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A field study on the subjective evaluation of soundscape

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Researches on soundscape are focused on the interactions among the sound source/s, the environment and the receiver/s. While the effects of sound sources and sound environment are relatively easily described by objective means, the subjective nature of human perception, which depends on sociological, psychological and cultural factors, creates the main challenge. This paper is a study on the subjective evaluation of soundscape aiming to create a basis to be used in further soundscape researches. A survey form consisting of two parts; a questionnaire and a semantic differential test, is prepared. The questionnaire part covers categories such as; personal information, usage of field, concordance with the expectations and sound environment evaluation, aiming to investigate the pleasantness of soundscape. Semantic differential test is utilized to examine the quality of sound environment. The pairs of adjectives, which are used in the semantic differential test, are selected accordingly to both the vernacular language of the related community and the soundscape literature. Data held from the field study, which is realized in four areas, is statistically analyzed and the soundscapes of the areas are subjectively evaluated. The information obtained from this study will be used to progress in the next stage which is laboratory studies.

1 Introduction

The word 'soundscape' was first introduced by Schafer [1] to denote an auditory equivalent to landscape, defined as an environment created by sound, without any judgment about what we hear. Schafer [2] categorized the main themes of a soundscape as keynotes (the basic sounds of the landscape created by its geography and climate), signals (foreground sounds which are surprising, sudden or annoying) and soundmarks (sounds by which one can identify a place).

The observation of the insufficiencies of the methods, associating acoustical comfort to the sound level (mainly LAeq) lead soundscape studies gain increasing importance in the evaluation of urban noise. Soundscape concept treats the sound environment as a multi-dimensional entity, based on the complex interaction between sound source, physical environment and human being. While the effects of sound sources and sound environment are relatively easily described by objective means, the subjective nature of human perception, which depends on sociological, psychological and cultural factors, creates the main challenge. Derivations of objective and subjective data from field and laboratory studies, and attempts of correlating these data, are the common features of the soundscape studies. The flow diagram (Figure 1) derived after a widespread examination of soundscape literature summarizes the main scheme of soundscape studies. On the other hand the review of the related literature shows that there is not a common reconciliation about the properties of the subjective and objective data, the methods of data collection and evaluation, the statistical methods to be used in the correlation.

Therefore, a wide-frame study aiming to develop an approach based on soundscape for the evaluation, conservation and rehabilitation of acoustical comfort in urban areas, is planned and realised. The hypothesis of this study is that **“soundscape quality may be judged depending on its components (keynotes, signals, soundmarks), and moreover the perceptibility of the soundmark may be an important factor on the evaluation”** as observed from the previous studies realised by the authors [3-6]. In this study, in-situ measurements (sound level measurements, binaural sound recordings) and sound quality metrics are defined as the objective data, and pairs of adjectives suitable for describing the sound environment (obtained by semantic differential test), surveys (questionnaire, semantic differential test), jury and listening tests are obtained as the subjective data.

This paper gives a summary of the first part which covers the selection of the pairs of adjectives, field studies (in-situ sound measurements, surveys, binaural sound recordings) and the analysis of the subjective data of the mentioned wide-frame study.

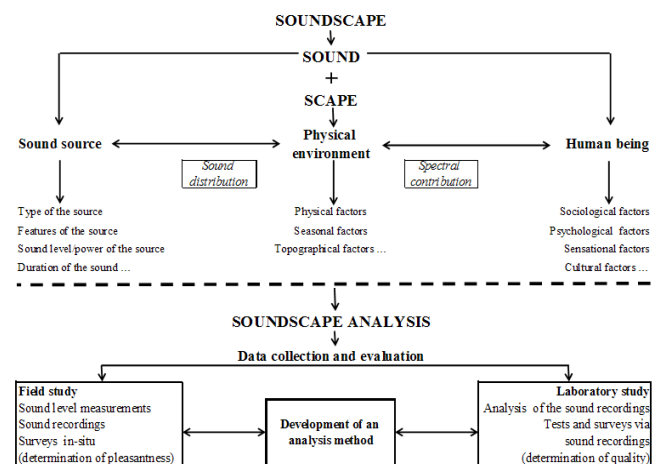


Figure 1. The complex interaction among sound source, physical environment and human being, at the soundscape researches

2 Selection of the pairs of adjective – Semantic differential test

Semantic differential test is utilized to examine the quality of sound environment as the common technic used for subjective evaluation in soundscape researches. In this test, subjects are expected to judge the sound by means of pairs of adjectives using a given scale. There are two basic issues in the selection of the pairs of adjectives; the adequacy to the cultural, sociological, linguistic formations (vernacular language) of the related community, and the capability to describe the concerned sound environment.

