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Reporting physical parameters in soundscape studies

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Most reports on soundscape studies concentrate on the perceptual aspects of the experiment. It is therefore difficult to extract generic knowledge from these studies due to the lack of a physical description of the situation. A number of soundscape scientists have responded to a small survey and reported on both what kind of measurement procedures they are currently using, and on what kind of data (acoustical and non-acoustical) they would like to see in other studies.

Binaural recordings are preferred by many of the respondents, but these recordings are only used for subjective lab assessments and comparative studies. They are not used for any objective measurements or analysis. Simple mono recordings are used to measure standard acoustical parameters like level, level distribution, loudness, roughness, sharpness, etc. The paper will not discuss the relevance of these parameters.

Some of the soundscape data requested by the survey respondents can only be found and assessed subjectively, for instance identification of sound sources, signal to background level for individual sources, etc. A proposal for minimum requirements for reporting physical parameters, and in particular acoustical parameters, in soundscape studies will be discussed.

1. Introduction

Most reports on soundscapes suffer from a lack of a good physical description of the soundscape that has been studied. Environmental noise studies are usually accompanied by detailed physical measurements of relevant acoustic parameters such as level (instantaneous or accumulated), frequency, temporal pattern, etc. Most noise researchers know from experience which parameters should be reported, and there are several "good practice guides" or "recommendations" on how to report on environmental noise studies.

A similar situation does not exist in the soundscape arena. Up until now most of the soundscape work has been carried out by non-acousticians. Therefore most of the reports concentrate on perceptual aspects of the studies, and a good physical description of the situation is often lacking.

This paper discusses the relevance of different acoustical parameters in connection with soundscape studies and recommends a list of physical parameters that should be reported.

2. Why measure?

A key question when reporting a scientific experiment is: can it be repeated? And when repeating an experiment it is absolutely necessary to duplicate the original setting as closely as possible. In order to do so, it is important that all "relevant parameters" are described or quantified in a way that is meaningful and that can be controlled.

The objectives for many soundscape projects are to "improve" or "enhance" a certain situation. In order to do so the "soundscape designer" needs to know which are the elements that warrant a "good" soundscape and which elements should be avoided. This knowledge can be found by studying previous soundscape projects, but only if these projects have been properly reported with sufficient data. This process of analyzing an existing case in order to synthesize a new case is a classical engineering approach. This type of procedure requires sufficient relevant data.

The soundscape concept is often applied to a special situation that someone wants to preserve for posterity. The idea is that *this soundscape is so unique* that it should be protected and preserved for future generations. Again it is necessary to measure. Without a very exact and detailed description of the soundscape that should be preserved, it is not possible to guaranty that after some time you still have the same soundscape. How much has a certain parameter deviated from its original value? Are the changes small enough to be defined as insignificant, and hence the present soundscape can be considered identical to the former one.

3. What is being measured?

Assessment of environmental noise is highly dependent on physical parameters like level, frequency, temporal pattern, etc. Noise assessment deals with *dissatisfaction.* However, there is a growing understanding that assessment of *preference* or *satisfaction* which is usually the case for soundscape assessments is unlikely to be primarily determined by physical dimensions of the sound [1, 2].

Preference of a soundscape seems to depend on the presence (and/or absence) of certain types of sounds, and less on the level of these sounds [3].

Several scientists [4, 5, 6] report that they measure or calculate psycho-acoustical parameters such as loudness, roughness, sharpness and fluctuation strength, for their soundscape analysis. Such parameters may be meaningful for characterizing short periods (less than one minute) of a single dominating sound, but they seem to be less useful when applied to longer periods with more than one type of sound source [7].

Brown [1] claims that there is little evidence to date that these parameters help explain human preference for outdoor sound environments, or improve the correlation between physical measures of the sound and assessed human preference.

Some scientists [6, 8] report that they routinely make binaural recordings as part of their soundscape studies. Such recordings may be useful for subjective comparisons or for "transferring" the real soundscape into a laboratory setting. However, the same scientists give no information about how these binaural recordings can be used to quantify certain properties or parameters of the soundscape. Binaural recordings thus seem to be of little or no value when searching for objective ways to classify and quantify soundscapes and soundscape parameters.

One type of measurements that seems to be widely used is the fluctuation of the instantaneous sound level characterized by percentile levels: L_5, L_{10}, L_{50} etc. The definition of these metrics is somewhat ambiguous. L_5 usually denotes that level that is exceeded 5 percent of the time, but sometimes it is also used to identify the opposite: the level that is exceeded 95 % of the time.

Some authors apply the percentile calculations to the total soundscape, whereas others prefer to use percentiles to characterize the presence of separate sound sources [7, 9]. People seem to categorize and assess urban soundscapes by source when specific sound sources can be isolated, and by the presence or absence of specific sounds where many sources contribute to the background [10]. This means that soundscapes first need to be assessed subjectively and relevant semantic features must be identified, and only then can quantifiable acoustic parameters be assigned to separate features [1]. The percentile levels can be applied to separate sources, but this requires very accurate measurements by an experienced operator. Meaningful information seems to be the relative mix of different (wanted and unwanted) sources, rather than the absolute sound level. Thus a *quiet area* in a soundscape context is not necessarily *quiet* in an acoustical sense: an area where the integrated sound level is low, say below L_{den} 45 dB.

