

Objective parameters for acoustic comfort in enclosed spaces

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ABSTRACT

In order to thoroughly analyse aural environments and their impact on users, a multidisciplinary perspective concerning fields of acoustics, psychology, sociology, and architecture should be introduced. A widely accepted approach regarding soundscape analysis and acoustic comfort in enclosures has not been fully developed. Based on the classification of architectural spaces from the viewpoint of acoustic comfort, in this paper, soundscape evaluation in relation with objective acoustic indices within enclosures that have similar space dissolutions are presented. The primary concern is to examine how sound behaves under certain architectural conditions. Existing literature using certain temporal and spatial parameters for sound fields and speech intelligibility is firstly reviewed. Then some parameters specifically relating to soundscape and acoustic comfort are discussed, considering various architectural formations. It is also considered that, certain architectural elements and spatial organisations could have a range of influences regarding the formation of aural environments.

INTRODUCTION

Soundscape research is one of the most common topics studied in the field of acoustics. In order to study soundscape, several different methodologies and techniques are present in the literature. This topic mainly deals with auditory perception and acoustic comfort that is classified as the qualitative aspects of soundscape assessment. In addition, the objective analysis and its correlation with the subjective assessment are widely covered by previous research, yet such studies mainly concentrate on the objective characteristics and acoustical formations of open/urban spaces (Yang and Kang, 2005; Raimbault and Dubois, 2005). Enclosed areas such as shopping centers, food courts, dining spaces or other leisure venues are important examples for such ‘non-acoustic’ public spaces that need attention (Kang, 2003, Chen, Kang, 2004).

Assessment of sound environments should be handled through various ways. As indicated in Figure 1, in order to carry on an acoustics research in enclosed built entities, assessment of the sound environment by several objective and subjective methods in addition with the analysis of aspects for the built entity and its soundscape is crucial. As for indoor environments, their soundscape show variations depending on three main built entity aspect as, its pre-defined function, its users and its architectural characteristics. All such aspects should be referred and introduced before discussing or assessing the acoustic properties of a space. This third aspect has not been commonly addressed in the literature, yet should be highlighted when it comes to use soundscape approach, in enclosed spaces.

The main purpose of this study is to highlight ‘soundscape methodologies’ that should not mix up with noise control

techniques. Although objective measurements and parameters are crucial for deciding upon guidelines and palpable findings, there is a need to shift from a physical point of view to a more psychological one. The users with their sensory experience are the key to gather better information regarding the sound environments. In the literature, many studies show that the qualitative aspects of sound are crucial for the assessment of annoyance and acoustic comfort (Marquis-Favre, Premat, and Aubree, 2005). Other things addressed in this paper are the several discussion topics that are raised in congresses, meetings and workshops concentrating on the study of soundscape and acoustic comfort.

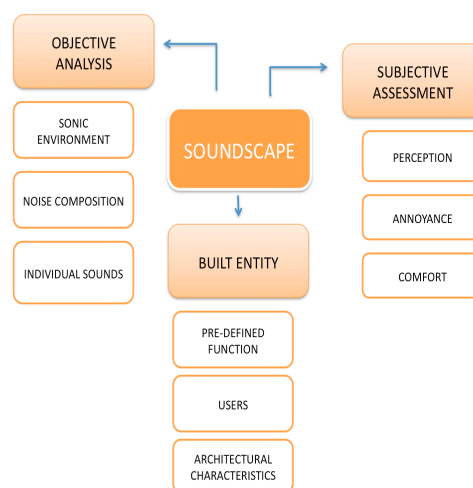


Figure 1: Three main aspects of soundscape research.

ASPECTS OF SOUNDSCAPE RESEARCH

Objective Analysis

There are many studies, which aim to put forth how the objective criteria regarding a sonic environment relate with the human perception (Memoli et al 2009). In such studies, first, some basic LAeq and Lmax measurements are done. The surveys that concentrate on the classification of sounds being pleasant-unpleasant or relaxing-stressing were given to the subjects. It is discussed whether the terminology 'positive-negative sounds' is the appropriate that fulfils the real meaning or perception of the sound environments (Memoli et al. 2009).