In this context, the pairs of adjectives are listed according to the soundscape literature [7-17], and are translated in Turkish considering the national researches related to the adjectives [18-20], as well as the findings of pilot studies realized by the authors [3-6] as a part of the wide-frame study. 30 pairs of adjectives selected to be used for the study are determined in English (EN) and in Turkish (TR) as listed below (Table 1).

Table 1: Selected pairs of adjectives (EN and TR versions)

Pairs of adjectives	
EN version	TR version
Quiet – Loud	Sessiz / Gürültülü
Pleasant - Unpleasant	Memnuniyet Verici / Mem. Verici Değil
Comfortable - Disturbing	Rahatlatıcı / Rahatsız edici
Stressing – Relaxing	Stres Yaratici / Dinlendirici
Artificial – Natural	Yapay / Doğal
Calming - Agitating	Yatıştırıcı / Heyecanlandırıcı
Boring - Exciting	Sıkıcı / İlgi Çekici
Preferred - Not Preferred	Tercih Ederim / Tercih Etmem
Open – Enveloping	Açık / Sarmalayıcı
Harmonic - Discordant	Ahenkli / Ahenksiz
Soft - Hard	Yumuşak / Sert
Sharp – Not Sharp	Keskin / Keskin Değil
Crowded – Uncrowded	Kalabalık / Tenha
Organised – Disorganised	Düzenli / Düzensiz
Nearby – Far Away	Yakın Plan Ses / Uzak Plan Ses
Continuous - Discontinuous	Devamlı / Devamsız
Steady - Unsteady	Monoton / Değişken
Calming - Eventful	Sakin / Hareketli
Lively – Deserted	Yaşayan / Terk Edilmiş
Joyful – Empty	Neşeli / Durgun
Exciting – Gloomy	Coşturucu / İç Karartıcı
Weak - Strong	Zayıf / Güçlü
Soft - Loud	Yavaş / Hızlı
Dark -Light	Boğucu / Ferah
Muffled - Shrill	Boğuk / Net
Dull - Sharp	Donuk / Keskin
Light - Heavy	Hafif / Ağır
Smooth - Rough	Pürüzsüz / Pürüzlü
Unclear – Distinct	Karışık / Ayırtedilebilir
Common – Strange	Alışılmış / Farklı

3 Field study

Researches on soundscape are mostly realised on urban spaces such as residential area, squares and parks, open market places, playgrounds etc. Urban squares and streets which are transit crossing and/or recreational spaces of the urban life, and which have specific sound environment due to the diverse range of sound sources and the physical environment, are selected for this study to analyse urban acoustical comfort.

3.1 Study areas and sound environments

Four urban areas in Istanbul; two pier squares in Bosphorus (Beşiktaş and Ortaköy) and two streets (Barbaros in European and Bağdat in Asian side of Istanbul) are chosen to be studied. Following issues are considered in the selection;

- LAeq levels over the acceptable limits
- Soundscapes' reflect the urban identity.
- Soundscapes' are judged as having different acoustical pleasantness (having a pleasant soundscape or not).

Sound sources that form the soundscape in selected areas are listed (Table 2), and soundmarks are determined (Table 3) by the observations on site, interviews with citizens and findings of in-situ pilot studies. Previsions of the acoustical satisfaction are introduced by considering the

soundmarks' perceptibility, preponderancy and continuity in time, spatial effects and familiarities.

Table 2: Main characteristics of soundscape in selected areas

Study areas	Sources that form the soundscape
Beşiktaş Pier Square	Dense traffic and sea transportation through Bosphorus Piers, bus and taxi stops Functional diversity in square Commercial hails as a type of sales approach
Ortaköy Pier Square	Sea transportation through Bosphorus Pier and mosque Functional diversity in square Commercial hails as a type of sales approach
Bağdat Street	Dense traffic (public transportation, luxury and modified cars) Music broadcast from the cars Pedestrian, bycles and buggies Functional diversity at street Commercial music broadcast
Barbaros Boulevard	Dense traffic Urban park near the street Student activities due to the proximity of the street to the university campus and highschool Functional diversity at street

Table 3: Determinations of the soundmarks and previsions of the acoustical satisfaction

