UNDERSTANDING SOUNDSCAPE IN PUBLIC SPACES: A CASE STUDY IN AKKÖPRÜ METRO STATION, ANKARA

A Master's Thesis

by

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Interior Architecture and Environmental Design

İhsan Doğramacı Bilkent University

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UNDERSTANDING SOUNDSCAPE IN PUBLIC SPACES: A CASE STUDY IN AKKÖPRÜ METRO STATION, ANKARA

Graduate School of Economics and Social Sciences
of
İhsan Doğramacı Bilkent University

by
ZEYNEP BORA

In Partial Fulfillment of the Requirements for the Degree of
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in

THE DEPARTMENT OF
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İHSAN DOĞRAMACI BİLKENT UNIVERSITY
ANKARA

January, 2014

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Interior Architecture and Environmental Design.

(Assoc. Prof. Semiha Yılmazer)

Supervisor

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Interior Architecture and Environmental Design.

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ABSTRACT

UNDERSTANDING SOUNDSCAPE IN PUBLIC SPACES : A CASE STUDY IN AKKÖPRÜ METRO STATION, ANKARA

Zeynep Bora

MFA in Interior Architecture and Environmental Design

Supervisor: Assoc. Prof. Semiha Yılmazer

January, 2014

In 2008, a working group of ISO/TC 43/SCI/WG 54 "Perceptual Assessment of Soundscape Quality of the International Organization for Standardization" was established and they published the first part of standardization "ISO 12913-1 Acoustics-Soundscape-Definition and conceptual framework" In their framework the acoustic environment divides into two main categories according to places; indoor and outdoor acoustic environment. The working group ISO/TC 43/SCI/WG 54 is being to standardize the methods and parameters of soundscape quality outdoors and point out both the negative and positive aspects of sounds environment as perceived by people. Besides the soundscape quality outdoors, indoors are also needed to be studying in the field. This study has been designed to understand the indoor acoustic environment of the metro station which is chosen as a public space. Aim of this study is to find out both negative and positive aspects of indoor acoustic environment as perceived by users in metro station. In order to compare outdoor and indoor soundscape qualities, Akköprü Metro Station and its immediate surrounding were chosen as a case study in Ankara, Turkey. The park shared the same environment with metro station was chosen as an outdoor environment/open public space. Entrance of the metro station was chosen as a semi open public space and the platform of the metro station was chosen as an indoor environment/enclosed public space. Within "a degree of enclosure" context, objective, subjective and psychoacoustics parameters for soundscape quality were measured in three spaces. As *objective parameters,* A-Weighted Equivalent Continuous Sound Levels (LeqA), Sound Pressure Levels" (SPL), Reverberation Time (RT), Speech Transmission Index (STI) were measured. For *subjective parameters,* sound recordings were taken with soundwalk method and noise annoyance surveys were applied simultaneously. A listening test and a survey were prepared to understand if spaces could be recognized/understood just by hearing. For *psychoacoustics parameters*, questionnaires were prepared and subjects were asked to fill in personal information and for each sound recording they listen, they were asked to fill in four open ended questions and choose from seventeen adjective pairs prepared with one to five likert scale. Ninety applicants participated in a listening test. Results showed that, acoustical measurements were higher than the permissible limits given in regulations. According to the noise annoyance survey results, enclosed spaces have the highest noise annoyance rating. Demographic factors such as age, gender, education level and space recognition did not showed any significant correlation. According to the listening test results, 70% of the subjects were able to determine spaces correctly as open, semi open or enclosed. Only 55% of the subjects were able to recognize the spaces. Soundmarks of the spaces show similarities. In open spaces subjects tended to choose adjectives such as "pleasant", "calming", "natural", "joyful"; while in enclosed spaces they tended to choose adjectives such as "unpleasant", "stressing", "artificial" , "empty".

Keywords: Soundscapes, soundwalk, soundmarks, noise annoyance, sound quality, auditory perception, sound recognition

ÖZET

KAMUSAL MEKANLARDA İŞİTSEL PEYSAJIN İRDELENMESİ: ANKARA, AKKÖPRÜ METRO İSTASYONU ÖRNEĞİNDE

Zeynep Bora

İç Mimarlık ve Çevre Tasarımı Yüksek Lisans Programı

Danışman: Doç. Dr. Semiha Yılmazer

Ocak, 2013

2008 yılında, ISO/TC 43/SCI/WG 54 " Perceptual Assessment of Soundscape Quality of the International Organization for Standardization- Standartlaşma için Uluslararası Organizasyondaki İşitsel Peysaj Kalitesinin Algısal Değerlendirmesi" başlıklı bir çalışma grubu kurulmuştur. Grup, standardizasyon çalışmalarının ilk bölümünü " ISO 12913-1 Acoustics-Soundscape-Definition and conceptual framework - Akustik -İşitsel Peyzaj -Tanım ve kavramsal çerçeve" başlığı ile yayınlamıştır. Akustik çevre bu çalışmada, iç mekan akustik çevresi ve dış mekan akustik çevresi olmak üzere iki ana başlığa bölünmüştür.
ISO/TC 43/SCI/WG 54 çalışma grubu, ISO 12913-1 ile, kamusal açık mekanlarda işitsel peyzaj kalitesinin yöntem ve parametrelerinin standardize edilmesi için çalışmakta ve akustik çevrenin insanlar tarafından algılanan pozitif ve negatif yönlerine değinmektedir. Ancak, açık mekanlardaki işitsel peyzaj kalitesi çalışmalarının yanı sıra, kapalı mekanlardaki işitsel peyzaj kalitesi çalışmaların da yapılması gerekmektedir. Bu çalışma, kamusal alan olarak seçilen bir metro istasyonundaki kapalı mekan akustik çevresini irdelemek üzere tasarlanmıştır. Çalışmanın amacı, metro istasyonu kullanıcılarının, kapalı mekana dair pozitif ve negatif algılarının araştırılmasıdır. Kapalı ve açık mekanların işitsel peyzajlarının karşılaştırmalı irdelenmesi için, Ankara' da bulunan Akköprü Metro İstasyonu ve yakın çevresi seçilmiştir. Mekanların kapalılık dereceleri bağlamında, açık mekan olarak istasyon ile aynı çevreyi paylaşan park; yarı açık mekan olarak istasyonun giriş katı ve kapalı mekan olarak da istasyonun platform katı seçilmiştir. Belirtilen

üç mekanda, nesnel, öznel ve psikoakustik ölçümler yapılmıştır. *Nesnel ölçümler* kapsamında; A-Ağırlıklı Eşdeğer Ses Seviyesi (LeqA), Ses Basınç Seviyesi (SPL), Çınlama Süresi (RT), Konuşmanın Anlaşılabilirliği İndeksi (STI) ölçülmüştür. *Öznel ölçümler* kapsamında; eş zamanlı olarak, ses yürüyüşü (soundwalk) yöntemi ile ses kayıtları alınmış ve gürültü rahatsızlığı anketleri uygulanmıştır. *Psikoakustik ölçümler* kapsamında, mekanların, ses kayıtlarının dinleme yoluyla algılanabilirliğinin / anlaşılabilirliğinin araştırılması üzere bir dinleme testi ve anketi hazırlanmıştır. Ankette katılımcılardan kişisel bilgiler yanı sıra, dinledikleri ses kayıtlarının her biri için dört adet açık uçlu soru sorulmuş ve likert ölçeği ile hazırlanmış on yedi sıfat çifti için bir ile beş arasında değerlendirme yapmaları istenmiştir. Doksan denek dinleme testine katılmıştır. Sonuç olarak, yapılan akustik ölçümlerde elde edilen değerler, yönetmelikte izin verilen sınırın üzerinde çıkmıştır. Gürültü rahatsızlığı anketi sonucuna göre, kapalı mekandaki gürültü rahatsızlığı, açık mekandaki gürültü rahatsızlığına göre daha fazla çıkmıştır. Deneklerin yaş, cinsiyet, eğitim durumu gibi demografik özellikleri ile mekân algısı arasında kaydadeğer bir istatistiksel ilişki gözlenmemiştir. Dinleme testi sonuçlarına bakıldığında, deneklerin %70’ inin mekanların açık/kapalı olduğunu doğru şekilde yanıtladıkları görülmüştür. Ancak deneklerin sadece % 55’ I mekanları tanıyabilmiştir. Mekanlara özgü sembol sesler (soundmarks) benzerlik göstermiştir. Deneklerin mekanlar için kullandıkları sıfat çiftleri, açık mekanda, "memnuniyet verici", "dinlendirici", "doğal" "neşeli" iken; kapalı mekanlarda "memnuniyet verici değil", "stres yaratıcı", "yapay", "durgun" olmuştur.

Anahtar Kelimeler: Ses peyzajı, ses yürüyüşü, sembol sesler, gürültü rahatsızlığı, ses kalitesi, duyumsal algı, ses tanıma

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

With the evolution of urban acoustical environment, a new term called "soundscape" has emerged. Nowadays, soundscape studies has become one of the most common topics in the field of acoustics.

During late 1960s, R. M. Schafer, composer and scholar, believed that, aural environment has been treated in an offhand manner. In early 1970s, World Soundscape Project was established with his effort. They started a series of hearing exercises based on Schafer's worries about the increased dominance of "eye culture" and the loss of the "sonological competence". He believed that, the interaction between people and the aural environment has a great importance on the human psychology. In his first study, he hypothesized that, in acoustical places, people either try to control the noise or shout it out permanently and this wall between the sound and people blocks the inner dialogue and decreases the psychological health (Lercher & Schulte-Fortkamp, 2003).

In 1977, Schafer released his most important work, "The Soundscape: Our Sonic Environment and the Turning of the World", where he summarizes his soundscape research, philosophies, and theories. The term "soundscape" was firstly introduced with these worlds;

> The soundscape is any field of study. We may speak of a musical composition as a soundscape, or a radio program as a soundscape, or an acoustic environment as a soundscape. We can isolate an acoustic environment as a field of study just as we can study the characteristics of a given landscape (Schafer, 1977: 4,7).

These studies lead him to a series of ideas that initiates the basis of the term "*soundscape*" that we understand today. Based on his studies, soundscape can be briefly explained as: any kind of natural or artificial sound, that forms the acoustical environment of a space.

Soundscape has a variable characteristic depends on regions and users; so it causes every study to resulted with different outcomes. As a reason, researchers have been focusing on this area. There are hopeful developments on the standardization of soundscapes in open public spaces. In 2008, a Working Group of ISO/TC 43/SC1 / WG 54 was established to standardize the methods and parameters of soundscape quality outdoors and point out both the negative and positive aspects of sound environment as perceived by people. They are planning to publish their work of standardization of outdoor soundscapes.

However; a standardization of soundscape methods and parameters in enclosed spaces requires more case samples from different regions in different space types. With this study, it has been aimed to increase the samples in enclosed soundscape studies and as a public space; metro stations have been aimed to be included into the literature.

1.2. Aim and Scope

This study has been designed to understand the soundscape qualities of open/semi open and enclosed spaces. Aim of this study is to compare the soundscapes of open-semi open-enclosed spaces, which share the same environment. In this respect, the park between Ankamall Shopping Mall and Akköprü metro station was chosen as open space; the entrance level of the station as a semi-open space; and the platform (landing) level of the station as an enclosed space.

The study has been conducted in two phases. In the first phase, in all three spaces (open- semi-open- enclosed); equivalent sound levels and sound pressure levels were measured and noise annoyance questionnaires were simultaneously carried out. In the second phase, sound recordings of the spaces were taken with soundwalk method proposed by Semidor (2006). In a semi-anechoic room, subjects were asked to listen to sound recordings and fill out a questionnaire. This phase was aimed to understand if spaces could be recognized/understood just by hearing. The results were compared both with each other and with older studies, in terms of demographic differences (gender, age, education and location), space recognition and auditory perceptions.

1.3. Structure of the Thesis

The study has five main chapters. Introduction gives a framework on soundscape definitions, and continues with the aim of the study and the structure of the thesis.

The second chapter "Soundscape " is divided into three main parts. Part one; "Soundscape in Open Public Spaces" gives general information about the development and current situation of open space soundscapes studies. In this part, a recently proposed taxonometric system by Brown and Kang (2011) was also described and discussed. Part two " Soundscape in Open Enclosed Public Spaces" gives general information about the development of enclosed space soundscapes studies. Last part "Acoustical parameters for soundscape" explains objective, subjective and psychoacoustic parameters under three sub-titles. The objective parameters explained under this title are Sound Pressure Level (SPL), Equivalent Continuous A-weighted Sound Level (Leq A) and reverberation time; subjective parameters are sound preferences, noise annoyance and sound recognition; psychoacoustic parameters are Loudness, Sharpness and Roughness.

The third chapter ;" Comparison Study Between Soundscape Of Open- Semi-Open and Enclosed Public Spaces" is the main chapter that gives the prior information about the study. Research questions, hypothesis and methodology; site description, methodology and results of objective and subjective measurement results were given in this chapter. Used technical equipments were described according to usage order and technique.

Results of the study were given in chapter four under two main sections; in the first section , real-size measurement results and computer simulations results were given under the title objective measurements; noise annoyance survey results, sound recordings and listening results were given under the title subjective measurements.

The five chapter is "Discussion". In this chapter, results were compared and discussed with each other and with the literature and discussion chapter is followed by the conclusion chapter which summarizes the whole study.

CHAPTER 2

SOUNDSCAPE

Some concepts and definitions are clarified following, for further understanding the context of the thesis.

Open space: "A land and/or water area with its surface open to the sky, consciously acquired or publicly regulated to serve conservation and urban shaping function in addition to providing recreational opportunities." (Marilyn, 1975)

Semi-open space: According to the Regulations of Environmental Noise Assessment, semi open space is a space type which has openings (window, door, ventilation) on at least one façade, which allows the passage of indoor sound to the outdoor environment; or spaces with at most three open façades or façades with portable/folding elements.

Enclosed space: According to the Regulations of Environmental Noise Assessment, enclosed space is a space type which all its façades are covered with construction elements (concrete, brick, glass etc.) that prevents the passage of indoor sound to outdoor environment .