4. What to measure

Environmental noise issues deal with *unwanted sounds* and *sounds of discomfort*. These sounds can be described in an integrated manner. In soundscape studies the focus is on *wanted sounds* or *sounds of preference.* An appropriate description of soundscapes could therefore be a description (listing) of sources, both wanted and unwanted, and a report on their relative audibility: for how long and how loud do they appear and to what extent are the wanted sounds masked by the unwanted ones. Davies et al [11] states…*soundscape assessment relies upon the identification of the sounds, the prominence of the sound, and potentially the ratio of certain sound types to other sound types within the soundscape.*

Nearly all acoustic environments outdoors will consist of sounds from many sources and also many different types of sources. The soundscape should be disaggregated and each source or group of similar sources should preferably be treated separately.

A soundscape is usually, but not always, associated with a "place" (physical location), and it is possible to construct an imaginary border around the area that represents the soundscape. One should distinguish between sound sources located within the "soundscape area" and sounds coming from sources outside this area. The sound from "local" sources, for instance a water fountain, will vary in level and direction depending on the location of the observer ("within the soundscape"), whereas sounds from "external sources", for instance distant road traffic, will appear more stationary both in level and direction. The location of the observer "within the soundscape" with respect to outside sound sources is therefore less critical.

Spatial hearing, the ability to locate a specific source in a wide sound field, improves the signal-to-noise ratio, and thus reduces masking. In addition to a list of the sources, a map with the location (direction) of each source is therefore recommended.

Some soundscapes vary considerably over time and space. Long term average values have little or no meaning. It is therefore necessary to report the situation for specific time periods and, if necessary, also for different listening locations.

4.1 Useful information

A report on a soundscape study should of course describe the outcome of the study in relation to a specific activity. Note that the same physical soundscape can be experienced or assessed very differently depending on the activity or expectations of the user/observer.

In addition we would recommend that a report on a soundscape study comprises the following information about the acoustic properties of the soundscape. If deemed

appropriate this information should be provided for all relevant listening positions (different locations "within" the soundscape):

- Diurnal patterns of hourly sound level distribution (Lmin, L90, L50, L10, Lmax, etc.).
- A list of the sound sources that can be identified (type and location)
- Characteristics of the sound source (spectrum, impulsiveness, etc.)
- For selected hours the level distribution for separate sound sources (Lmin, L90, L50, L10, Lmax, etc.).
- For selected hours audibility times of the sources. For how long periods is the sound audible?
- Which sounds act as maskers, and which sounds are masked by other sounds?
- Which sources seem to be dominating, and which sources contribute mostly to the background noise?

4.2 Other considerations

As can be seen from the list above a number of the parameters rely on a combination of objective measurements and a subjective assessment of what to measure. Several attempts have been made to develop "intelligent" measuring systems but so far these have not been very successful.

The list of information that should be reported is not comprehensive. Some researchers like to include binaural recordings, sometimes in combination with video recordings. Again, such recordings can only be used for "second hand subjective assessments". There are so far no methods or procedures for an objective analysis of these recordings.

References

1. Brown, A L: A review of progress in Soundscapes and an approach to soundscape planning, *International Journal of Acoustics and Vibration* (in press, 2012)
2. Raimbault, M and Dubois, D: Urban soundscapes, experience and knowledge. *Cities,* vol 22: pp339-350, (2005)
3. Brambilla, G and Maffei, L: Response to noise in urban parks and in rural quiet areas. *Acta Acustica united with Acustica,* vol 92 (6), pp 881-886, (2006)
4. Genuit, K and Fiebig, A: Need for Standardization of Psychoacoustics, *Proc. Noise-Con 2010,* 19-21 April 2010, Baltimore, MD, US.
5. Rychtarikova, M and Vermeir, G: Soundscape categorization on the basis of objective acoustical parameters, *Applied Acoustics,* 21 Feb 2011 (on line), in press.
6. Schulte-Fortkamp, B: The tuning of noise pollution with respect to the expertise of people's mind, *Proc. Internoise 2010,* 13-16 June 2010, Lisbon, Portugal
7. Lavandier, C: Private communication, IUT de Cergy Pontoise, 2012
8. Axelsson, Ö: Private communication, Stockholm University, 2012
9. Miller, N: Private communication, Harris Miller Miller & Hanson, Inc., 2012
10. Dubois, D, Guastavino, C and Raimbault, M A: A cognitive approach to urban soundscapes: using verbal data to access everyday life auditory categories, *Acta Acustica united with Acustica,* vol 92, pp 865-74, 2006
11. Davies, W, Adams, M, Bruce, N, Marselle, M, Cain, R, Jennings, P, Hall, D, Irwing, A, Hume, K and Plack, C: The positive Soundscape Project: a synthesis of results of many disciplines, *Proc. InterNoise2009,* Ottawa, Canada