Urban sound planning – A soundscape approach

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ABSTRACT

In the field of environmental acoustics, the conventional approach, i.e. reduction of 'sound level', does not always deliver the required improvements in quality of life. Soundscape, by considering sound environment as perceived, in context, with an interdisciplinary approach, represents a step change. This paper explores a soundscape approach in the urban sound planning process. A framework is first proposed for designing soundscape in urban open public spaces, considering four key components: characteristics of each sound source, acoustic effects of the space, social/demographic aspect of the users, and other physical conditions. Consequently, the design potentials for the four key components, namely sounds, space, people and environment, are demonstrated. Designing/planning tools/models for soundscapes are then presented, including an auralisation software package for design modification and public participation, and an artificial neural network model for predicting acoustic comfort based on various design variables. Finally, the potentials and scope of soundscape approach are discussed, in terms of increasing safety, cultural preservation, and management of the various noise sources such as delivery sounds and traffic sounds.

1 INTRODUCTION

Environmental noise is often the main cause of environmental distress in terms of the number of complaints received. The EU Directive Relating to the Assessment and Management of Environmental Noise (END) has led to a number of major actions (EU, 2002), where reducing noise level has been the focus. However, such a conventional approach does not always deliver the required improvements in quality of life. For example, in urban open spaces it has been shown that when the sound level is below a certain value, as high as 65-70dBA, people's acoustic comfort evaluation is not well related to the sound level, whereas the sound type, the user characteristics and other factors play an important role (Yang and Kang, 2005a; 2005b; Kang, 2006). The importance of considering the overall sound environment may also become more significant with the development of quieter vehicles.

The soundscape strategy, by considering sound environment as perceived, in context, with an interdisciplinary approach (ISO, 2014), is a growing field for addressing this gap (Kang and Schulte-Fortkamp, 2016). Although the term soundscape was introduced in the 1960s (Schafer, 1977), significant attention to it has only been paid in the last decade by researchers and practitioners, with the END actions on creating quiet areas as a main driver. In the major international conferences, an increasing number of special sessions have been organised. Moreover, a number of national research projects relating to this field are being carried out. Soundscape also has significant practical relevance in terms of policies as well as the planning/design process, with many cities including Greater London, Berlin, Stockholm and Antwerp actively promoting practical examples of soundscape projects (Kang and Schulte-Fortkamp, 2016). A number of networks have been formed, for example, the EU-COST network on Soundscape of European Cities and Landscapes (http://soundscape-cost.org/), with partner organisations from 23 COST countries and 7 outside Europe.

This paper explores a soundscape approach in the urban sound planning process (Kang, 2007; 2010a; 2010b; 2017; 2018). An overall framework is first proposed for designing soundscape in urban open public spaces. Then the designing potentials for the four key components in the framework, including characteristics of each sound source, acoustic effects of the space, social/demographic aspects of the users, and other aspects of the physical environmental conditions, are demonstrated. Designing/planning tools/models for soundscapes are then presented. Finally, the potentials and scope of the soundscape approach are discussed, in terms of increasing safety, cultural preservation, and management of various noise sources (Kang et al, 2016; Zhang and Kang, 2007).

2 SOUNDSCAPE DESIGN STRATEGY

Figure 1 shows a framework for designing/engineering the soundscape of urban open public spaces (Kang, 2006; 2008), where four key components are included: (1) sources - characteristics of each sound source; (2) space - acoustic effects of the space; (3) people – social/demographic aspect of the users as well as their activities and behaviours; and (4) environment - other aspects of the physical environmental conditions.