2.1. Soundscape in Open Public Spaces

After World Soundscape Project (1970) and Schafer's consequent studies, a lot of studies have been conducted in this area. Researchers have focused on understanding and developing soundscapes of urban open spaces.

In 1977, Truax, who also participated in Word Soundscape Projecs, has published his book "Handbook for Acoustic Ecology" as a reference work for acoustic and soundscape terminology. In 1989, Zwicker and Fastl made a lot of contributions in the field of psychoacoustics. In their study, they suggested some metrics as a criterion to understand the limitations in A-weighted sound level in dB. From the early 1990s, Kang has become one of the prominent names in the field of acoustics and soundscape. In 2002, he published his work "Soundscape in urban open spaces" which his previous studies lead him into.

In 2004, Brown published a study explaining the differences between soundscape planning and noise control. He also mentioned the possible application areas of soundscape; with emphasizing urban open public spaces and mentioned limited on enclosed spaces (Table Q) . Besides, he claims that the noise control is mostly about indoor acoustic environment and soundscape is mostly about outdoor acoustic environment.

	Urban space	Non-urban space
Constructed and other spaces	Parks and gardens Squares Malls Dwelling and apartment precincts	Recreation sites such as ski fields golf courses Walking trails
	Pedestrianized areas	Pastoral and agricultural areas
	Sites of religious worship and meditation	Cultural sites
		Beaches
	Heritage precincts Thoroughfares Meeting places Locations for: water structures sound installations outdoor speech or music venues River banks Waterfronts Markets	National parks Wilderness

Table 1: Potential application areas of soundscape (Brown, 2004)

It is known that enclosed spaces have much more complex acoustical environment than open spaces and any kind of enclosed space (restaurants, opera-concert halls, hospitals, metro stations) should be included in soundscape studies. However, Brown wrote this article in 2004; when there was no standardization on soundscape studies and methods. So, his study is an important step on a standardization.

It should be noted that, since soundscape has a variable characteristic depends on regions and users. With this reason, despite the profusion of usages, there are still no standardized models, criteria or applications of soundscape studies. As a result, every researcher and designer has been dealing with this discipline from different approaches, so, it causes every study to resulted with different outcomes.

Based on preceding studies, several other explanations came out on *soundscapes*. In 2008, a Working Group of ISO/TC 43/SC1 / WG 54 was established to standardize the methods and parameters of soundscape quality outdoors and point out both the negative and positive aspects of sound environment as perceived by people. They are planning to publish their work of standardization of outdoor soundscapes. Yet the members of this group could not be able to agreed on the same side; some of them suggested to specify the limits of the definition of *soundscape*, while others would settle for more fuzzy definition so that it could be evolved during future work of the group. For some members, soundscape is not a separate thing but exists in other aspects; *1) A physical, mainly outdoor area/space/location('place') that can be described by a set of physical parameters such as geographical coordinates, dimensions, topography 2) A 'place' that also exhibits certain properties such as 'landscape', 'nature', man-made constructions, as well as micro climate conditions 3) A 'place' with certain acoustical parameters such as type of sound sources, levels, spectrums, temporal pattern 4) A 'place' where people (and/or other creatures) live or occasionally spend some time 5) A 'place' where people may interact with the physical environment and with each other* (Brown et.al.2011, pp.387-388).

Despite the plentitude of explanations, there is no confliction between them, and somehow, they all guide to understand how the soundscape works by integrating with each other. To sum up, the term "*soundscape*" refers to a lot of meaning; it is a physical environment itself and the context of that environment: the total collection of sounds; it is the way how people perceive and understand this physical environment: the personal knowledge and experiences.

In terms of soundscape planning, it can be seen that, it is a very similar context to noise control; they can easily be confused with each other. According to Brown (2004), these two concepts diverge on three main points;

1) First; noise annoyance and noise control in urban areas mostly deals with the highly exposed sounds that discomforts and interfere the users' daily life; the undesired acoustic situations, while soundscape and soundscape planning deals with the preferred sounds and/or desired environments.

2) Second; the diverge is seen on the application areas. Noise control progresses on three situations; either the source can be controlled, the transmission path can be controlled or the receiver can be protected. Based on this, Brown claims that the noise control mostly deals with the protection of the indoor users from outdoor noises. On the contrary, soundscape planning mostly deals with the sounds heard in open spaces.

3) As a third point, noise control sees sound as a "by-product" while soundscape planning uses the sound as a "source".

According to his explanations, the basic difference between noise control and soundscape planning occurs on the user's cognition. It is an acceptable point of view because soundscape is about the preferred sound sources and desired acoustic environment while noise control deals with the negative effects of acoustic environments.

2.1.1. Current Situation in Open Public Soundscape Studies

World Soundscape Project was a beginning for soundscape to spread all over the world and after Schafer, one of the biggest steps on soundscape came from Kihlman and Berglund, who developed the first European soundscape research program "Soundscape support to health" in 1999–2007 (Gidlöf Gunnarsson, 2008).

Following, in United Kingdom, another substantial research program "Positive Soundscape Project" was conducted between the years 2006 and 2009. (Davies et al., 2009). Those research programs ended up with the formalization of a model for measuring soundscape quality (Axelsson, Nilsson & Berglund, 2009, 2010; see also Berglund & Nilsson, 2006a; Nilsson & Berglund, 2006b). After the finalization of both research programs, International Organization for Standardization Organization (ISO) united a research group to, propose the first International Standard on soundscape.

In September 2008, a working group of ISO/TC 43/SC1/WG 54 "Perceptual Assessment of Soundscape Quality of the International Organization for Standardization" was established and the group aims to propose the first international standardization on soundscape definitions and measurement techniques. In May 2012, they published the first part of the standardization "ISO 12913-1 Acoustics — Soundscape — Definition and conceptual framework" In their first proposal, the soundscape was defined by “Acoustic environment as perceived and experienced and understood by people, in context.” (Axelsson, 2011a, 2012). The group planning to release the full standards in 2015.

While these developments emerging, individual studies were also accelerated. In 2011, two main names, Brown and Kang, became prominent with their soundscape studies and finally a taxonometric proposal on sound sources.

2.1.1.1. A Taxonometric Approach

In 2011, Brown, Kang and Gjestland suggested a taxonometric system; which can be used as a "common framework or a checklist", that classifies all the sound sources (Brown et al. 2011:389). In their framework, the acoustic environment divides into two main categories according to places; "indoor acoustic environment" and "outdoor acoustic environment", and "outdoor acoustic environment" divides into four sub-categories; "urban acoustic environment", "rural acoustic environment", "wilderness acoustic environment" and "underwater acoustic environment".

As it can be seen in the Figure 1, framework classifies the sound sources only under the "urban acoustic environment" title. Under other acoustic environments, sound sources were not classified and depicted as "ditto" which means that the same classification under the "urban acoustic environment" can be used to all other titles. They explain this situation in their article "Towards standardization in soundscape preference assessment" with these words;

> While human experience of the underwater acoustic environment may be limited, its soundscape is increasingly being revealed through underwater recordings, or by the use of real-time transducers in, for example, a whale-watching activities. One can thus refer, for example, to the acoustic environment of a wilderness place, or the acoustic environment of an urban place (Brown et al. 2011:390).

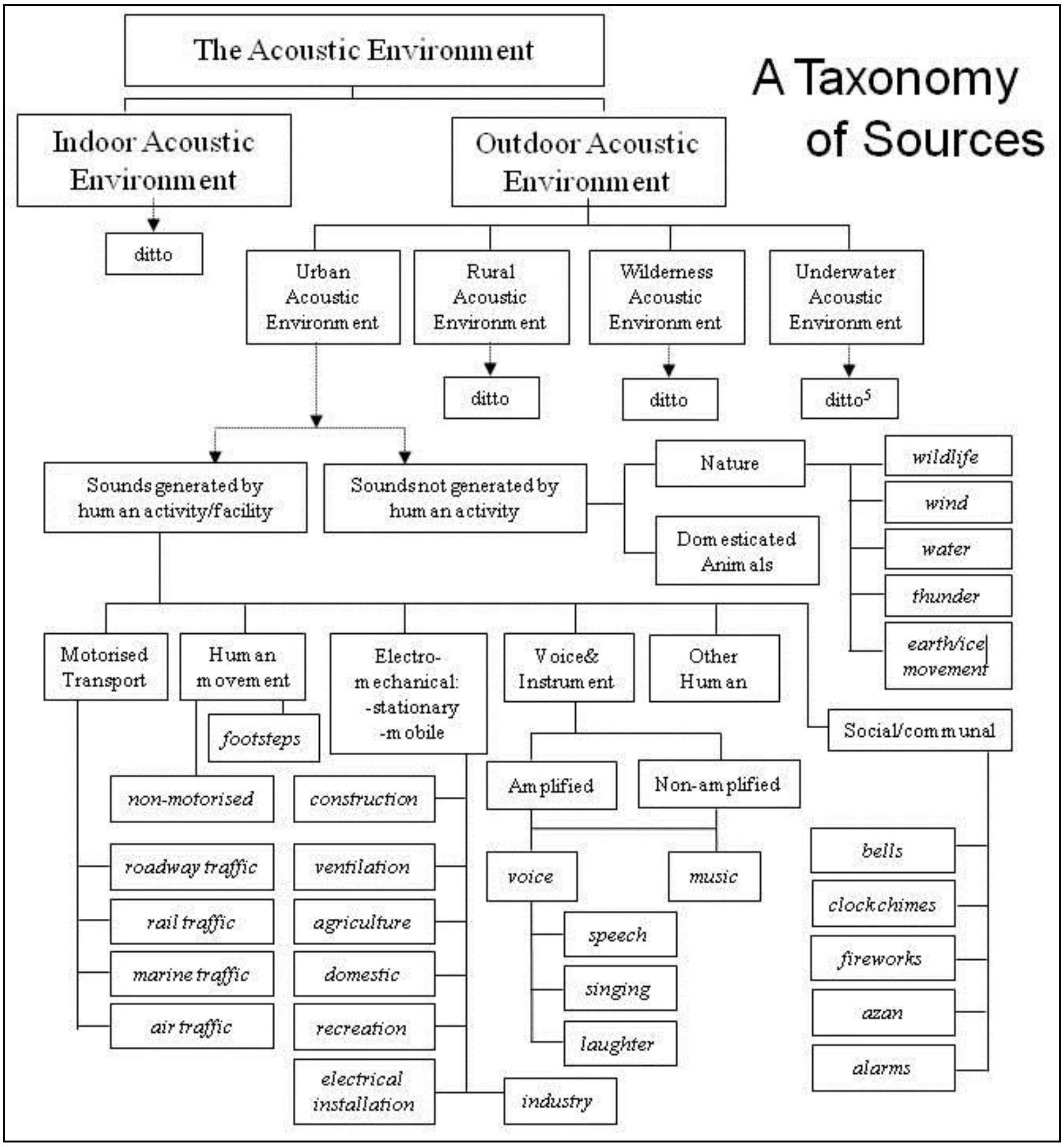


Figure 1. A Taxonomy of the Acoustic Environment for Soundscape Studies.

(Brown et al. 2011:390)

According to their explanation, the classification of sound sources of urban acoustic environment is adequate to be counted as a common framework, which all the studies under different acoustic environments can refer to it. However, with different acoustical environments; soundscapes and the sound sources that underlies also changes. Especially in indoor acoustic environment; there occurs the effect of building shapes, a great variety of finishing materials, different sound sources caused by different activities, reverberation etc. It is known that an indoor environment has much more complex acoustic quality than an open urban environment. Therefore, the classification of sound sources should be developed with more case studies by considering all types of acoustic environments.

2.2. Soundscape in Enclosed Public Spaces

Until 2000s, researchers have been focusing on the soundscape in urban environments and there has been a lack of case studies in enclosed spaces.

In 2007, with their study "Perceptual study of soundscapes in train stations", Tardieu, Susini and Poisson became prominent names on soundscape studies in train stations. They indicated that; in public spaces such as metro stations, users learn how to use that space and how to understand their location in a space; so they aimed to understand how the users learn and memorize the soundscapes of such spaces.

With their studies in Ankara and Warsaw metro stations, Su and Caliskan drew a guideline to the acoustical measurements of enclosed soundscape studies (2007,2011).

After his studies in open spaces, Kang started to investigate the soundscape in enclosed spaces. In 2010, Kang and Dokmeci published their work "Objective parameters for acoustic comfort in enclosed spaces", in which they tried to highlight soundscape methodologies and create a guideline for further studies.

Özçevik and Can has started a series of studies and in 2011 they published the article "İşitsel peysaj kavramı ve kapalı mekanların akustik konfor değerlendirilmesinde kullanılabilirliği"(soundscape and the adaptation of soundscape to covered spaces). Their study analyses both acoustical values and human perception in open and enclosed spaces. Besides, they investigated the applicability of outdoor soundscaping techniques for the enclosed spaces. In 2012, they used semantic differential test and because of the linguistic problems, they translated adjective pairs into Turkish (table) . In 2013, they analyzed the relationship between Zwicker metrics and adjective pairs (table).

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

Table 2.adjective pairs with TR and EN versions (Özçevik & Can, 2012)

Environmental Sound Assessment	Sound Quality Metrics	Adjective Pairs	Relationship with Soundmarks
General Assessment	Loudness (5%, 50%, 95%)	"loud-quiet" , "unpleasant-pleasant", disturbing-comfortable", "stressing-relaxing", "agitating-calming", "discordant-harmonic", "hard-soft", "crowded-uncrowded", "empty-joyful","exciting-gloomy", "loud-soft", "dark-light", "heavy-light - ", "rough-smooth"	
Detailed Assessment	Roughness (%10)	"far away-nearby"	Perception of the soundmarks (distance between soundmarks and the receiver)
	Sharpness (%10)	"sharp-not sharp"	Spectral structure of the soundmarks
		"unsteady-steady"	Stability of the soundmarks in time and its effect to the space
		"strange-common"	Familiarity of the soundmarks

Table 3. Relationship between sound quality metrics, adjective pairs and soundmarks (Özçevik & Can, 2013)

2.3. Acoustical Parameters for Soundscape

In order to conduct a strong in public spaces, there are some parameters that should be measured and considered; acoustical parameters which are sound pressure level (SPL) and equivalent continuous a-weighted sound level (Leq A), reverberation time; psychoacoustic parameters which are loudness, sharpness and roughness and fluctuation strength; and subjective parameters which are sound preferences, noise annoyance.

