Landscape and Urban Planning 141 (2015) 78–87

Contents lists available at ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan

Research paper

Influence of urban contexts on soundscape perceptions: A structural equation modeling approach

Joo Young Hong[1], Jin Yong Jeon*

Department of Architectural Engineering, Hanyang University, 17 Haengdangdong, Sundong-Ku, Seoul 133-791, Republic of Korea

HIGHLIGHTS

- Holistic relationships among the soundscape factors were investigated in urban spaces.
- The composition of sound sources influences soundscape perceptions.
- Relationships among soundscape factors differ according to the main functions of places.

ARTICLE INFO

Article history:
Received 12 November 2014
Received in revised form 20 April 2015
Accepted 5 May 2015

Keywords:
Soundscape
Structural equation model
Urban contexts
Perception
Sound sources

ABSTRACT

This study aims to investigate relationships between soundscapes and landscapes within various functions of space, and to examine the influence of functional aspects of places on soundscape perceptions in urban environments. Surveys were conducted to assess soundscape and landscape perceptions in 25 locations in Seoul. Urban contexts were classified into four categories based on main functions, activities, and visual properties of the spaces: commercial, residential, business and recreational. A structural equation model of urban soundscape was constructed using seven factors, namely sound sources (traffic, human, and natural), pleasantness and eventfulness, visual quality, and the harmony of the environment. The model appropriately fit the data measured in the survey. The results showed that dominant factors affecting soundscapes differed in accordance with the main functions of the place. In commercial areas, sounds from human activities played a significant role in evaluating soundscapes. For residential and business functional areas, traffic noise was a dominant sound source influencing the soundscape quality. In addition, human sounds from leisure activities played an important role in constructing a relevant soundscape in urban recreational areas. The findings of this study provide an empirical evidence for understanding the holistic relationships among soundscape factors in urban contexts and demonstrate that functions of place should be taken into consideration as an important context for soundscape design.

1. Introduction

A soundscape is defined as an acoustic environment understood or perceived by people within a specific context (ISO 12913-1, 2014). Based on this definition, it can be said that the relationship between perceptions of a sonic environment and contexts is important to understand the soundscape of a place. In term of perceptual constructs, many researchers have investigated the perceptual components of soundscapes using psychological evaluations. A semantic differential method has been widely adopted to extract the soundscape components using various attributes describing acoustic environments, and various principal perceptual components of soundscape have been found such as pleasantness, eventfulness, familiarity, loudness, and the spectra-temporal characteristics of sounds (Axelsson, Nilsson, & Berglund, 2010; Jeon, Lee, You, & Kang, 2010; Kang & Zhang, 2010). The perceptual components of soundscapes are closely related to the identified types of sound sources (Axelsson et al., 2010). A taxonomy of sounds sources has been suggested in previous studies where sound sources can be categorized as sounds generated by human activity or otherwise (Brown, Kang, & Gjestland, 2011; Pijanowski, Farina, Gage, Dumyahn, & Krause, 2011). In addition, individual sound sources were evaluated in term of preference in previous studies (Guastavino, 2006; Jeon, Lee, Hong, & Cabrera, 2011; Jeon, Hong, & Lee, 2013); In general, natural sounds such as birds, wind, and water sounds are preferred sounds, while mechanical sounds

* Corresponding author. Tel.: +82 2 2220 1795; fax: +82 2 2220 4794.
E-mail addresses: st200045@hanmail.net (J.Y. Hong), jyjeon@hanyang.ac.kr (J.Y. Jeon).
[1] Tel.: +82 2 2220 1795; fax: +82 2 2220 4794.

http://dx.doi.org/10.1016/j.landurbplan.2015.05.004
0169-2046/

such as traffic, ventilation, and construction noises are considered unfavorable sounds. This demonstrates that the composition of sound sources of a place can influence the soundscape qualities.

From a soundscape perspective, context plays an important role in evaluating soundscapes because the context influences every element, including auditory sensation, interpretation of auditory sensation, and outcomes to the acoustic environment (ISO 12913-1, 2014). This indicates that soundscape studies encompass not only acoustic and but also non-acoustic contexts affecting human perceptions of sonic environments (Brown et al., 2011; Jeon et al., 2011; Kang & Schulte-Fortkamp, 2011). Contexts related to soundscape include place/location, non-auditory sensations, socio-cultural factors and personal dimensions (Brambilla, Maffei, Di Gabriele, & Gallo, 2013; Jeon et al., 2011; Kang & Zhang, 2010). Among these contexts, landscape factors such as visual quality, morphology, and functions of places are closely associated with soundscape. It has been found that the visual quality of an environment can influence soundscape evaluations (Carles, Barrio, & Lucio, 1999; Hong & Jeon, 2013; Hong & Jeon, 2014; Viollon, Lavandier, & Drake, 2002). Urban morphology also affects physical and perceptual acoustic environments (Ariza-Villaverde, Jiménez-Hornero, & Gutiérrez De Ravé, 2013; Hao & Kang, 2014; Hao, Kang, & Krijnders, 2015; Liu, Kang, & Behm, 2014a; Liu, Kang, Behm, & Luo, 2014c). In particular, soundscape assessments are influenced by the functions of places. Even if the same sound source exists in a place, the values for that sound source may be differently evaluated depending on the function of a place. For instance, a peaceful, or tranquil acoustic environment might be preferred in a place for meditation or relaxation, while sound sources which create lively or eventful acoustic environment might be appropriate in playgrounds or amusement parks (Brown et al., 2011). This implies that the contributions of sound sources to soundscape quality might be different in the function of a place in an urban environment.