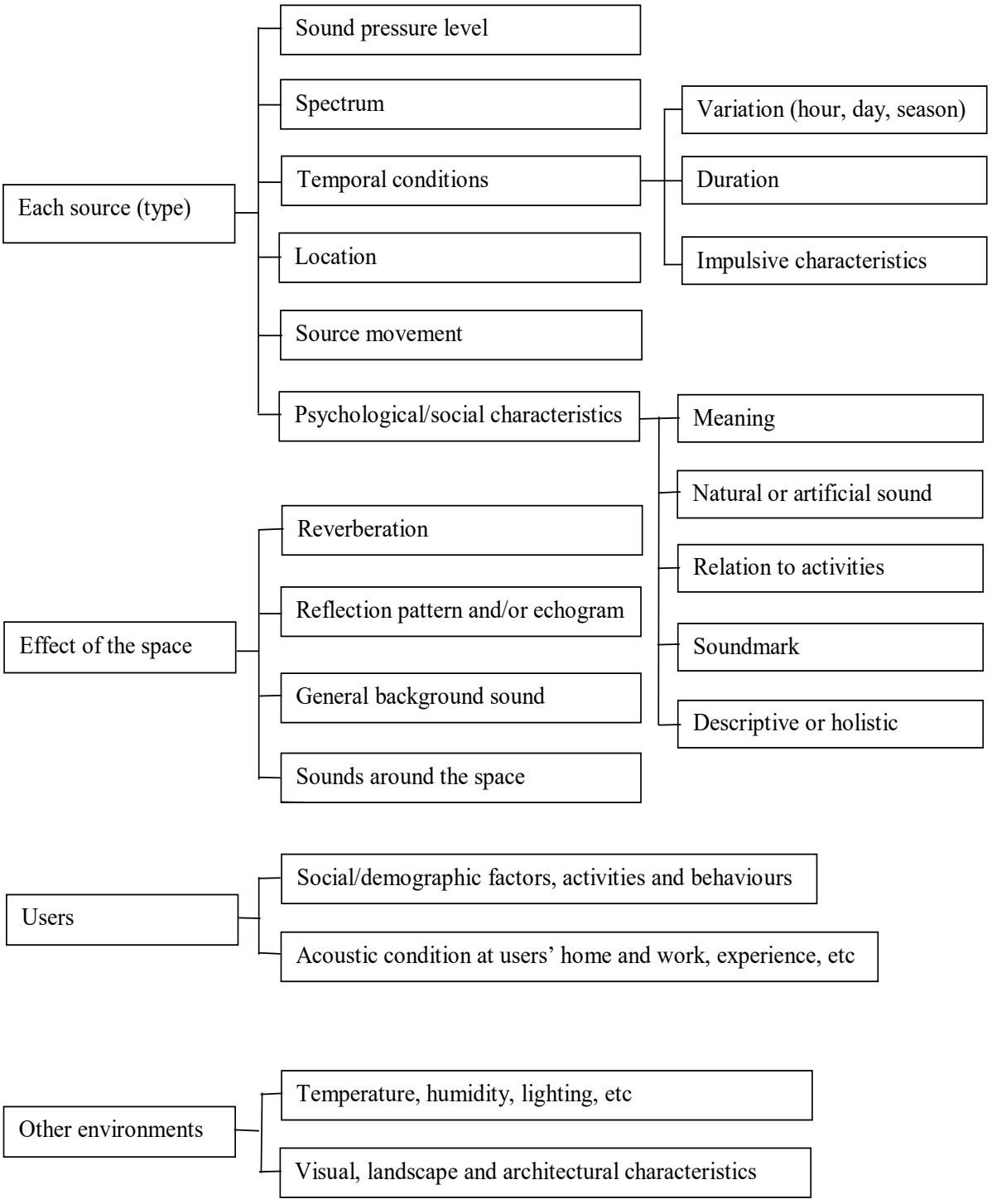

Figure 1: A framework for soundscape description in urban open public spaces (Kang, 2006).

3 SOUND

There is a great potential for planning and designing various sounds, considering the parameters listed in Figure 1. It would be important to consider soundmarks, reflecting traditional and cultural characteristics, given that the first noticed sounds do not have to be the loudest (Yang and Kang 2005a; 2005b). Spectrum analysis is vital, both for individual sounds and for the overall acoustic environment. The design of soundscape in an urban open space should also be considered as a dynamic process. From the design viewpoint, preferred sounds in urban public spaces can be divided into sounds from human activities, defined here as 'active sounds', and sounds from the landscape elements, for functional and aesthetical purposes, defined here as 'passive sounds' (Kang and Yang, 2002).

Live music is a typical active sound. An extensive field survey shows that people are not only interested in the music itself, but are also attracted by the activities of the players. In this case, the type of music (e.g. classical music or pop music) is not a very important issue. In terms of spectrum characteristics, case studies in Sheffield suggest that the low frequency components in music are often not loud enough to mask traffic sound, whereas the high frequency components can result in the music emerging over other background sounds, making the soundscape more pleasant. It is important to note that when music is from a store or played through a public address (PA) system, the type of music and the sound level needs to be considered carefully. Most people do not like loud music played from loudspeakers, regardless of the music type (Kang, 2007)

Water is a typical passive sound. In the form of fountains, springs or cascades, it is often used as a landscape element in open public spaces, with endless effects in colouring the soundscape. In the visual aesthetic field, there are contents called 'primary landscape qualities', which have a special effect on preference, and water and foliage were two of the contents first identified (Yang and Kang, 2002). Similarly, water sounds can be defined as a 'primary soundscape quality'. Figure 2 shows a wide range of diversity of water sounds in terms of spectrum and dynamic process, measured in the Sheffield Gold Route (Kang, 2012). Different flow methods result in different frequencies. Generally speaking, high frequency components come from the water splash itself, whereas when a large flow of water is raised to a significant height and then dropped to a water body or hard surface, notable low frequency components can be generated.