Literature review showed that, the outstanding studies either look up parameters individually, or in pairs such as acoustic-psychoacoustic, psychoacoustic and subjective or acoustic-subjective. There are limited studies which consists of both three type of parameters that listed above.

2.3.1. Objective Parameters

2.3.1.1. Sound Pressure Level (SPL) and Equivalent Continuous A-Weighted Sound Level (LeqA)

Equivalent Continuous Sound Pressure Level is a single value of constant sound level being produced over a stated period of time which would result in the same total sound energy. It is measured with the filters named by A, C or Z which mimic subjective response of human hearing system. It can be measured within the logarithmic scale by the unit (dB), with a sound level meter. According to Long, SPL corresponds with the loudness which is perceived by human and it gives clear cues on noise annoyance (Dökmeci, 2009).

2.3.1.2. Reverberation time (RT)

Reverberation is the persistence of a sound within a room and reverberation time can be simply defined as; the time requires for a sound to decay by 60dB after its termination (Rettinger, 1988). It can be controlled by the volume of the space and the acoustical absorption properties of the used materials. According to the literature, the common sense is shortening the RT, mostly in speech weighted rooms. If it is longer that required, it negatively affects the speech intelligibility both for the speaker and the audience. three major formulas that are used for the calculation of RT; Sabine's formula, Eyring's formula and Millington-Sette's formula.

Sabine's formula:

Sabine has made a correlation between the volume of the room (m^3) and total area of absorption in the room (sabins) (Egan, 1988:62).

$$T_{60} = 0,161 \text{ x } V / \Sigma\alpha_S$$

where,

- T60 = reverberation time, or the time requires for a sound to decay 60dB (s)
- V = volume of the room (m^3)
- $\Sigma\alpha$ = total area of absorption of the room (sabins)

2.3.1.3. Speech Transmission Index (STI)

Speech transmission index is an objective parameters which measures the quality of speech intelligibility (Egan, 2007). STI is a 0 to 1 scale; in which 1 refers to perfectly intelligible speech while approaching to 0 means decrease of the intelligibility. With various subjective intelligibility tests, certain ranges of STI are linked through various intelligibility ratings (Table 2). Speech intelligibility of a space is determined by the Speech Transmission Index (STI) parameter.

Intelligibility rating	Sentence score %	Meaningful PB-word[1] score %	CVC_{EQB}-nonsense word score %	STI
Excellent	100	> 98	> 81	> 0,75
Good	100	93 – 98	70 – 81	0,60 - 0,75
Fair	100	80 – 93	53 – 70	0,45 - 0,60
Poor	70 – 100	60 – 80	31 – 53	0,30 - 0,45
Bad	< 70	< 60	< 31	< 0,30

Table 4. Showing the relationship between the intelligibility ratings and STI

2.3.2. Subjective Parameters

Besides acoustic and psychoacoustic parameters and measurements, there are three subjective parameter, which also play an important role on defining a soundscape in an environment are: sound preferences, noise annoyance and sound recognition.

2.3.2.1. Sound Preferences

Sound preference is a psychological aspect, which refers for a user to determine the preferred or unwanted sounds in an environment. Therefore, it may vary from person to person or different locations; with memories, age, education etc. Sound preferences are the basic difference between acoustical comfort and soundscape. In 2007, Kang and Yang conducted a study in Sheffield, which explains the relationship between soundscape and sound preferences.

2.3.2.2. Noise Annoyance

Noise annoyance can be defined as the unwanted feelings of disturbance or irritation against a specific sound (Ouis, 2001). Noise annoyance based on users sound preferences and a variable aspect from one person to another. Thus, there are no measurement parameters; but methods such as semantics helps researchers to understand user behaviour under different circumstances (Long, 2006).

2.3.2.3. Sound Recognition

In his book, "The Image of City", Kevin Lynch mentioned about the relationship of soundmarks, city images and sound and space recognition, where Venot and Semidor explains this relationship these words; "every sound event can be preserved in a way which enables us to identify it" (VenotandSemidor, 2006). Based on their approach, hearing activity creates a mental image of the sound source, the activity and the environment, which may not be as strong as vision but still an important one.

Recognition is a term identifies a process of collecting information about an object in environment in order to fully understand its characteristics and working principles (Martin, 1999:11). Sound recognition, refers to a process of understanding what a specific sound is, what is its source, and where it stands in a specific environment. To be able to understand this process, the relationship between sound and social context must be well understood.

2.3.2.3.1 Soundwalk Method

Soundwalk method , is a subjective empirical method. It was firstly introduced by Schafer (1977) and developed by Semidor (2006). According to Schafer (1977), perception occurs in three categories; keynote sound, figure sound and soundmarks. 1) Keynote sound is the basic environmental sound which is constant and predictable and it forms the basis of the sound. 2) Figure sounds are the ones which are in front of the perceptive focus. They are unpredictable, sudden and/or annoying. 3) Soundmarks are the sounds which the user unconsciously learn and match with the space; which are the basis of the space recognition (Broccolichi et.al.,2009).

Soundwalk method starts with identification of a space. After that, a group of people/ or an individual start to walk through an area, in a specific time, and take binaural recordings of the space. The purpose of this method is to specify all the sound sources that forms the soundscape of that area. The duration of this activity can change depending on the size of the area, number of people in the group, number of sound sources etc. After the walking session ends, walkers discuss about the sound sources, architectural situations etc. Another way to conduct this method is to record the sound sources of the desired area with specified durations, and afterwards; in a listening test, make subjects to listen to the recordings and write down the sound sources that they hear, to write down whether they recognize the recorded space and so on. There are no précised rules or questionnaires of this method, and it is possible to find lots of different applications on the literature (Broccolichi et.al.,2009).

2.3.3. Psychoacoustic Parameters

Psychoacoustics is a scientific field which aims to explain the psychological and physiological responses of the users in an environment. There are three basic sound metrics which were proposed by Zwicker and Fastl (1990); loudness, sharpness and fluctuation strength and roughness.

2.3.3.1. Loudness

Loudness is a subjective term describing the magnitude characteristic of a sound (Dirac Delta). Actually, loudness and sound pressure level are two very relevant and confusable terms. As it was mentioned before, sound pressure level is the logarithmic measure of variations of a force which is caused by air-borne sound vibrations. It is logarithmic value, which can be measured by sound level meters. Loudness, on the other hand, is a psychoacoustic term which is related both the sound pressure level and duration of a sound. Loudness is basically deals with the frequencies (20Hz-20kHz) that people hear, on the other hand, sound pressure level can measure any frequency, even we do not hear. In 1960, Zwicker proposed a model to calculate the loudness, and it has been improved since (Zwicker and Fastl, 1983; Zwicker et al.,1990).

2.3.3.2. Sharpness

Sharpness is an important term related with the pleasantness of a sound, describing the tone color (Bismarck, 1974:159-172). The amount of sharpness changes the powerfulness of a sound; low level of sharpness makes a noise to be classified as dull, on the contrary, high level of sharpness makes a noise to be classified as shrill. If the loudness of a sound is known, the sharpness value can be easily calculated (Fastl, 2006).

2.3.3.3. Fluctuation Strength and Roughness

Fluctuation strength and roughness are psychoacoustic magnitudes which describe temporal variations of sound. Fluctuation strength is a value describes the slow variations of sound up to 20 Hz, while roughness is a value describing the faster variations (Rychtáriková & Vermeir, 2013:242).

Fluctuation strength has an important relation with the human speech. It is perceived highest around 4 Hz, which fluctuation of fluent speech also gives the same result. Roughness, on the other hand, is mostly used in sound engineering and reaches its maximum perception around 70 Hz (Fastl, 2006).

CHAPTER 3

COMPARISION STUDY BETWEEN SOUNDSCAPES OF OPEN; SEMI-OPEN AND ENCLOSED PUBLIC SPACES

3.1. Design of the Study

This study was designed and conducted to analyze soundscape qualities of open- semi-open- enclosed spaces in terms of comparing the noise annoyance, space recognition, soundmarks and semantic results. In order to fulfill this achievement, an enclosed, a semi,-open and an open public space was chosen which all shares the same environment. Subjective and objective measurements were taken in-situ simultaneously. For subjective evaluations; a-weighted equivalent sound levels (LeqA) and sound pressure levels (SPL) were measured and reverberation time of the all and speech transmission index parameters were calculated with computer simulations. For subjective evaluations; noise annoyance surveys and listening tests were conducted. The results were analyzed with comparison method. In this context; the park between Ankamall Shopping Mall and Akköprü metro station was chosen as open space; the entrance level of the station was chosen as a semi-open space; and the platform (landing) level of the station was chosen as an enclosed space were chosen as a case study.

3.1.1. Research Questions

The following research questions were investigated;

1. Can users recognize a space just by hearing the recordings taken from a location?
2. Are there any relationships between auditory perception and different space types?
3. Is there any correlation between the age, gender and education level and space recognition?

3.1.2. Hypotheses

The hypothesis is that; in the contrary of the open spaces, the enclosed spaces have more complex acoustic environments. 1)Auditory perception would be different considering the adjective pairs. 2) The semi-open and enclosed spaces could not be recognized by hearing, by the users. 3) Space recognition is not affected by demographic factors.

3.2. Methodology

Methodology and results are grouped under two main titles; objective measurements and subjective measurements.

As objective measurements; real size measurements were taken with Bruel & Kjaer 2230 sound level meter (figure 7) . Acoustical measurements were taken at the most crowded day of week; Saturday between 14:00 to 17:00 at eight different spots. In all three spaces; a-weighted equivalent sound level (LeqA) and sound pressure level (SLP) were measured. Computer simulations were done with ODEON 8.2 Auditorium Acoustics Software.

As subjective measurements; noise annoyance survey was prepared (appendix B) and conducted. Sound recordings were taken simultaneously with objective measurements and noise annoyance surveys from the site; with ZOOM Handy Recorder H2. Total 34 sound recordings, each for 30s, were taken from selected spaces in specified eight spots. Eight sound recording, which thought to be contain the soundmarks of the spaces, were chosen to be used in the listening test. Listening tests were conducted in a semi-anechoic room with Quiet Comfort 3 Acoustic Noise Cancelling headphones. Surveys used in listening tests were prepared according to the previous studies (appendix B). Results were analyzed with cross comparison technique both with each other and with the literature.

3.2.1. Site Description

Being public, sharing the same environment and continuous flowing of the human were the main factors on site selection for this study. The park between Ankamall Shopping Mall and Akköprü metro station was chosen as open space; the entrance level of the station was chosen as a semi-open space; and the platform (landing) level of the station was chosen as an enclosed space.

Akköprü metro station is located in Akköprü, Çankaya, one of the most running places of Ankara, in the intersection of Fatih Sultan Mehmet Boulevard and Mevlana

Boulevard. It is nearby to Ankamall Shopping Center, EGO General Directorate, Veterinary General Directorate, Head of Ankara Fire Department (figure 2).

Figure 2 . Site view of Akköprü Metro Station

As a plan layout, Akköprü Metro Station Consists of two levels; entrance level where the entrances, pay gates and ticket offices are located; and the platform level. The entrance level has lots of openings which creates a great flow of people and air, thus, it works as a transition in between the platform level and the outside. The station is 895 m long and 216 m wide. Height of the entrance level is 3,19 m and height of the platform level is 3,36m from the waiting line (under the suspended ceiling) and7,33 m from the rails (no suspended ceiling) .

Floor finishing material is artificial marble 40 x 40. Aluminum suspended ceiling is used overall the station. In the entrance level; walls, columns and stairs are covered with glass ceramic. In the platform level, columns are covered with acrylic paint. Ballast stone was used in the rails.

Figure 3. Entrance level of the Akköprü Metro Station

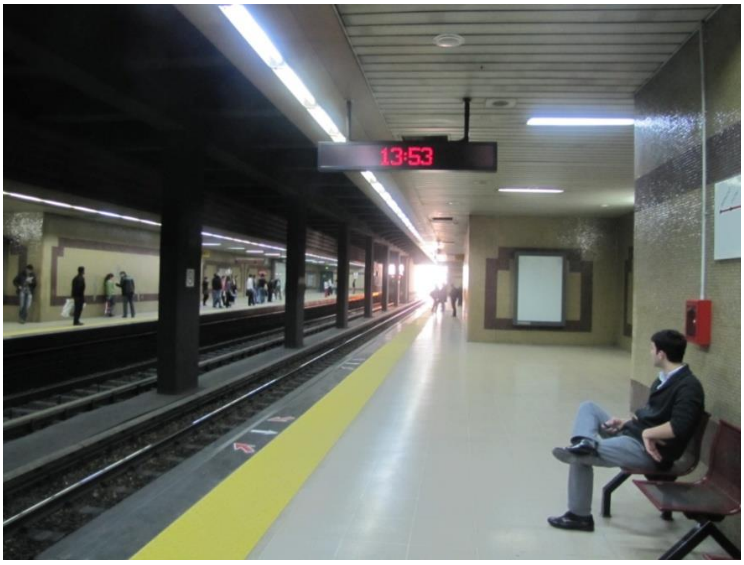


Figure 4. Platform Level Of The Akköprü Metro Station

The park between Akköprü metro station and Ankamall shopping mall is located in between the Akköprü Metro Station and Ankamall shopping center. It consists of a small square which is approximately 20 m in diameter and 50 m away from the station. The square is connected to a walking path which has 11 decorative pools in the middle axis, each in 5 diameters; 18 sitting unit placed alongside the path, and it directly fines with the shopping mall.