Study areas	Soundmarks	Prevision of the acoustical satisfaction
Beşiktaş Pier Square	traffic and sea transportation noise, sounds from the pier, sounds of wind, sea/wave, birds, sale approach (commercial hails) and voices	Unsatisfactory
Ortaköy Pier Square	sea transportation, sounds from the pier, sounds of wind, sea/wave, birds, shopping, Ezan, sale approach (commercial hails) and voices	Satisfactory
Bağdat Street	traffic noise, sounds of children and shopping, music and voices	Unsatisfactory
Barbaros Boulevard	dense traffic noise, siren and voices	Unsatisfactory

3.2 Sound measurements and binaural sound recordings

Soundwalk method providing the binaural sound recordings is used for this study in order to evaluate the soundscapes of the selected urban areas. The soundwalks are done;

- at the season having suitable climate conditions to acquire high quality binaural recordings
 - on the day the sound environment exemplify the identity of the area
 - at the time interval where predicted soundmarks are present.
- Photos are also taken to conserve the visual memory of the spaces.

Binaural recordings and measurements of overall sound levels are simultaneously obtained. In the walks which lasted approximately 15 min., the routes for soundwalks are determined in order to have a general opinion about the sound environments of the selected areas, by considering how citizens act in these areas in their daily life (Figure 2).



Beşiktaş Pier Square



Ortaköy Pier Square



Bağdat Street



Barbaros Boulevard

Figure 2. Routes of the soundwalks in the selected areas

3.3 The survey on-site

A survey form is prepared in order to be used for the studies on the subjective perception and evaluation of the soundscape. Questions in survey are gathered from soundscape literature and rearranged in consequence with the findings of mentioned pilot studies to obtain fast/practical, reliable and compatible subjective evaluation on site.

The survey form is composed of two parts; a questionnaire part where the general information about sound environment with the soundmarks and their pleasantness are investigated; and a semantic differential test where the quality of sound environment is analyzed. The questionnaire part consisted of 16 questions on the categories listed below;

- Personal information (sex, age, education, job, existence period in Istanbul, precision to the environmental sound sources, noise sensitivity).

Answers were to be given at multiple-choices.

- Area usage (density of the area usage, frequency of visiting the area, time spent in the area, reasons of coming to this place).

Answers were to be given at multiple-choices.

- Congruity of the physical environment to the respondents expectations (general judgment, listing the several environmental factors -given as landscape, scenery, vegetation, cleanliness, safety, clean air, silence, odour, functional structure, location, ratio between constructed and circulation/recreational areas, building heights, historical / touristical value, sales approach, social aspects, entertainment structure-; according to priority on the perception of area and their congruity to the respondents expectations)

Answers were to be given on a five-point bipolar category scale with the response alternatives 'Very congruous (5)', 'Neutral (3)', 'Very incongruous (1)'.

- Sound environment evaluation of the area (determination of soundmark/s of the area and the satisfaction from the soundmark/s).

- General assessment of acoustical environment

Answers were to be given on a five-point bipolar category scale with the response alternatives 'Very good (5)', 'Neutral (3)', 'Very bad (1)'.

- Determination of soundmarks from the listed sound sources classified under the three types of sound source heard predominantly in the areas (nature, human and technological sound sources).

Answers were to be given at double-choices (yes or no).

- The satisfaction of the listed sound sources which are defined as 'soundmark' by respondents.

Answers were to be given on a five-point bipolar category scale with the response alternatives 'Very satisfactory (5)', 'Neutral (3)', 'Very unsatisfactory (1)'.

In semantic differential test, the selected 30 pairs of adjectives are used to determine acoustical pleasantness in detail. For each selected areas, 30 surveys are done by 120 citizens who are randomly selected on-site and have no hearing problems.

4 Subjective data analysis

Subjective data held from the field study which is realized in four areas, is analyzed by using statistical software SPSS 18. Statistical reliability is calculated for each data on a percentage basis according to Cronbach's Alpha value which necessitates the percentage rate over %60, referring the reliability of data in interest. This value is %79 for the survey; %63 for the questionnaire part and %86 for the semantic differential test.

The responses given for the reasons of coming to the related spaces are congruent with given frequency of visiting the area and the time spent in the area.

In general, respondents are satisfied with the physical environment of the areas (%53 in Beşiktaş Pier Square, %67 in Ortaköy Pier Square, %93 in Bağdat Street and %63 in Barbaros Boulevard).