One controversial concept is the usage of A-weighted measurements. There are studies putting forth the pros and cons of using this weighing (McKell, 2009). The question of how an objective measure (SPL) estimates upon a subjective concept (loudness) and the perception of loudness are discussed to be not uniform with increasing or decreasing intensity as well as the frequency response that vary by changing intensity. Similarly, studies point out that A-weighting does not take account the non-acoustic factors and not cope well with low frequency noise whereas; using phon can be better correlated with subjective judgement (McKell, 2009).

Researchers also try to assess whether speech intelligibility (SI) is an important indicator of the perceived quality of the sonic environment. These studies search through the ways to better measure, clarity, quality and intelligibility and better rate STI, SII, AI and PESQ for the cases of soundscapes (Davies et al, 2009a).

In the literature, one common decision is that, for urban soundscape improvement, decreasing noise levels and eliminating various noise sources would not be sufficient (Raimbault and Dubois, 2005). This kind of generalisation is not possible for indoor soundscape environments, as the composition and types of sound sources are different than those in urban cases. In addition, studies on enclosed sound environments concerning non-acoustics public spaces are insufficient when compared to urban and open environments.

More over, while studying soundscape of enclosures, sound propagation and attenuation as well as wave behaviour, reflection, refraction and transmission should be addressed relating to the acoustic characteristics of case spaces.

Subjective Assessment

The study of soundscape for enclosed spaces is necessary for the improvement of the acoustic conditions of living environments. There are many studies concentrating on the objective and subjective aspects of sound by using various methodologies. The main purpose of such studies is to search the effects of different types of sound or noise on humans and on their living conditions. Human health and well being is the main concern.

There are many surveys used by researchers that focus on various aspects of subjective assessment of sound or noise. Multidisciplinary studies would best conclude upon widely expected results and palpable universal assessment tools like questionnaires or semantic surveys. Studies regarding this issue also underline that; the meaning based on auditory perception should be put into concepts by surveys where social science takes place (Schulte-Fortkamp, 2009). The relation between the environmental sound and how people perceive it should be discussed by several case studies. The attention should be gathered on the context of sound and the psycho-

acoustic measurements that would lead to specific assessment tools where a common terminology is put together. The basic approach should be to identify between methods that focus on concepts of sound perception, acoustic comfort and noise annoyance. Current studies talk about these concepts in a mixed way and as a result, they often do not relate with each other and each party tries to progress through their own methodology type.

The studies on how to create a method to better manage the sound environments and how to assess and classify soundscapes, as the individuals and society perceive them, are crucial. In such studies, three categories are introduced to analyse the sound environment, including sound source, sound and soundscape descriptors (Davies et al, 2009b). Other similar studies try to explore the expectations from a sonic environment by the questions including: does it sound as you expected? How did you experience this place or similar places before? It has been noted that expectation analysis leads better understand expectations of the users (Bruce et al, 2009).

The aim of one important study carried by Axelsson et al (2009) is to develop a classifier for good or bad soundscapes. The study presents the preliminary version of the questionnaire which includes, identification of perceived sound sources, binary classification of soundscape quality on a good-bad scale and qualitative measurement of a set of perceived soundscape attributes defined in a two-dimensional pleasantness - eventfulness measurement model. Such a research is very crucial as it can lead to a more universally accepted subjective assessment models and tools. This working group, ISO/TC 43/SC 1/WG 54, is working on 'perceptual assessment of soundscape quality'. The aim is to form some questionnaire techniques that could be applicable to assess perceived quality of soundscapes.

Built Entity Aspects

The aspects of the built entity are discussed under three main topics, the pre-defined function of the space, its users and the architectural elements and details of the enclosure. In studies regarding with the enclosure, there are several important factors that have been found to be crucial. First of all analysing the built entity through all aforementioned factors is needed (Dokmeci and Kang, 2010). In particular, the architectural analysis of an enclosure is directly related with the acoustic formations and highly effectual on its soundscape.

There are several important features that have been studied so far, which are found to be somehow significant with the enclosure's acoustic totality. This includes complexity of the interior volume shapes, and differences in room volume, size and surface characteristics (Sumarac-Pavlovic and Mijic, 2007).

Although each study concentrating on the acoustic formations within large and complex volumes present in the literature is significant in its own field, generalisations and approximations seem to be the final conclusion.