Figure 5. View of the Urban Park and Akköprü Metro Station from Ankamall Shopping Center

3.2.2. Objective Measurements

3.2.2.1. Real Size Measurements of Open - Semi-Open - Enclosed Spaces

Acoustical measurements were taken at the most crowded day of week; Saturday between 14:00 to 17:00 at eight different spots. In all three spaces; a-weighted equivalent sound level (LeqA) and sound pressure level (SLP) were measured.

Figure 6. Bruel & Kjaer Sound Level Meter type 2230

3.2.2.2. Computer Simulations of the Station

Because of the high background noise level in metro station, acoustical analysis of the station was made by simulation. Station was 3D modeled with Google Sketch-Up modeling software and transferred into ODEON Acoustic software to calculate the reverberation time (RT) in middle frequencies (500Hz-1000Hz) and speech transmission index (STI). When the model is successfully imported into ODEON, surface materials of the space were determined and assigned into the model.

ODEON is an acoustic software for prediction and auralisation of room acoustics. It helps to simulate the acoustics of large rooms like concert halls or complex spaces like metro stations and it has a large material library that gives the opportunity to create real-like simulations.

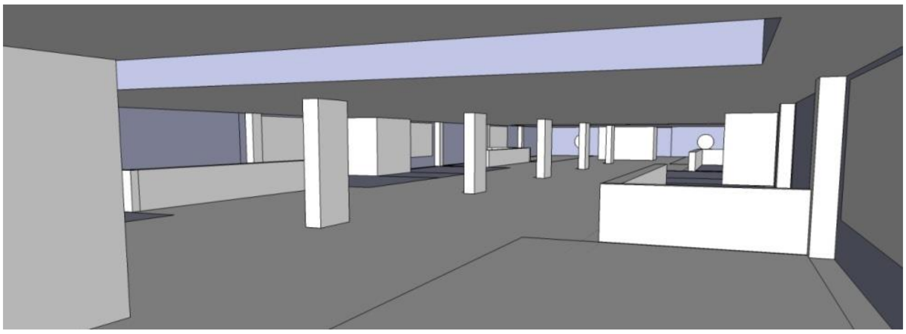


Figure 7. Google Sketch-Up 3D Modeling of the Entrance Level of the Station

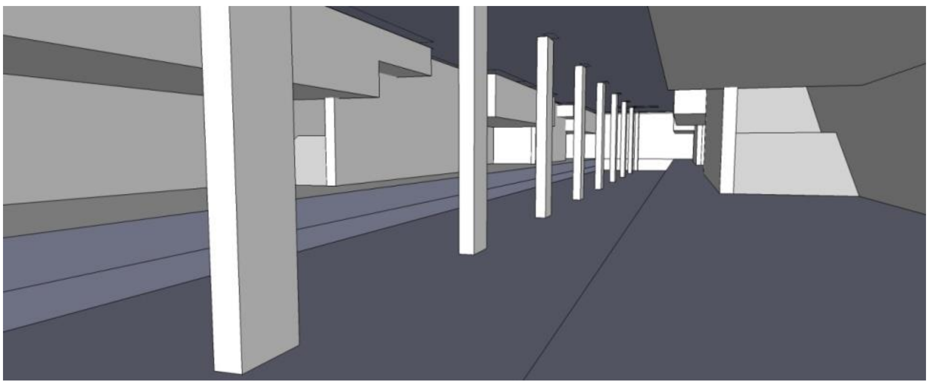


Figure 8. Google Sketch-Up3D Modeling of the Platform Level of the Station

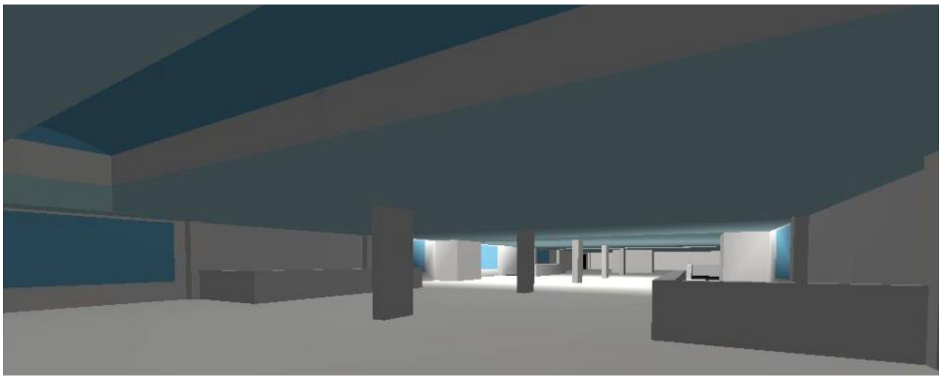


Figure 9. ODEON 3D View of the Entrance Level

Figure 10. ODEON 3D View of the Platform Level of the Station

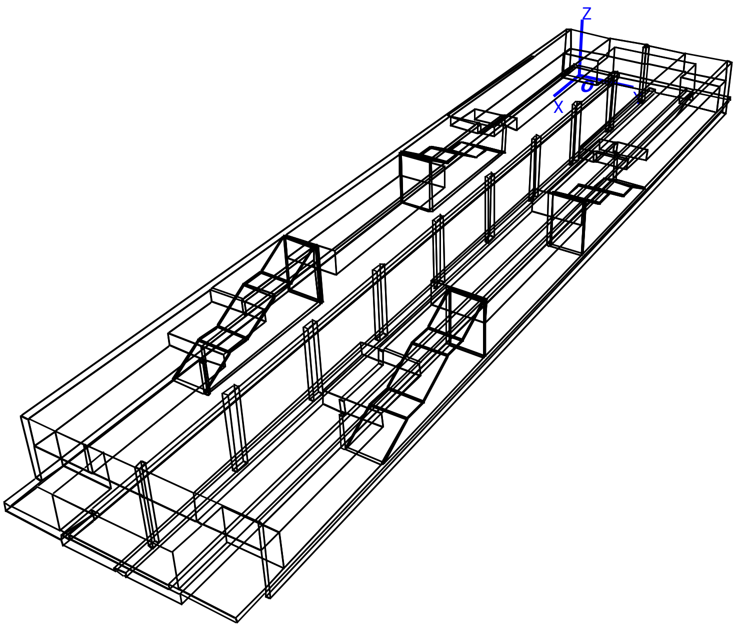


Figure 11. ODEON 3D Elevation View of the Platform Level

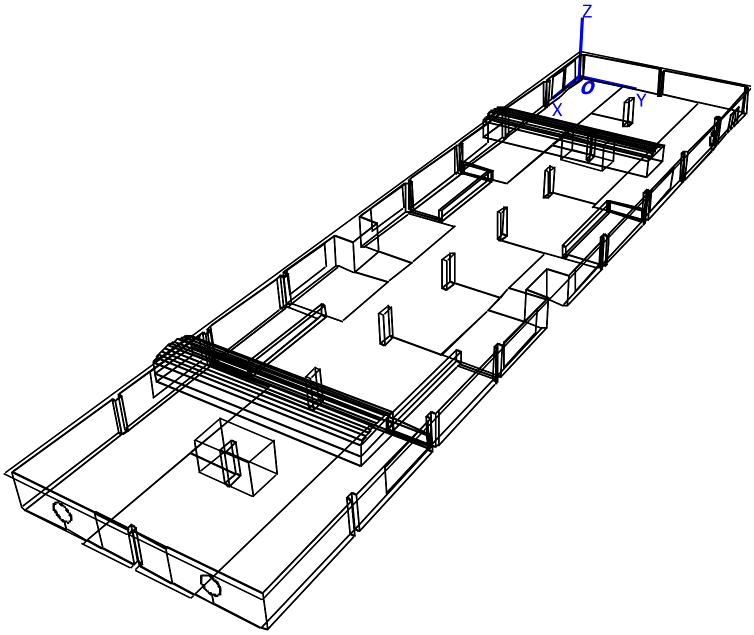


Figure 12. ODEON 3D Elevation View of the Entrance Level

3.2.3. Subjective Measurements

3.2.3.1. Noise Annoyance Surveys

In selected spaces; equivalent sound level and sound pressure level were measured and noise annoyance surveys were conducted simultaneously. Separate questionnaire were prepared for both three spaces (appendix B). Interviewees were asked to fill in demographic information such as gender, age, education level, usage frequency etc. and grade the general noise level and annoyance level, as well as annoyance level from different sound sources, from one to five.

3.2.3.2. Sound Recordings and Listening Test

Total 34 sound recordings, each for 30s, were taken from selected spaces in specified eight spots (figure 13). Duration of recordings were kept short to avoid the distraction of the subjects. Eight sound recording, which thought to be contain the soundmarks of the spaces, were chosen to be used in the listening test.

A questionnaire, which consists of 9 pages with two parts, was prepared. (see appendix B.6-B.7). In the first part, interviewees were asked to fill in personal information, such as; gender, age, education level with closed ended questions. In the second part, for each sound recording, subjects were asked to explain the recorded spaces (usage of the spaces), make estimation of the recorded space (if they are open/semi open/ enclosed space), and define the sound sources. Besides, in order to understand the sound quality of the selected spaces, subjects were asked to choose from 17 pairs of adjectives for each recording, which were selected from the previous studies (Ozcevik & Can,2012).

90 uninformed subjects were taken into a semi-anechoic room one-by-one and attended to the listening test. Each recording was played twice to the interviewees and each interview took thirty minutes. Sound recordings were played randomly to each subject.

Figure 13. Picture Of An Interviewee From The Anechoic Room

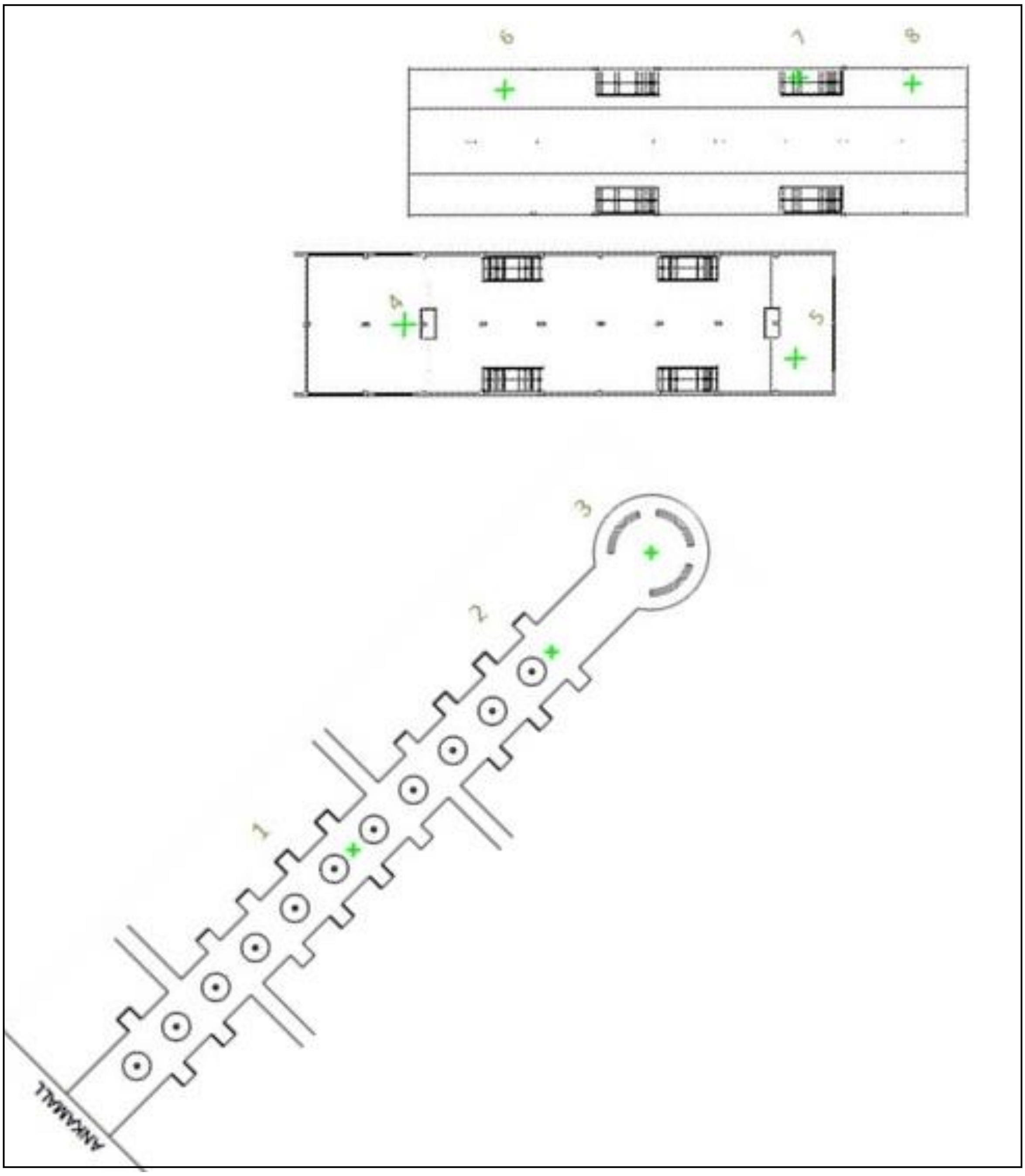


Figure 14. Measurement and recording points

CHAPTER 4

RESULTS

4.1. Objective Measurements

4.1.1. Sound Pressure Level (SPL) and Equivalent Continuous A weighted Sound Level (Leq A)

Measurement results are higher than the permissible limit according to the Regulations of Environmental Noise Assessment and Administrations from Ministry Of Environment And Forestry of Turkey. Results were given in table 5.

