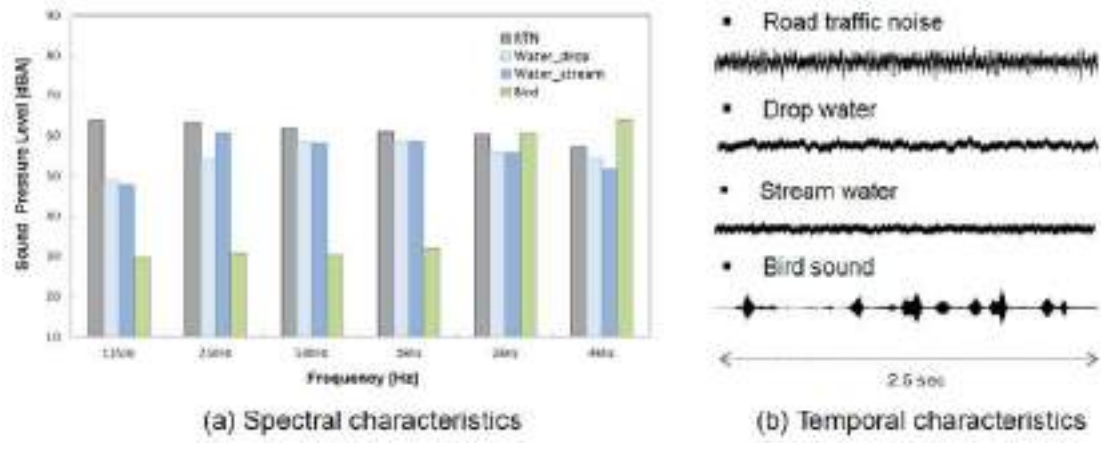

Figure 1. Spectral and temporal characteristics of acoustic stimuli

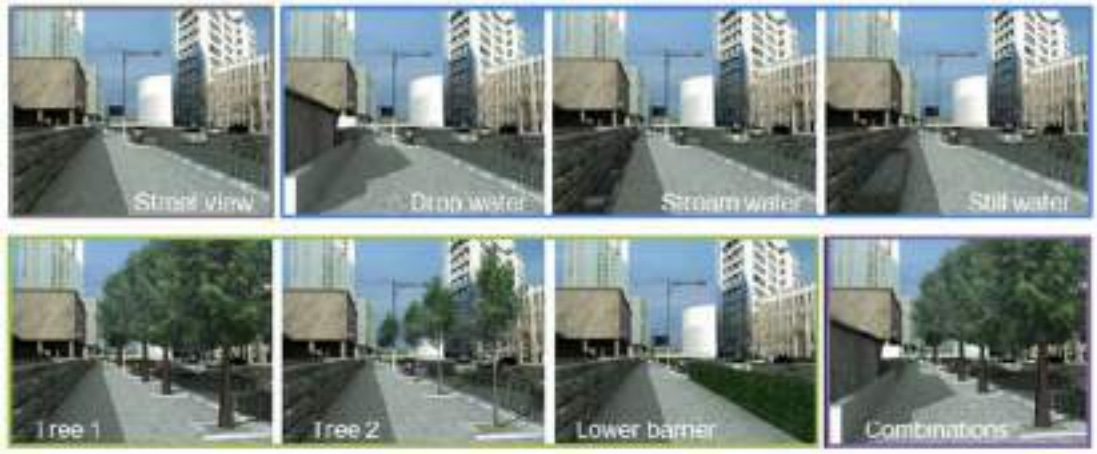

Figure 2. Samples of streetscape images

2.2 Experimental design

Laboratory experiments were performed to investigate the effect of soundscape design elements on soundscape perception of different streetscapes. The laboratory experiments consisted of three conditions: 1) a visual-only condition, 2) an audio-only condition, and 3) a combined audio-visual condition, where, images were provided along with the sound stimuli during the experiments.

A total of 9 experimental sounds were constructed: individual (road traffic noise, drop and stream water sounds and bird sounds) and combined sounds (road traffic noise combined with three natural sounds). The experiments were conducted twice with two presentation levels of road traffic noise: 55 and 70 dBA. The signal-to-noise ratios (SNR) between the water sounds and road traffic noise were set to -3 dBA so that the levels of the natural sounds were 52 and 68 dBA. Stimuli were randomly presented to subjects in order to overcome order effects. In the present study, the subjects rated their preference to each stimulus using an 11-point scale, with 0 representing ‘not at all’ and 11 as ‘extremely’. In addition, soundscape quality was assessed by using twelve pairs of adjective attributes (“open-closed”, “wide-narrow”, “quiet-noisy”, “calm-loud”, “pleasant-unpleasant”, “comfortable-uncomfortable”, “stable-unstable”, “harmonious-disharmonious”, “ordered-disordered”, “various-monotonous”, “distinct-ordinary” and “natural-artificial”).