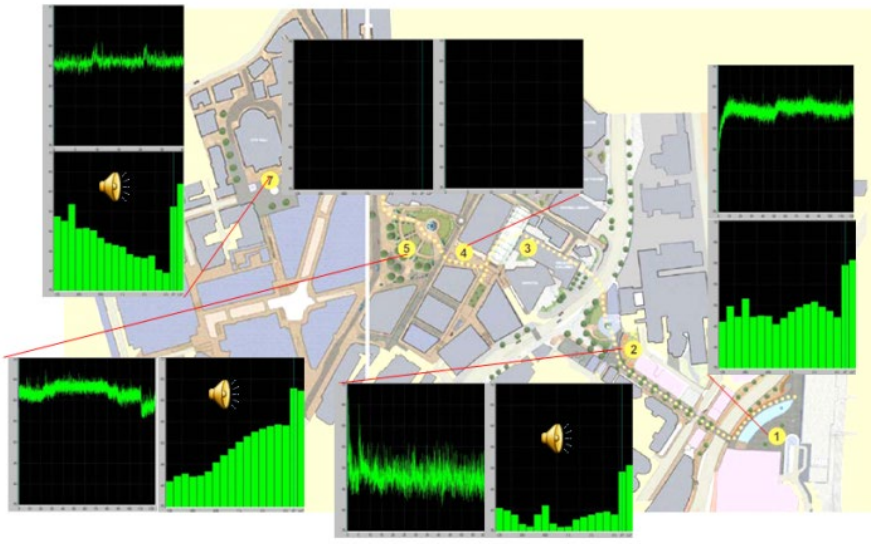

Figure 2: Diversity of water sounds in terms of spectrum and dynamic process, measured at 1m from each water feature along the Sheffield Gold Route (Kang, 2012)

4 SPACE

Simulations of sound propagation were made in a number of hypothetical urban squares surrounded by buildings (Kang, 2005) and it has been shown that if a relatively far field is considered, the sound pressure level (SPL) is typically 6-9dB lower when the square side is doubled; 8dB lower when the height of buildings surrounding the square is decreased from 50m to 6m (diffuse boundaries); 5dB (diffuse boundaries) or 2dB (geometrical boundaries) lower if the length/width ratio is increased from 1 to 4; and 10-12dB lower if the boundary absorption coefficient is increased from 0.1 to 0.9. Similarly, other landscape elements may be effective too, such as vegetation,

urban furniture and barriers. Reverberation time (RT) is also an important index for the soundscape in urban open public spaces. Calculation shows that compared to diffusely reflecting boundaries, spaces with geometrically reflecting boundaries have RT and early decay times (EDT) that are significantly longer, typically by 200-400%. Overall, those results suggest that in urban open public spaces, architectural changes and urban design options could affect the sound field significantly (Kang, 2006; 2007).

An urban open public space can be designed to encourage activities which generate active soundmarks. For example, a green space may enhance the natural appeal of a public space, attract wild animals' activities such as bird singing, and improve the microclimate conditions and sound level distribution. Hard spaces are useful for generating many activities, especially for young people, such as dancing and skateboarding. Some patterns of design are more suitable for certain activities, for example, defined edges, such as by walls, colonnades, or shrub plantings, often encourage activities to take place (Kang, 2007).

5 PEOPLE

Understanding how soundscape affects its users is a key part of soundscape research. Much work has been carried out, both under field and laboratory conditions, considering a range of spaces and locations, sound sources and people (Kang, 2010b). Various factors have been examined, including (Kang, 2006) (1) social and demographic factors, including age, gender, education, profession, residential status (i.e. local and non-local), cultural background, and acoustic environment at home and at work; (2) activities including moving types such as walking, playing with children, and sport; and non-moving types such as sitting, standing, reading, and watching; and (3) behaviours such as wearing earphones and sunglasses. The results have clearly demonstrated the importance and potential in considering the characteristics of the users. For example, with increasing age, people tend to prefer bird songs, a typical natural sound. In other words, if an urban open public space is mainly designed for older people, more natural sounds like bird songs should be introduced (Kang, 2007). For those the design process is also vital (Xiao et al, 2017).