Measurement Spots		Permitted Noise Level	A-weighted Equivalent Sound Level (LeqA)	Sound Pressure Level (SPL)
Open Space	1	60 dBA	66 dBA	63 dBA
	2	60 dBA	59,7 dBA	61 dBA
	3	60 dBA	69 dBA	75 dBA
Semi-Open Space	4	55 dBA	60,1 dBA	60,2 dBA
	5	55 dBA	70 dBA	76 dBA
Enclosed Space	6	80 dBA	64 dBA	66,3 dBA
	7	55 dBA	60,7 dBA	65 dBA
	8	80 dBA	90 dBA	75 dBA

Table 5. Permitted and measured sound levels in measurement spots

4.1.2. Reverberation Time

4.1.2. Reverberation Time (RT)

Reverberation time results were given in the figures below (Figure 13,14, see also appendix figure C). In the bar charts, there are two values indicated; (T20) is the reverberation time over the first 20 dB decay and (T30) is the reverberation time over the first 30 dB decay. Results showed that; in middle frequencies (500Hz-1000Hz) reverberation time (T30) was calculated as 5,65 seconds in entrance level and 3,15 seconds in platform level

Measurement results are higher than the permissible limits. According to the Regulations of Environmental Noise Assessment and Administrations from Ministry Of Environment And Forestry of Turkey, the optimum reverberation time values at 500 Hz for unoccupied metro stations are between 1,2 seconds and 1,4 seconds. However there are no indications whether this values are for T20 or T30.

4.1.3. Speech Transmission Index (STI)

Speech transmission index (STI) results were given in figures below (Figure 15, 16, see also appendix C.3, C4). Results showed that, in station entrance level, STI values are in between 0,29 and 0,39. This result is fairly low than the desirable values, and it is in *poor class*. In station platform level, STI values are in between 0,39 and 0,57; which generally are in *poor-fair class*, low than the desirable values but a better result than the entrance level. These results were calculated for an unoccupied station. However, with the passengers and even distribution of loudspeakers may improve the STI results; thus a better sound intelligibility classes may be gained; yet the results are fairy below than the desirable values [Su, Caliskan, 2007].

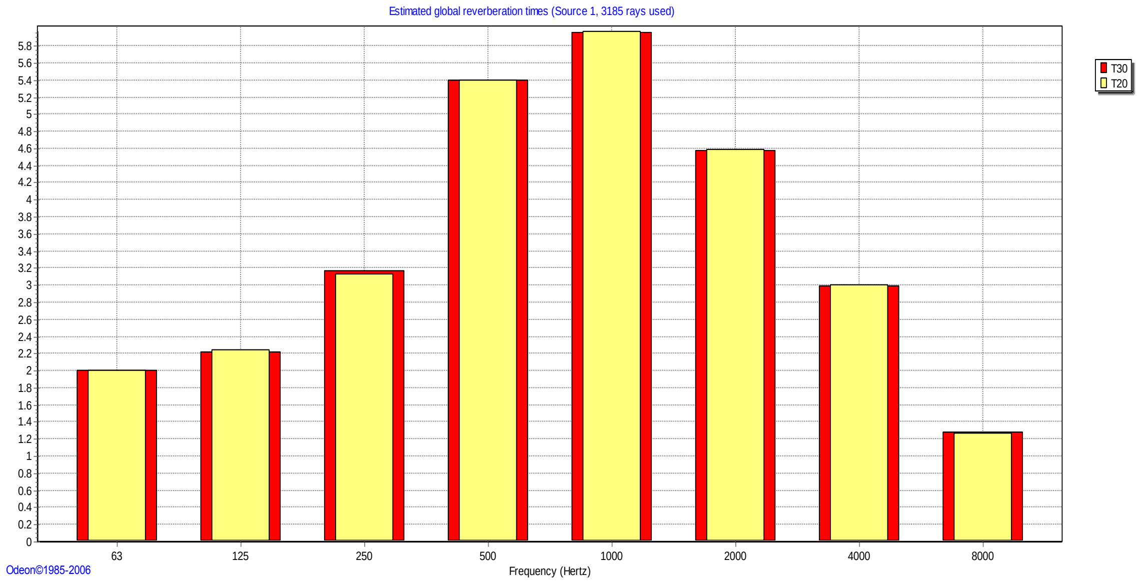


Figure 15. Bar chart showing the estimated global reverberation time in entrance level

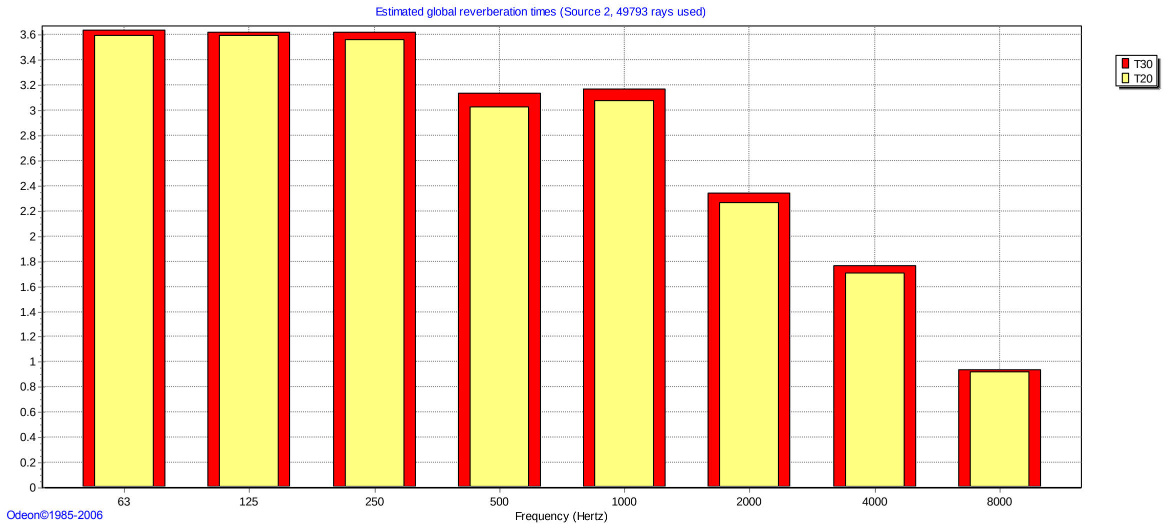


Figure 16 . Bar chart showing the estimated global reverberation time in platform level

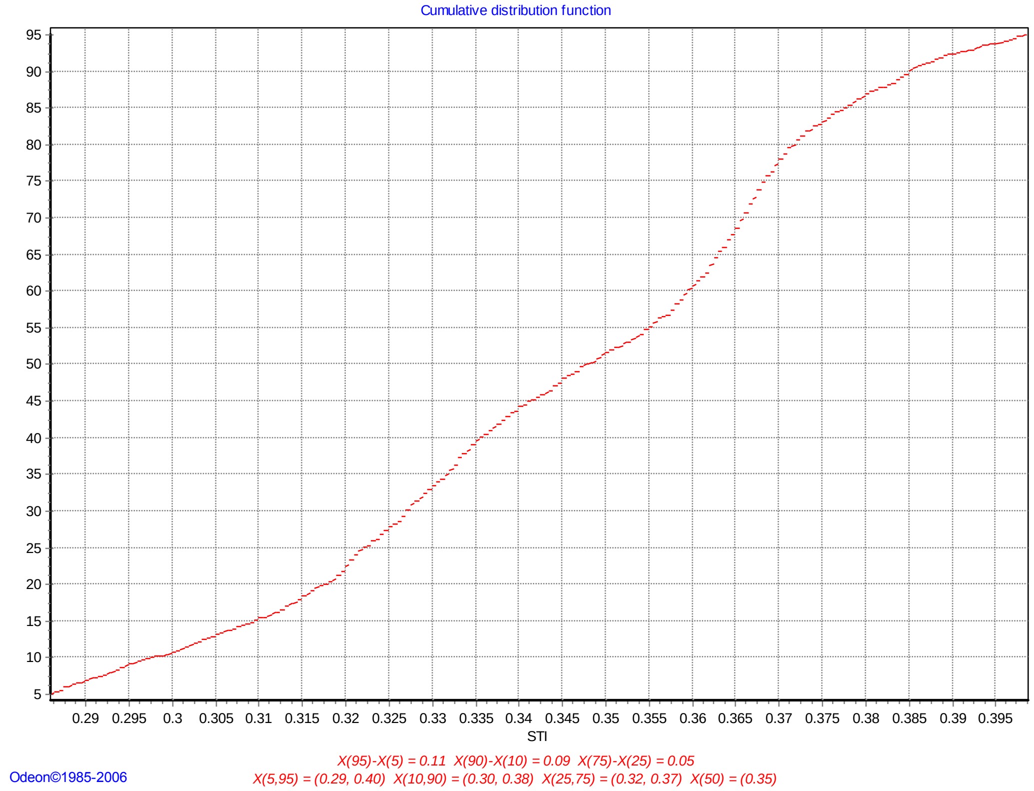


Figure 17. Speech Transmission Index (STI) graphics of the station entrance level

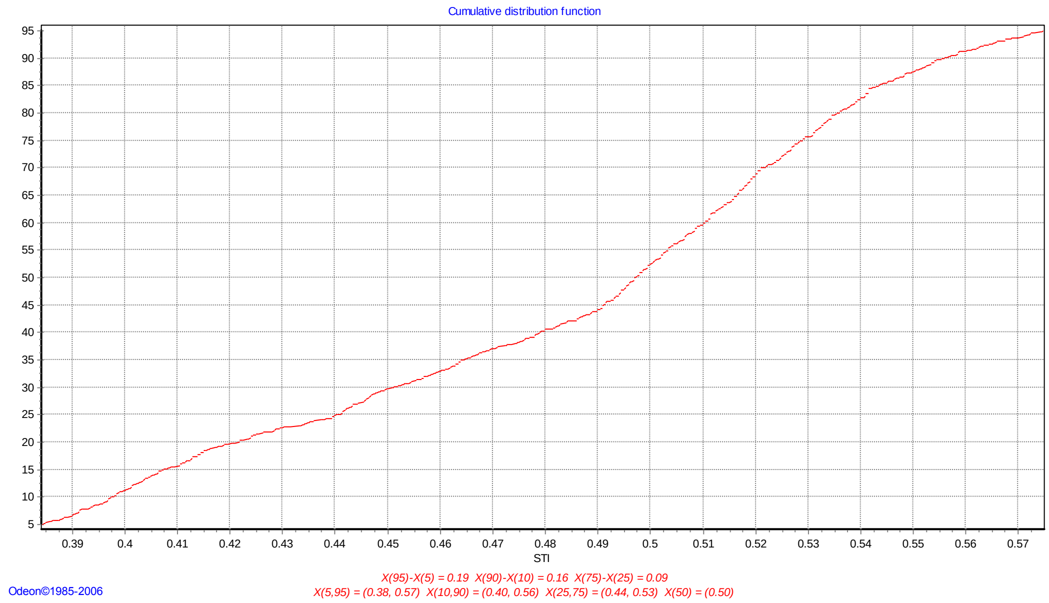


Figure 18. Speech Transmission Index (STI) graphics of the station platform level

4.2. Subjective Measurements

4.2.1. Noise Annoyance

Results of the noise annoyance surveys showed that; in open (park) and semi-open (station entrance level) spaces, $leq_{(A)}$ levels were close while noise annoyance levels resulted higher in semi-open space. In enclosed space (station platform level) $leq_{(A)}$ level was lower than the semi-open space, yet the noise annoyance levels resulted similar (figure 17) (For noise annoyance ratings on specific sound sources see appendix C.5).

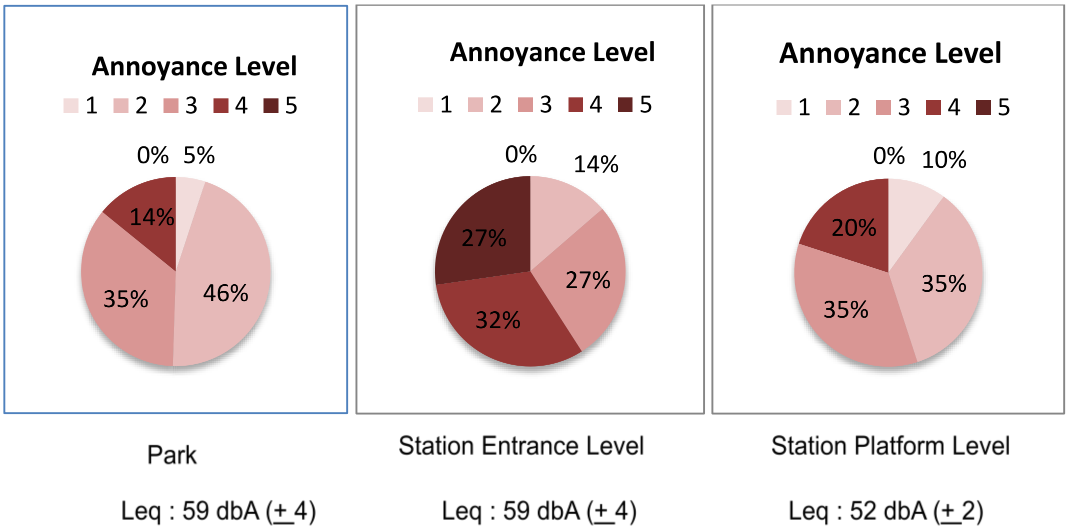


Figure 19. Sound level / Noise annoyance chart in open - semi-open - enclosed spaces

4.2.2. Sound Recognition

In terms of *sound recognition*, listening test results showed that 70% of the subjects were able to determine the spaces correctly as open, semi-open and enclosed. All of the subjects determined open spaces correctly, enclosed spaces were determined with 84% percentage and semi-open spaces were recognized with 5% percentage. Only half of the subjects were able to determine the usage of the spaces (Figure 18, see also appendix C, D).