Through the listed environmental factors, 'silence' is defined as incongruous with the respondents' expectations in all areas except in Ortaköy Pier Square. This evaluation is also noted from the general assesment of acoustical environments, accordingly Ortaköy Pier Square is assessed as 'good' with %57; and the others are assessed as 'bad or very bad'; Beşiktaş Pier Square with %57, Bağdat Street with %60 and Barbaros Boulevard with %70 by the respondents. 'Sales approach' directly affecting the sound environment is defined as congruous in the streets and as incongruous in the pier squares because of the commercial hailes between sellers and purchasers.

Answers given to determine the soundmark/s of the area/s and the satisfaction from the soundmark/s can be summarized as follows;

- 'Traffic noise' and 'horns' are defined as soundmarks which also were defined as 'unsatisfactory' in correspondence with the predictions, in all of the selected areas except Ortaköy Pier Square.
- In the squares (Beşiktaş and Ortaköy Pier Squares), there are several and diverse sound sources from all types (especially the nature sounds). The nature sounds are defined as satisfactory soundmarks in both of the area; because of the absence of traffic noise in Ortaköy, more number of them is heard predominantly in the square. 'Voices' which is one of the most significant soundmarks in the squares is defined as 'satisfactory' in Ortaköy and 'neutral' in Beşiktaş. 'Commercial hails' is defined as unsatisfactory soundmark in both of the area. 'Sound of Ezan' and 'sound of shopping' are also defined as soundmarks in Ortaköy differently from Beşiktaş, which are assessed as 'satisfactory'.
- In the streets (Bağdat Street and Barbaros Boulevard), several types of sound sources except the nature sounds, are perceived in the sound environment; however, most of them

are defined as 'unsatisfactory'. 'Voices' is defined as soundmark in both of the areas, but only assessed as 'satisfactory' in Bağdat Street, besides 'sound of children', 'sound of shopping' and 'music'.

Variance analysis (valuing the Post Hoc Test after ANOVA test) is done with the data held from semantic differential test in order to investigate the relation (the similarities and/or differences) among the evaluations of sound environments. Pairs of adjectives showing statistical significance are found by using the results of this analysis.

According to the evaluation of this analysis; all pairs of adjectives; except 'Crowded – Uncrowded', 'Continuous – Discontinuous', 'Muffled – Shrill', 'Dull – Sharp', 'Unclear – Distinct' and 'Calming – Eventful', denote significant statistical differences regarding selected sound environments. Considering the differences between the sound environments upon the pairs of adjectives, the results can be listed as below;

- The evaluations of all of the sound environments represent a significant difference upon 'Preferred - Not Preferred'.
 - The sound environments of;
 - Beşiktaş Pier Square, upon 'Open – Enveloping',
 - Ortaköy Pier Square, upon 17 pairs of adjectives which are 'Quiet – Loud', 'Pleasant - Unpleasant', 'Comfortable – Disturbing', 'Stressing – Relaxing', 'Artificial – Natural', 'Calming – Agitating', 'Boring – Exciting', 'Harmonic – Discordant', 'Soft – Hard', 'Sharp – Not Sharp', 'Joyful – Empty', 'Exciting – Gloomy', 'Soft – Loud', 'Dark – Light', 'Light – Heavy', 'Smooth – Rough' and 'Common – Strange',
 - Bağdat Street, upon 'Sharp – Not Sharp', 'Steady – Unsteady', 'Soft – Loud' and 'Smooth – Rough'
- are evaluated as different due to the other environments.

5 Review

A wide-frame research is realised in order develop an approach based on soundscape for the evaluation, conservation and rehabilitation of acoustical comfort in urban areas. The hypothesis of this study is determined as; "soundscape quality may be judged depending on its components and the perceptibility of the soundmark may be an important factor on the evaluation".

In this paper the field study part of the above mentioned wide-frame reseach is presented. The objective of this part is to create a basis to be used in further soundscape researches. The selection of the pairs of adjectives, in-situ sound measurements, surveys, binaural sound recordings and the analysis of the subjective data are the steps of this part.

30 pairs of adjectives (given in Table 1) are selected and used in the semantic differential test. Subjective data held from the field study is analyzed by using statistical software SPSS 18. Statistical reliability is checked for each data on a percentage basis according to Cronbach's Alpha value. 24 pairs of adjectives showed statistical significance after variance analysis (valuing the Post Hoc Test after ANOVA test). The evaluation of the data showed that the soundscapes can be discriminated by using appropriate pairs of adjectives. Consequently the steps of the selection of the pairs of adjectives had been clarified by the studies realized in this part of the research. On the other hand, the soundmarks of the areas are highlighted by the questionnaire part of the survey. The information obtained

from this part of the research is used in the laboratory study part which is presented in another paper.

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