6 ENVIRONMENT

The interaction between acoustic and other physical environments is an essential consideration in soundscape planning and design in urban open public spaces. For example, if a place is very hot or very cold, the acoustic comfort could become less critical in the overall comfort evaluation. Various interactions have been studied, including between smell and noise, namely with better smell from fragrant trees (Ba and Kang, 2019a; 2019b), traffic noise annoyance is reduced; and between thermal comfort and noise annoyance (Jin et al, 2019). Among various physical conditions the aural-visual interactions have been intensively studied. Based on the data of 14 urban open public spaces in Europe in terms of subjective evaluation of various physical indices, factor analysis shows that visual and auditory aspects are always in the same factor, covering 17-19% of the total variance (Kang, 2006). Recently this has also been proved from neural science viewpoint (Hunter et al, 2010). Given these aspects have interactions, working together towards the overall comfort, they should be integrated and optmised in design considerations.

7 DESIGN TOOLS

Efforts have been made in developing tools to aid design, from various points of view, including an evaluation tool, integrating perceptual results with outlines of what can be measured and how user behaviour can be characterised (Davies et al, 2009); a synthesis tool to derive psychoacoustic maps (Fiebig and Genuit, 2009); an instrument which would be capable of characterising a sound field in terms of the relative contributions of different noise sources (Bunting et al, 2009).

In relation to the framework in Figure 1, it is important to develop a model to predict the subjective evaluation of soundscape quality at the design stage, using known design conditions such as physical features of a space, acoustic environmental variables, and social/demographic characteristics of the users, and consequently to aid planners/designers in making decisions. Given the complicated relationships between various factors, an efficient way to integrate them is to use the artificial neural networks (ANN) model. Based on a series of field surveys and laboratory tests, a database suitable for ANN modelling has been established (Yu and Kang, 2009). Since there are considerable differences in soundscape evaluation between various case study sites in terms of the effects of different factors, it is necessary to classify urban open spaces into typical categories, and develop sub-models for each category (Yu and Kang, 2009).

It would be useful to present the 3D visual environment with an acoustic animation/auralisation tool, which is vital for aiding urban soundscape design as well as for public participation. Considerations should be given to various urban sound sources, dynamic characteristics of the sources, and the movements of sources and receivers. The computation speed should be reasonably fast, so that a designer can adjust the design and then immediately listen to the difference. A key issue of achieving fast acoustic animation/auralisation for urban soundscape is to simplify the simulation algorithms, while retaining reasonable accuracy (Kang, 2008). Since human sensitivity to a particular sound source might be reduced within a complex sound environment with multiple and moving sources, to provide a fast urban acoustic animation/auralisation, simplifications of calculation parameters have been explored through a series of subjective experiments (Smyrnova and Kang, 2010).

8 SOUNDSCAPE IN WIDER CONTEXT

Although much work has been carried out for designing soundscape in urban open public spaces, the potentials for applying soundscape approaches are much greater. For example, a model has been developed for managing the delivery sounds in London, where the acoustics parameters such as sound level, as well as contextual parameters, have been taken into account (Kang et al, 2015). Conservation is also an important application of soundscape, such as the soundscape conservation in Tibet (Huang and Kang, 2015) and Guizhou (Mao et al, 2013), and in religious context (Zhang et al, 2016). Rural soundscape has also been subject to increasing attention (Ren et al, 2018; Yu and Kang, 2018). The soundscape approach has also been applied in changing people's behaviour, for example, in way-guidance (Aletta et al, 2016).

It is also important to note that soundscape could be applied at different scales, from micro-scale such as a square and a street, to meso scale, such as a residential area, to macro-scale, such as a city (Kang et al, 2018; Margaritis et al, 2018; Margaritis and Kang 2017a; 2017b).

9 CONCLUSIONS

In this paper a framework for soundscape description in urban open public spaces has been established and correspondingly, the design potentials of the four key components, sounds, space, people, and environment, has been demonstrated. The usefulness of the design tools has been revealed. It is expected such a systematic approach towards intentionally planning and designing soundscape will greatly benefit practice and polices, in urban open public spaces and beyond – in different context and at different scales (Kang, 2007).

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