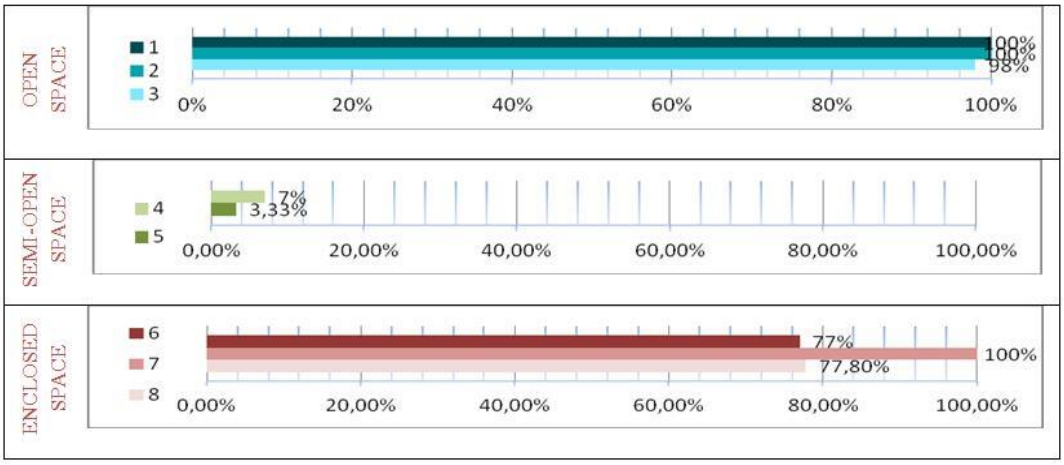


Figure 20. Listening Test results - defining space types (as open /semi open/enclosed) (see figure 14 for measurement points)

Listening test results showed that the demographic characteristics of the subjects such as gender, age, education level and *space recognition* (if subjects correctly define spaces as open-semi open or enclosed, and recognize the spaces) did not show any correlation with .000 significance factor. In the literature, there are similar studies which resulted with 100% space recognition by the subjects in listening tests. (Tardieu et al., 2007, Özçevik & Can, 2011).

In order to challenge these results, hypothesis tests were conducted in between space recognition and gender (M= .27, SD= .44 space recognition and age (M= .27, SD= .44), space recognition and education (M= .27, SD= .44); defining space types and gender (M=.04, SD=.20), defining space types and age (M=.04, SD=.20), defining space types and education level (M=.04, SD=.20).

In the test, initial hypothesis was taken as 1, which signifies 100% rate of space recognitions by the subjects.

Results showed that, none of the matches has any correlation with each other, with =~ .000 significance factor. This result rejects the initial hypothesis. The results of this study shows that, 100% rate of space recognition, just by hearing the sound recordings taken from spaces, is insignificant. In other words, results of this study conflicts with the findings from previous studies; it has been claimed that, in similar studies, all of the subjects defined spaces as open / enclosed correctly. However, hypothesis test has rejected this possibility.

Hypothesis tests could not be conducted on some of the data due to random sampling (table 6,7).

	Values						
Row Labels	**Sample Mean**	**Sample Standard Deviation**	**Sample Size**	**Initial Hypo**	**Test Stat**	**Hypothesis**	**p-value**
M	0,066667	0,252262	45	1	-24,8193	Rejected	2,8E-136
F	0,022222	0,149071	45	1	-44	Rejected	0
16-26	0,030303	0,174078	33	1	-32	Rejected	5,5E-225
27-37	0,073171	0,263652	41	1	-22,5093	Rejected	1,7E-112
38-48	0	0	12	1	N/A	N/A	N/A
49-59	0	0	4	1	N/A	N/A	N/A
Doc.	0	0	19	1	N/A	N/A	N/A
Univ.	0,125	0,337832	24	1	-12,6886	Rejected	3,42E-37
Masters	0,021277	0,145865	47	1	-46	Rejected	0
Grand Total	0,044444	0,207235	90	1	-43,7436	Rejected	0

Table 6: Hypothesis tests results on defining space types (open /semi open/enclosed)

	Values						
Row Labels	Sample Mean	Sample Standard Deviation	Sample Size	Initial Hypo	Test Stat	Hypothesis	p-value
M	0,466666667	0,504524979	45	1	-7,09124	Rejected	6,64568E-13
F	0,069767442	0,257769631	43	1	-23,6643	Rejected	4,2033E-124
16-26	0,272727273	0,452267017	33	1	-9,2376	Rejected	1,26039E-20
27-37	0,375	0,490290338	40	1	-8,06226	Rejected	3,7449E-16
38-48	0	0	12	1	N/A	N/A	N/A
49-59	0	0	3	1	N/A	N/A	N/A
Doc.	0,157894737	0,374634325	19	1	-9,79796	Rejected	5,74417E-23
Univ.	0,375	0,494535355	24	1	-6,19139	Rejected	2,98176E-10
Masters	0,266666667	0,447213595	45	1	-11	Rejected	1,91066E-28
Grand Total	0,272727273	0,447914009	88	1	-15,2315	Rejected	1,09183E-52

Table 7: Hypothesis tests results on space recognition

According to listening tests and site analysis, sound sources and soundmarks of the spaces were also determined. The order of the sound source lists written by subjects, gave the clue of how users perceive sounds in an environment (Yang & Kang, 2005). Evaluating the spaces in terms of "soundmarks"; marching sound, speech and children sound perceived common in all three spaces. Traffic sound, horn and siren perceived common in open and semi-open spaces. As soundmarks; bird, wind and water sounds denoted in open space; pay gates and coin sounds denoted in semi-open space; metro, break, door and paging denoted in enclosed space (Table 8).

Spaces	Sound Sources	Soundmarks
Open Space	Heavy Traffic Decorative Pool Weather Conditions Flow of Human	Bird Sound Wind Sound Water Sound Marching Sound Speech and Child Sound Traffic Sound; horn and siren
Semi-Open Space	Ticket Office Pay Gates Flow of Human Heavy Traffic	Coin Sound Pay Gate Sound Marching Sound Speech and Child Sound Traffic Sound; horn and siren
Enclosed Space	Metro Loudspeaker Flow of Human	Marching Sound Metro Sound; break and door Paging Speech and Child Sound

Table 8**:** Listening Test results - Sound sources and soundmarks determined by the listening test and site analysis (see figure 14 for measurement points)

4.3. Psychoacoustic Measurements

4.3.1. Semantic Differential and Correlations

Subjects tented to choose "quiet", "pleasant", "comfortable", "relaxing", "natural", "calming", exciting", "preferred", "uncrowded", "organized", "steady", eventful", "cheerful", "joyful", "exciting", "light", "common" pairs open space; while they tended to choose "loud", "unpleasant", "disturbing", "stressing", "artificial", agitating", "boring", "not preferred", "crowded", "disorganized", "unsteady", calming", "deserted", "empty", "gloomy", dark", "strange" pairs in enclosed space, (table 9).

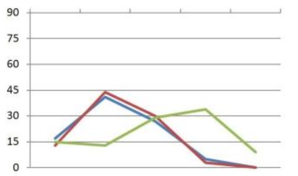
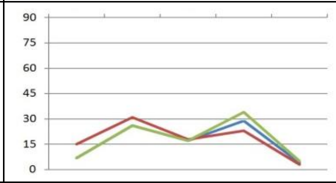
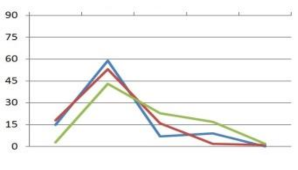
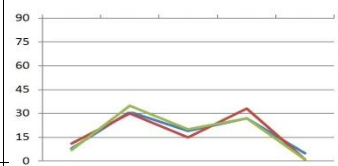
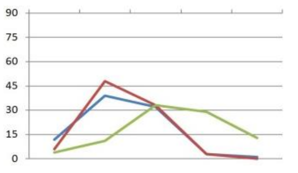
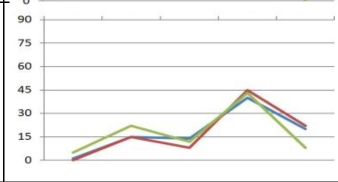
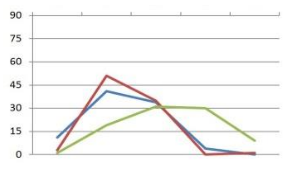
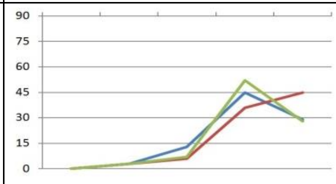
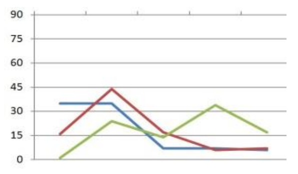
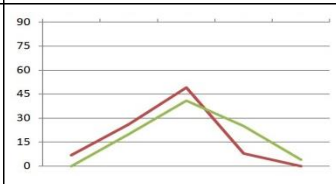
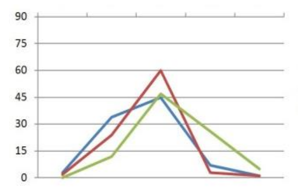
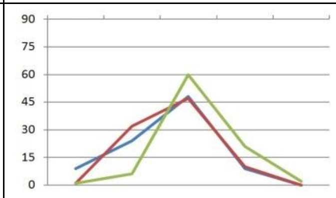
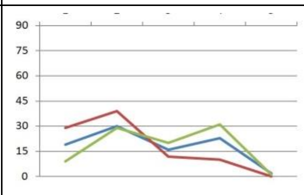
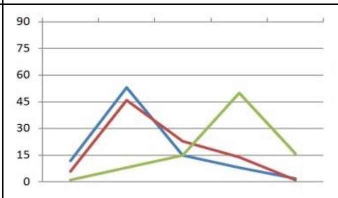
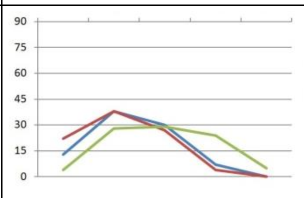
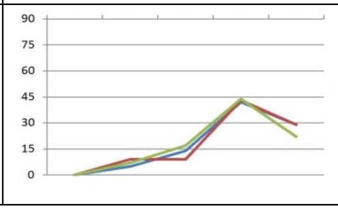
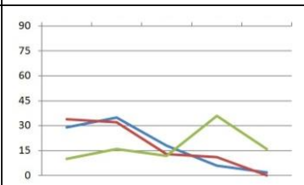
	1 2 3 4 5			1 2 3 4 5	
Loud		Quiet	Disorganized		Organized
Unpleasant		Pleasant	Unsteady		Steady
Disturbing		Comfortable	Calming		Eventful
Stressing		Relaxing	Deserted		Lively
Artificial		Natural	Empty		Joyful
Agitating		Calming	Gloomy		Exciting
Boring		Exciting	Dark		Light
Not Preferred		Preferred	Strange		Common
Crowded		Uncrowded	Enclosed Space Semi-Open Space Open Space		

Table 9. Listening test results - Relationships of adjective pairs/space types

Correlations between the adjective pairs answers gained from listening tests were analyzed. Highly correlated adjective pairs can be seen in the table below (table 10, see also appendix D).

Correlations	Loud quiet	Unp. Pleas.	Distur. Comf.	Stress. Relax.	Artific. Natur.	Agitat. Calm.	Boring excit.	Not pr. preferr.	Crowd. Uncr.	Disorg . Org.	Unste. steady	Calm. event.	Disert. lively	Empty joyful	Gloo. excit.	Dark light	Stran. Comm.
Loud - quiet		■	■						■							■	
Unpleasant - pleasant			■					■								■	
Disturbing- comfortable							■	■								■	
Stressing - relaxing						■	■										
Artificial - Natural																	
Agitating - calming																	
Boring - exciting								■		■				■	■		
Not preferred-																	
Crowded - uncrowded																	
Disorganize d -																	
Unsteady - steady																	
Calming - eventful													■				
Diserted - lively																	
joyful															■		
Gloomy - exciting																■	
Dark - light																	
Strange - common																	

Table 10. Highly positive correlated adjective pairs

Correlations suggests that, loud environments makes users unpleasant and disturbed. Users found loud spaces crowded. Users suggested that they are very pleasant with comfortable spaces. Agitated environments makes users highly stressful. Users claimed that they get bored in stressful and disturbing spaces. Comfortable and pleasant spaces are highly preferred than uncomfortable and unpleasant ones. Users do not prefer gloomy spaces. Eventful spaces labeled as lively and joyful. Eventful and lively spaces are labeled as loud. Users get bored in empty spaces. Users found disorganized and gloomy spaces boring. Gloomy spaces denoted as empty. Users found loud, disserted and gloomy spaces as dark.

According to results, there are negatively correlated adjective pairs too (table 11, see also appendix D). Eventful, lively and joyful spaces were labeled as loud. Users get disturbed from eventful spaces and get more comfortable in calming spaces. Users found eventful spaces disorganized. Empty spaces are chosen as more common than joyful spaces. Users found natural spaces gloomy and labeled artificial spaces as exciting. Users get stressed from eventful spaces. Users found eventful spaces crowded and calming spaces more light.

Correlations	Loud quiet	Unp. Pleas.	Distur. Comf.	Stress. Relax.	Artific. Natur.	Agitat. Calm.	Boring excit.	Not pr. preferr.	Crowd. Uncr.	Disorg. Org.	Unste. steady	Calm. event.	Disert. lively	Empty joyful	Gloo. excit.	Dark light	Stran. Comm.
Loud - quiet																	
Unpleasant - pleasant																	
Disturbing-comfortable																	
Stressing-relaxing																	
Artificial - Natural																	
Agitating-calming																	
Boring-exciting																	
Not preferred-preferred																	
Crowded-uncrowded																	
Disorganized - organized																	
Unsteady-steady																	
Calming-eventful																	
Diserted-lively																	
Empty-joyful																	
Gloomy-exciting																	
Dark-light																	
Strange-common																	

Table 11. Highly negative correlated adjective pairs

4.3.2. Semantic Differential and Sound Quality Metrics

In their study, Özçevik and Can (2013) explained the relationship between semantic differential adjective pairs and sound quality metrics (loudness, sharpness, roughness) (table 3).

Considering their work, "Loud-Quiet", "Unpleasant-Pleasant", "Disturbing-Comfortable", "Stressing-Relaxing", "Agitating-Calming", "Uncrowded-Crowded", "Unsteady-Steady", "Empty-Joyful", "Gloomy-Exciting", "Dark-Light", "Strange-Common" adjective pairs found to be related with loudness. "Unsteady-Steay" and "Strange-Common" adjective pairs found to be related with sharpness. In other words, these adjective pairs can be explained with the related sound quality metrics.