Many studies on soundscape quality assessments have been conducted in specific functions of a space such as parks (Liu, Kang, Luo, & Behm, 2013a; Liu, Kang, Behm, & Luo, 2014b; Nilsson & Berglund, 2006), residential areas (Berglund & Nilsson, 2006; Ge & Hokao, 2006), and squares (Yang & Kang, 2005a; Yang & Kang, 2005b). However, these studies focused on a single functional space are limited to provide comprehensive knowledge of the relationship between the soundscape and landscape, which is essential for soundscape design and management. In addition, even though some work has evaluated soundscapes in multiple functional spaces in urban environments (Jeon et al., 2011; Liu, Kang, Luo, Behm, & Coppack, 2013b), the influence of urban contexts regarding the functions of spaces on soundscape quality have not yet been specifically examined and compared.

Therefore, the aims of this study are to explore the holistic relationships among the soundscape and landscape across various functions of space in urban environments, and to examine the effect of urban context on soundscape perceptions. To achieve these goals, the critical factors related to soundscape were extracted based on literature reviews, and a questionnaire was constructed for the assessment of urban soundscapes. Social surveys were performed using the questionnaires to evaluate soundscape perceptions in various functional areas in urban space. Based on the survey results, the conceptual soundscape model was tested using structural equation modeling.

2. Method

2.1. Site selection

Twenty-five locations in Seoul were selected to include various urban contexts, as shown in Fig. 1. Urban contexts were classified into four categories (Types I–IV) based on the main functions, activities and visual properties of spaces (see Table 1): Type I includes the six locations in commercial districts consisting of shops and restaurants in the Jung-gu, Jongno-gu and Gangnam-gu areas that represent primary shopping districts in the northern and southern parts of Seoul. Locations with high- and low-rise residential buildings in Seoul were considered Type II. Locations classified in Type III were situated in central business districts (CBD) and consist mainly of office buildings with heavy traffic. Type IV represents urban recreational areas including urban parks and city streams. The five locations in an urban park, Seoul forest, include diverse spaces with different landscapes and uses such as open green spaces, playgrounds, and an outdoor theatre. Additionally, four locations with different water features on Chunggye-cheon, one of the popular city streams in Seoul, were classified as Type IV.

The measured sound pressure levels at each location are presented in Table 1, including the mean and standard deviation, statistical levels (L_{A90}, L_{A50}, L_{A10}), $L_{A10}-L_{A90}$, and $L_{Ceq}-L_{Aeq}$. $L_{A10}-L_{A90}$ and $L_{Ceq}-L_{Aeq}$ values indicate the time variance of sounds and low frequency content of sounds, respectively. The measured L_{Aeq} ranged from 54.4 to 80.7 dBA across the locations.

2.2. Construction of the questionnaire

2.2.1. Sound sources

Identification of sound sources is important for understanding soundscape perceptions because the categories of sound sources provide more information on perceived soundscape quality (Nilsson, Botteldooren, & De Coensel, 2007). Several researchers have suggested categories of sound sources. Brown et al. (2011) categorized sound sources as comprising the acoustic environment, with sounds generated by human activities or facilities (e.g., motorized vehicles) and by non-human activities (e.g., nature and animals). Pijanowski et al. (2011) defined the soundscape as a complex composition of sounds from multiple sources and classified the sound sources as follows: biophony, geophony, and anthrophony. Biophony is comprised of the sounds generated by organisms. Geophony includes sounds from the geophysical environment such as wind, water, and thunder. Anthrophony is a collection of sounds produced by stationary or moving man-made objects such as air conditioning and moving vehicles.

Axelsson, Nilsson, and Berglund (2012) suggested types of sound sources to use in soundscape quality questionnaire protocols based on empirical studies (Berglund & Nilsson, 2006; Nilsson & Berglund, 2006): (1) traffic noise (e.g. car, buses, trains, etc.), (2) fan noise (e.g. ventilation) (3) other noise (construction, industry, machines, sirens, music, etc.), (4) sounds from human beings (conversation, laughter, children at play, and footsteps) and (5) natural sounds (wind, water, and birds). This classification of sound sources has been widely utilized in soundscape studies (Axelsson et al., 2010; Jambrošić, Horvat, & Domitrović, 2013; Jeon, Hwang, & Hong, 2014; Lindborg, 2015) due to its utility for laypeople. In addition, the previous studies using the protocol show significant correlations between sound source identification responses and perceptions of acoustic environments. In this context, in the first section of the questionnaire, sound sources were classified into four categories based on the study by Axelsson et al. (2012): traffic noise, sounds from human activities, natural sounds and other sounds. The category traffic noise included noises from cars, trains and airplanes. Human sounds were sub-classified as footsteps, talking, and sound of leisure activities. Natural sounds were comprised of three types: bird songs, water sounds, and wind sounds. Other sounds included construction noise, music and ventilation sounds. Prominence of perceived sound sources (referring to the importance of the sound sources (Lavandier & Defréville, 2006) at each location was assessed by respondents using a 5-point scale with the following response