INDOOR SPACE SOUNDSCAPING

In order to begin studying the sound environment of an enclosure with the soundscape approach, firstly the methods in urban soundscape research should be well understood. Urban acoustic studies or urban soundscape research have its own methods that is somehow similar yet in many areas different than the methods of room acoustics or architectural acoustics.

The four main factors concentrated in this study are shown in Figure 2.

The first factor is the objective criteria. It should be noted that, objective measurements and analysis totally depends on the space type so should be handled together with the spatial factors. The acoustic parameters and how they are measured or defined are different for urban/open and enclosed space types. Similar factors for both space types are the ones related with sound/noise itself, such as energy, duration and the frequency composition of the signal (Premat and Aubree, 2005). The tonal components are also found to be crucial (Brambilla and Pedrelli, 1996).

The subjective assessments are usually accomplished by noise surveys or acoustic comfort questionnaires. The integrity and intend of the questions vary by the space, source type and user profile. The assessment of auditory perception, noise annoyance and acoustic comfort should be handled separately, as each refers different areas and their assessment criteria should be diversified. For auditory perception, sound identification, sound preference, and change in exposure are some basic criteria to focus. In the area of noise annoyance assessment, criteria as level of annoyance and noise composition should be delved. As for acoustic comfort, positive-negative effects of sounds, the level of articulation and speech intelligibility (SI) are more important. Speech intelligibility and articulation tests may be used to gather further information, yet in such cases, the function of the enclosure and demand of the users and usage should be highlighted.

The third issue to be focused is the spatial factors as, the function of the defined or case space, its user profile that directly affects its soundscape and also acts as the perceiver, and the architectural components and characteristic influencing the acoustic formations within the enclosure. The function of an enclosure is defined and at the same time influenced by its entitlement within the built environment, the separate unit usage of its interior space and the users actions that is motivated with the space integration. As the users of a space are both sound sources and receivers, their attitude, personality, demographic properties and situation within the space are very influential in regards with their being as a source and receiver. Yet, the user and function of a space are not the only important criteria to be addressed under spatial factors. The main importance is on the architectural characteristics of the built entity. Its formal organisation, the relations between spaces and the circulation pattern of the interior space are crucial to analyse the acoustic formations and the sound environment within the space.

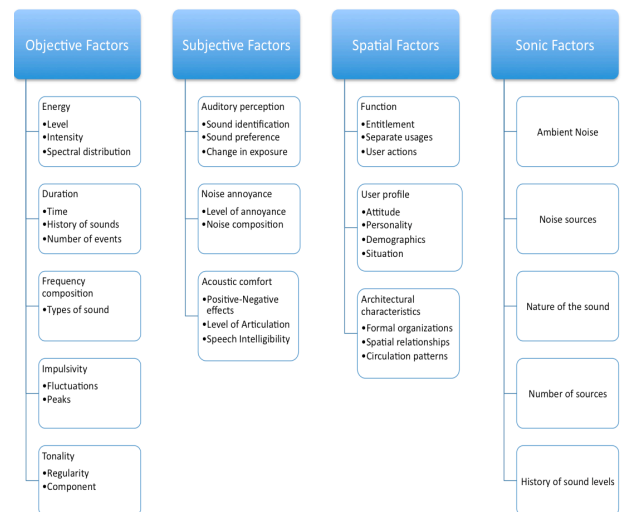


Figure 2: Factors to include in a soundscape study.

The fourth important factor is the sonic environment and how to characterise or analyse it. Criteria that should be included are mainly, the ambient noise present in the space, the separate noise sources, the nature of each different source or sound, the number or presence and the weight of sound sources and the history of the sound environment (Premat and Aubree, 2005, Guski, 1998). Such factors should be handled in close contact with the objective factors as both objective and sonic factor guide and give clues about one another.

CONCLUSIONS

The experimental and qualitative case studies should be the main focus driven from the previously assessed classifications and be rooted upon the logic and knowledge of such research. Methodologies structured in a very precise manner, laying out correlations that would lead to the assessment of useful soundscape parameters should be defined. In addition, a framework putting forth the multi-directional relation between the aspects of objective analysis, subjective assessment and the built entity should always be preserved. The influential factors including objective, subjective, spatial and sonic aspects should be defined and addressed before and during an indoor soundscape study.

While in this paper the framework is presented briefly, in the conference presentation more detailed analysis will be included.

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