CHAPTER 5

DISCUSSION

In this chapter, results are being discussed with the previous studies from the literature. The hypothesis of this study is; in the contrary of open spaces, enclosed spaces have more complex environments.1) Auditory perception would be different considering the adjective pairs. 2) Semi-open and enclosed spaced could not be recognized by hearing. 3)Space recognition does not get effected from the demographic factors. Based on this hypothesis, the study was conducted under 3 sections; the first section is about understanding what a soundscape is, and how it developed. Second section covers soundscape measurement techniques and developments in open and enclosed spaces. Third section explains selected sites, used methods and result. Results of the study supported the research questions and the hypothesis.

Acoustical quality of the spaces were gained through acoustical measurements and computer simulations. Gained results are above the permissible limits given in the

Regulations of Environmental Noise Assessment and Administrations. Reverberation time of the station was calculated as 5,65 seconds in the entrance level and 3,15 seconds in platform level. Theoretically, in non-musical spaces, such as metro stations, high reverberation time causes the sound to build up in a space, users to hear the background noise much more higher and decreases the speech intelligibility. Thus it would increase the noise annoyance of the user (Irvine & Richards,1998). Results showed that, acoustical requirements are specified within the laws but they are not being considered and applied in a construction or a renovation. Speech transmission index (STI) values were found fairly low than the optimum values around 0,60. In entrance level, (STI) values were calculated between 0,29 and 0,39. In platform level, it is calculated as 0,39 and 0,57. A Similar study was conducted by Su and Caliskan (2007, 2011). Their study analyzes three metro stations in terms of reverberation time (RT), sound pressure level (SPL), speech transmission index (STI) by comparing and with additional suggestions on used materials and space volumes. Their study drew a guideline to the acoustical measurements in metro stations. According to their study; reverberation times of the selected stations in middle frequencies are calculated between 1,37 and 1,46; which are higher than the permitted limits but more acceptable results when compared to the current study. Similarly, STI values in the study of Su and Caliskan (2011), were found around *good* and *excellent* class; while in the current study, STI values found below the *fair* class.

Another similar study was conducted by Dokmeci & Kang (2011); in which two enclosed cultural facility spaces were analyzed in terms of equivalent sound pressure level and psychoacoustic metrics of loudness, sharpness and roughness. Measured Leq levels were in between 60-85 db. According to activities and space type, the permissible noise level also changes. In this case, the permissible noise levels for enclosed cultural facility spaces are 30 dbA; thus the measured noise levels are above the limitations. With the comparison of the calculated psychoacoustic metric values and acoustic measurement results; it has been indicated that; listening tests and in-stu surveys are also important to be able to understand the enclosed soundscapes;

Auditory perception of the users were obtained by the *noise annoyance* surveys and semantic scale based on adjective pairs used in listening tests. Noise annoyance is a subjective parameter, thus results should be evaluated in regarding (Sobotova et. al.,2006). As recommended by the International Commission on the Biological effects of Noise, noise annoyance surveys consists of general socio-demographic data and estimated by the verbal annoyance scale (Fields et al. 1998). Results showed that; *noise annoyance* of the users are highest in the enclosed space, while resulted lowest in the open space. Literature review showed that, there are no studies comparing the noise annoyance ratings between open and enclosed spaces; but Paunovic et.al.(2009) compared the noise annoyance predictors in quiet and noisy urban areas. In their study, it is indicated that, there are lots of studies showing the relationship of noise annoyance and noise level (as cited in Paunovic et al., 3710) It has been indicated that; only in noisy streets, noise levels were found as an important factor on noise annoyance. Besides, traffic noise found as an important factor on both acoustical quality of the space and the noise annoyance of the users.

Evaluating the spaces in terms of "soundmarks"; marching sound, speech and children sound perceived common in all three spaces. Traffic sound, horn and siren perceived common in open and semi-open spaces. As soundmarks; bird, wind and water sounds denoted in open space; pay gates and coin sounds denoted in semi-open space; metro, break, door and paging denoted in enclosed space.

Adjective pairs were analyzed with correlations and t-test analysis. According to results, subjects tended to choose adjectives such as "loud", "unpleasant", "disturbing", "stressing", "artificial" etc. for the station platform level. Besides, correlations suggests that, loud environments makes users unpleasant and disturbed. Agitated environments makes users more stressful. Comfortable and spaces are more preferred. Eventful spaces labeled as lively and joyful. Eventful and lively spaces are labeled as loud. Users get disturbed from eventful spaces. Empty spaces are chosen as more common than joyful spaces. Users get stressed from eventful spaces. These result correspond to the first research question of this study; there are statistically significant relationships between auditory perception and different space types. It should be noted that this result may be affected by the poor acoustic quality of the metro stations. To be able to strengthen this result, similar studies should be conducted with different space types and additionally with sound preferences surveys. In 2005, Yang and Kang tried to explain the importance of auditory perception in user's choice of using an urban space and user preferences in an urban square. They used a sound preference survey similar to the *noise annoyance survey* used in the current study. Interviewees were asked to describe three sounds they hear in the space, classify fifteen verbally described sounds as "favorite", "neither favorite nor annoying" or "annoying" with three-scale rating. Additionally, interviewees were asked to select their preferred sound sources/environments. Their results show similarities with the current study. As soundmarks, water sounds from the fountains determined as first noticed sounds. As secondary sound sources, traffic noise, road construction, human speech were also found similar in both studies. As another result, in both studies, it is agreed that the loudest sounds do not have to be the first noticed sounds in an environment. (Yang & Kang, 2005, 76).

In terms of *sound recognition*, listening test results showed that 70% of the subjects were able to determine the spaces correctly as open, semi-open and enclosed. All of the subjects determined open spaces correctly, enclosed spaces were determined with 84% percentage and semi-open spaces were recognized with 5% percentage. Only half of the subjects were able to determine the usage of the spaces. This result corresponds the hypothesis and the second research question. Semi-open and enclosed spaces could not be recognized by hearing. However, these results conflict with the previous studies. In their study Tardieu and his colleagues (2007) took acoustical measurements, used soundwalk method to investigate the role of soundscape on space recognition in train stations and conducted a listening test. Their study results showed that 44 sound samples out of 66 were being recognized by more than 50% of the participants. They construed this result as the following;

> Very high scores were obtained for all the spaces, means that listeners were able to associate each sample with the type of space just by listening to it. This result confirms the assumption that the soundscape of a train station conveys information for the people who are listening to it (Tardieu et al., 2007; 14).

Özçevik and Can published their study which is based on the development of an approach on the usage of soundscape in urban acoustic planning and development (2012; 129). Their study covers acoustical measurements, in-stu interviews, soundscape recordings from 4 open urban areas and a listening test. They asked the subjects to write down what they hear in order to see if the listeners could understand the recording area, if it is open or enclosed and what the sound sources are. They stated their result as "all the subjects correctly defined the area as open" (2012; 138). Similarly, in their previous study, two open and two enclosed spaces were chosen as site; the same methodology was used and the result was also the same; "all the subjects correctly defined the areas as open or enclosed" (2011; 57).

The variance in results in terms of space recognition may be caused by several factors;

- Soundmarks of a space play very important role on space recognition. In this study, marching sound, speech and children sound perceived common in all three spaces. Traffic sound, horn and siren perceived common in open and semi-open spaces. As soundmarks; bird, wind and water sounds denoted in open space; pay gates and coin sounds denoted in semi-open space; metro, break, door and paging denoted in enclosed space.
- Reverberation time causes sound to build up and act like an echo, which is mostly unique for enclosed spaces, so its existence may be working as a separator in identifying enclosed spaces.
- Subjects have failed to identify the semi-open spaces. This may cause by several factors; pay gates sound, coin sound or high background noise with high reverberation time may made the participants thought the recording was taken from a totally enclosed space. On the other hand, traffic noise from the background directly lead them to identify the space as open.

Demographic factors of gender, age, education level and space recognition did not showed any correlation with =~ .000 significance factor. The results of these tests showed that, 100% rate of space recognition just by hearing, is insignificant as the initial hypothesis was rejected by the hypothesis tests. This result correlates with the hypothesis and third research question of the study. But it should be noted that, this result obtained due to random selection of the subjects. There are no previous studies comparing space recognition and demographic factors, however, similar results were obtained in previous studies. In her master thesis of Dokmeci (2009), although there are no indication of random sampling, selected subject have no systematic relationship in terms of age and gender. It is stated that; there are no significant correlation between demographics and noise annoyance ratings. In Chen and Kang's (2004) study, noise annoyance and different activities were compares and no significant relationship found. However, on the contrary to this studies results; Dokmeci and Kang (2012) found significant effects between noise annoyance and demographic factors such as gender, usage, academic level. Yang and Kang (2012) found significant relationship with age and sound preferences and less significant yet beneficial results were found in the sound preferences between male and female.

CHAPTER 6

CONCLUSION

Aim of this study is to compare the soundscapes of open-semi open-enclosed spaces, which shares the same environment. In this context, the park between Ankamall Shopping Mall and Akköprü metro station was chosen as open space; the entrance level of the station was chosen as a semi-open space; and the platform (landing) level of the station was chosen as an enclosed space.

Conducted and ongoing studies related with soundscapes are mostly covering open public spaces. On the other hand; more case samples are needed in enclosed spaces from different regions in different space types. With this study, it has been aimed to increase the samples in enclosed soundscape studies and as a public space; metro stations were been aimed to be included into the literature.

Within the context of this study; in selected spaces, a-weighted equivalent sound levels (Leq_A) and sound pressure levels (SPL) were measured, soundwalk recordings were taken noise annoyance surveys were applied simultaneously. Because of the high background noise level in metro station, acoustical analysis of the station was made by computer simulation. In order to understand the sound quality of the selected spaces, ninety applicants were attended to a listening test.

Acoustical quality of the spaces were obtained by acoustical measurements. Results showed that, sound levels, reverberation times and speech transmission index of the spaces are higher than permissible limits. In non-musical spaces; such as metro stations, high reverberation time decreases the speech intelligibility; thus, it is an unwanted situation (Irvine & Richards,1998) .

Auditory perception of the users were obtained by the noise annoyance surveys and semantic scale based on determinative adjective pairs. According to results, in park and station entrance level, sound levels were close while noise annoyance levels resulted higher in semi-open space. In station platform level, sound level was lower than the station entrance level, yet the noise annoyance levels resulted similar. In terms of determinative adjectives, subjects tented to choose adjective pairs such as "relaxing", "natural", "cheerful" in open space; while they tended to choose adjective pairs such as "artificial", "stressful" in enclosed space.

Correlations results shows that, loud environments makes users unpleasant and disturbed. Users suggested that they are very pleasant with comfortable spaces. Agitated environments makes users highly stressful. Users claimed that they get bored in stressful and disturbing spaces. Comfortable and pleasant spaces are highly preferred than uncomfortable and unpleasant ones. Users do not prefer gloomy spaces. Eventful spaces labeled as lively and joyful. Eventful and lively spaces are labeled as loud. Users get bored in empty spaces. Eventful, lively and joyful spaces were labeled as loud. Users get disturbed from eventful spaces and get more comfortable in calming spaces. Users found eventful spaces disorganized. Empty spaces are chosen as more common than joyful spaces. Users found natural spaces gloomy and labeled artificial spaces as exciting. Users get stressed from eventful spaces. Users found eventful spaces crowded and calming spaces more light.

Listening test results showed that the demographic characteristics of the subjects (age, gender, education level) and perception of space did not showed any significant correlation with =~ .000 significance factor. This result rejects the 100% rate of space recognition just by hearing. Listening test results showed that 70% of the subjects were able to determine the spaces correctly as open, semi-open and enclosed. All of the subjects determined open spaces correctly while semi-open spaces were recognized with 5% percentage. Only half of the subjects were able to determine the usage of the spaces Soundmarks of the spaces were determined by the listening tests and site analysis.

The literature review of previous studies showed that there are no common framework on how to conduct soundscape studies; how to gather data or how to analyze them (Özcevik & Can, 2012; 129). In this study, different than the literature, sound recordings of the spaces and subject numbers were limited due to the short period time. Random sampling was used for subject selection. No laboratory studies were conducted on sound recordings. Selected spaces has not been analyzed in terms of sound quality metrics. In addition, it should be noted that, used technical equipment may also affect the result. Soundscape has a variable characteristic depends on regions and users. This study only covers a metro station and a park. In further studies, these variables should be taken into consideration and more case studies, especially in enclosed spaces, are required to approach a international standardizati