A total of 20 subjects took part in the laboratory experiments. During the experiments, subjects were seated in a testing booth. Acoustic and visual stimuli were presented through headphones (Sennheiser HD 600) and a beam projector (Sony VPL-CX6), respectively.

3. Results

Figures 3(a) and (b) describe the preference scores in terms of stimuli from visual only and audio visual session when the level road traffic noise was fixed at 55 and 70dBA, respectively. In general, road traffic noise deteriorates the overall impression of environment. However, it was found that natural sounds contributed to an improvement in preferences under conditions with road traffic noise. In particular, stream water sound enhanced the environmental quality more than drop water did and the effect of bird sounds was most significant compared with selected water sounds. In terms of streetscape components, images of large trees improved urban streetscape quality.

The results of semantic differential test for 16 stimuli are listed in table 1. A factor analysis was conducted to classify 12 attributes and two factors were obtained in the session with 55dBA of road traffic noise while three factors were derived in the session with 70dBA of road traffic noise. For road traffic noise of 55 dBA, two factors were found: Factor 1—overall preference explained 79.5% of the total variance, Factor 2—spatial impression, explained 12.6% of the total variance. For road traffic noise of 70 dBA, three factors were: Factor 1—Harmony explained 70.1% of the total variance, Factor 2—acoustic comfort, explained 12.3% and Factor 3— spatial impression, explained 7.9% of the total variance. This indicates that when road traffic noise is louder, acoustic comfort becomes an important factor for evaluation of overall environment.

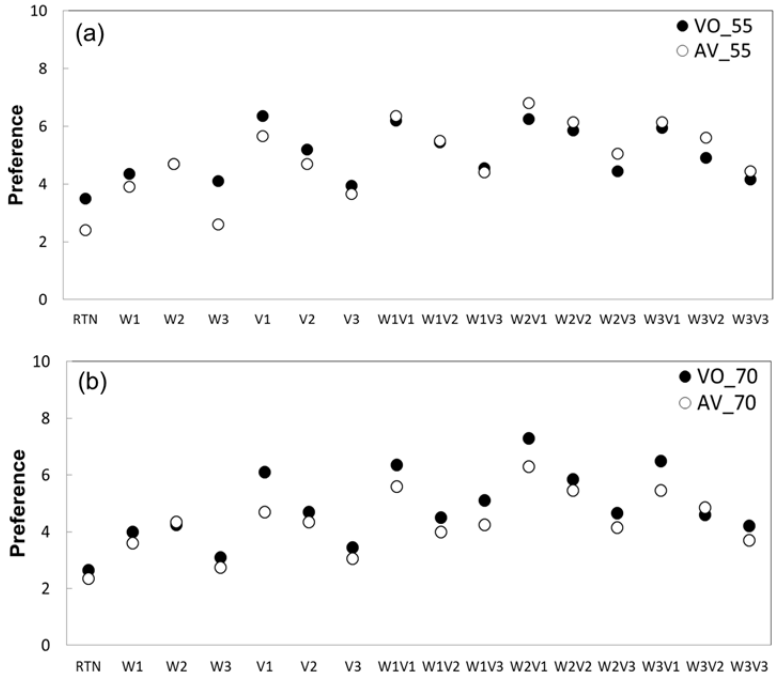

Figure 3. Experimental results for stimuli. black and white circles indicate the preference scores obtained from visual only sessions and audio-visual sessions, respectively.

Table 1. Results of factor analysis

Attributes	Component (55dBA)		Component (70dBA)		
	1	2	1	2	3
Open − Closed	-.187	-.944	-.400	-.184	-.874
Wide − Narrow	-.196	-.956	-.018	-.377	-.914
Quiet – Noisy	.938	.184	.080	.823	.303
Calm – Loud	.811	.307	.291	.914	.115
Pleasant − Unpleasant	.896	.371	.593	.738	.285
Comfortable − Uncomfortable	.947	.131	.850	.422	.208
Stable − Unstable	.862	.317	.828	.487	.116
Harmonious − Disharmonious	.885	.410	.853	.297	.273
Ordered − Disordered	.786	.035	.911	.060	.082
Various − Monotonous	.857	.481	.590	.697	.346
Distinct - Ordinary	.686	.597	.435	.617	.402
Natural − Artificial	.793	.516	.510	.687	.430

4. Conclusions

In the present study, enhancement of soundscape perception for the variation in streetscape design elements was investigated. Introduction of natural sounds including two types of water sounds and a bird sound was examined in terms of urban soundscape enhancement, when road traffic was a major noise source in urban spaces. As results, stream water sounds with image of large trees improve urban soundscape quality and acoustic comfort is a dominant factor affecting overall impression of streetscapes when road traffic noise level is 70dBA. In the future, the soundscape design elements in improving streetscape will be further investigated through multiple regression analysis.

5. References

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