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APPENDIX A

Figure A.1. Entrance Level of the Akköprü Metro Station

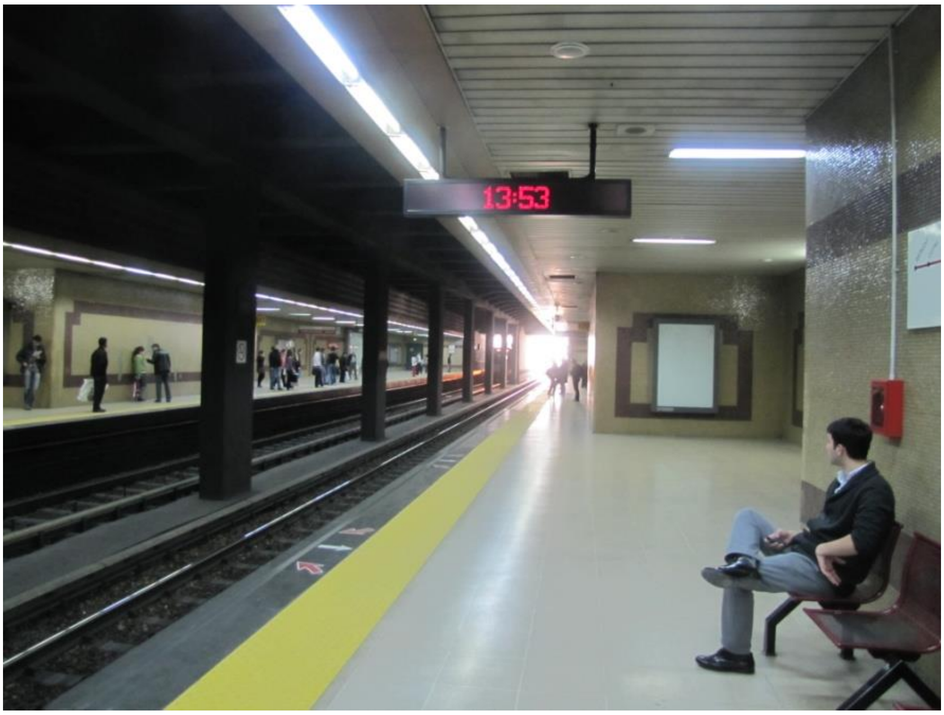
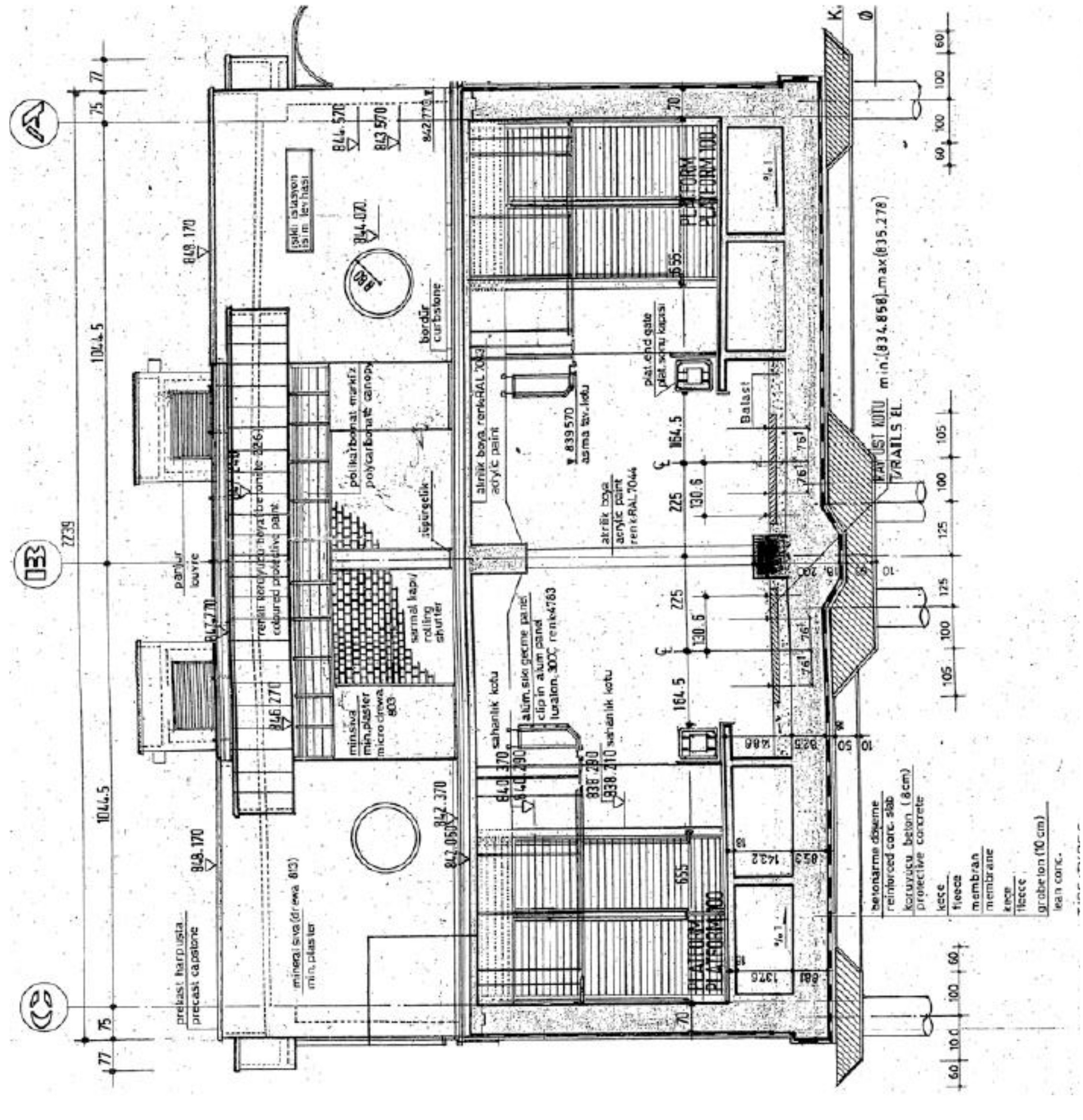


Figure A.2. Platform Level of the Akköprü Metro Station

Figure A.3. Entrance of the Akköprü Metro Station

Figure A.4. Entrance of the Akköprü Metro Station

Figure A.5. View of the Urban Park and Akköprü Metro Station from Ankamall Shopping Center



A.7. Cross Section of the Akköprü Metro Station

A.8. Plan drawings of Akköprü Metro Station

APPENDIX B

ACOUSTICAL COMFORT AND NOISE ANNOYANCE SURVEY

1) Gender:

☐ F ☐ M

2) Age:

☐ 16 - 26 ☐ 27 - 37 ☐ 38-48 ☐ 49 - 50 ☐ 60 +

3) Education Level:

☐ Elementary School ☐ Middle School ☐ High School ☐ University
☐ Master's Degree ☐ Doctoral's Degree

4) How often do you use this route?

☐ Everyday ☐ 1-2days in a week ☐ 3-4 days in a week
☐ Monthly ☐ Other ____________________

5) From what noise do you get annoyed most during your presence in here?

(ex: sound, light, darkness, smell, crowd, other)

....

6) Can you rate the current sound level from 1 to 5 ?

Very Low	Low	Avarage	High	Very High
1	2	3	4	5

Figure B.1. Noise annoyance survey

7) Can you rate your annoyance from current sound level from 1 to 5?

Very Low	Low	Avarage	High	Very High
1	2	3	4	5

8) Can you rate your annoyance from specified sound sources from 1 to 5?

	Very Low	Low	Avarage	High	Very High
	1	2	3	4	5
Air traffic					
Land traffic					
Siren /ambulance					
Bird sound					
Water sound					
Wind Sound					
Speech					
Marching					
Ventilation					
Other					

9) Which sounds you <u>like to</u> hear dominant during your presence?

……………………………………………………………………………………………

10) Which sound you <u>don't like to</u> hear during your presence?

……………………………………………………………………………………………

Figure B.2. Noise annoyance survey

Very Low Low Avarage High Very High

	1	2	3	4	5
Air traffic					
Land traffic					
Siren /ambulance					
Bird sound					
Water sound					
Wind Sound					
Speech					
Marching					
Ventilation					
Other					

Figure B.3. Eight question prepared for the noise annoyance survey for park

	1	2	3	4	5
Metro					
Pay gates					
Marching					
Conversation					
Paging					
Ventilation					
Land traffic					
Other					

Figure B.4. Eight question prepared for the noise annoyance survey for station entrance level

	1	2	3	4	5
Metro					
Lightening					
Paging					
Conversation					
Marching					
Ventilation					
Rails					
Other					

Figure B.5. Eight question prepared for the noise annoyance survey for station platform level

AKUSTİK KONFOR VE GÜRÜLTÜ DENETİMİ ANKETİ

1) Cinsiyetiniz:

☐ K ☐ E

2) Yaşınız:

☐ 16 - 26 ☐ 27 - 37 ☐ 38-48 ☐ 49 - 50 ☐ 60 +

3) Eğitim durumunuz:

☐ İlkokul ☐ Ortaokul ☐ Lise ☐ Üniversite

☐ Yüksek Lisans ☐ Doktora

4) Bu güzergahı ne sıklıkta kullanırsınız?

☐ Her gün ☐ Haftada 1-2 ☐ Ayda 1-2 ☐ Birkaç ayda bir

☐ Diğer ______________________

5) Bulunduğunuz süre boyunca sizi en çok rahatsız eden fiziksel koşul nedir?

(örneğin: ses, ışık, karanlık, koku, kalabalık, diğer)

....

6) Buradaki ses seviyesini değerlendiriniz.

Çok Az	Oldukça Az	Orta	Oldukça Fazla	Çok Fazla
1	2	3	4	5

Figure B.6. Noise annoyance survey (Turkish version)

7) Buradaki ses seviyesi sizi ne kadar rahatsız ediyor?

Çok Az	Oldukça Az	Orta	Oldukça Fazla	Çok Fazla
1	2	3	4	5

8) Aşağıdaki seslerden hangisi sizi ne derece rahatsız ediyor?

	Çok Az	Oldukça Az	Orta	Oldukça Fazla	Çok Fazla
	1	2	3	4	5
Trafik (hava)					
Trafik (kara)					
Siren /ambulans					
Kuş sesi					
Su sesi					
Rüzgar sesi					
Konuşma sesi					
Ayak sesi					
Havalandırma					
Diğer					

9) Burada bulunduğunuz süre boyunca en çok hangi sesi/sesleri duymak istersiniz?

....

10) Burada bulunduğunuz süre boyunca hangi sesi/sesleri duymak istemezsiniz?

....

Figure B.7. Noise annoyance survey (Turkish version)

8) Aşağıdaki seslerden hangisi sizi ne derece rahatsız ediyor?

	Çok Az	Oldukça Az	Orta	Oldukça Fazla	Çok Fazla
	1	2	3	4	5
Metro					
Turnike					
Ayak sesi					
Konuşma sesi					
Anons					
Havalandırma					
Trafik					
Diğer					

Figure B.8. Eight question prepared for the noise annoyance survey for station entrance level

8) Aşağıdaki seslerden hangisi sizi ne derece rahatsız ediyor?

	Çok Az	Oldukça Az	Orta	Oldukça Fazla	Çok Fazla
	1	2	3	4	5
Metro					
Aydınlatma					
Ayak sesi					
Konuşma sesi					
Anons					
Havalandırma					
Raylardan gelen ses					
Diğer					

Figure B.9. 8th question prepared for the noise annoyance survey for station platform level

8) Aşağıdaki seslerden hangisi sizi ne derece rahatsız ediyor?

	Çok Az	Oldukça Az	Orta	Oldukça Fazla	Çok Fazla
	1	2	3	4	5
Trafik (hava)					
Trafik (kara)					
Siren /ambulans					
Kuş sesi					
Su sesi					
Rüzgar sesi					
Konuşma sesi					
Ayak sesi					
Havalandırma					
Diğer					

Figure B.10. 8th question prepared for the noise annoyance survey for the park

SOUNDWALK SURVEY

1) Gender:

☐ F ☐ M

2) Age:

☐ 16 - 26 ☐ 27 - 37 ☐ 38-48 ☐ 49 - 59 ☐ 60 +

3) Education Level:

☐ Elementary School ☐ Middle School ☐ High School ☐ University

☐ Master's Degree ☐ Doctoral's Degree

Figure B.11. Soundwalk survey prepared for the listening test

<u>Recording 1</u>

4) In what kind of space do you think this recording was taken from - Open / Semi Open/ Enclosed ?

5) What kind of sound do you hear in the recording? / Can you describe the sound sources?

6) Where do you think this recording was taken from?

7) Can you evaluate the recorded space according to the specified adjectives?

	Strongly Agree	Agree	Avarage	Agree	Strongly Agree	
	1	2	3	4	5	
LOUD						QUIET
UNPLEASANT						PLEASANT
DISTURBING						COMFORTABLE
STRESSING						RELAXING
ARTIFICIAL						NATURAL
AGITATING						CALMING
BORING						EXCITING
NOT PREFERRED						PREFERRED
CROWDED						UNCROWDED
DISORGANIZED						ORGANIZED
UNSTEADY						STEADY
CALMING						EVENTFUL
DESERTED						LIVELY
EMPTY						JOYFUL
GLOOMY						EXCITING
DARK						LIGHT
STRANGE						COMMON

Figure B.12. Soundwalk survey prepared for the listening test

SES YÜRÜYÜŞÜ (SOUNDWALK) ANKETİ

1) Cinsiyetiniz:

☐ K ☐ E

2) Yaşınız:

☐ 16 - 26 ☐ 27 - 37 ☐ 38-48 ☐ 49 - 59 ☐ 60 +

3) Eğitim durumunuz:

☐ İlköğretim ☐ Lise ☐ Üniversite ☐ Yüksek Lisans ☐ Doktora

Figure B.13. Soundwalk survey prepared for the listening test (Turkish version)

Kayıt 1

4) Dinlediğiniz kayıt kapalı alanda mı, yarı açık alanda mı yoksa açık alanda mı alınmıştır?

5) Dinlediğiniz kayıtta hangi sesleri duyuyorsunuz? / Ses kaynaklarını tanımlar mısınız?

6) Dinlediğiniz kayıt sizce nereden alinmiştir?

7) Dinlediğiniz kayıttaki mekanı aşağıdaki sıfat çiftlerine göre değerlendirir misiniz?

	Oldukça Katılıyorum	Katılıyorum	Ortalama	Katılıyorum	Oldukça Katılıyorum	
	1	2	3	4	5	
GÜRÜLTÜLÜ						SESSİZ
MEMNUNİYET VERİCİ DEĞİL						MEMNUNİYET VERİCİ
RAHATSIZ EDİCİ						RAHATLATICI
STRES YARATICI						DİNLENDİRİCİ
YAPAY						DOĞAL
HEYECANLANDIRICI						YATIŞTIRICI
SIKICI						İLGİ ÇEKİCİ
TERCİH ETMEM						TERCİH EDERİM
KALABALIK						TENHA
DÜZENSİZ						DÜZENLİ
DEĞİŞKEN						MONOTON
SAKİN						HAREKETLİ
TERK EDİLMİŞ						YAŞAYAN
DURGUN						NEŞELİ
İÇ KARARTICI						COŞTURUCU
BOĞUCU						FERAH
FARKLI						ALIŞILMIŞ

Figure B.14. Soundwalk survey prepared for the listening test (Turkish version)

APPENDIX C

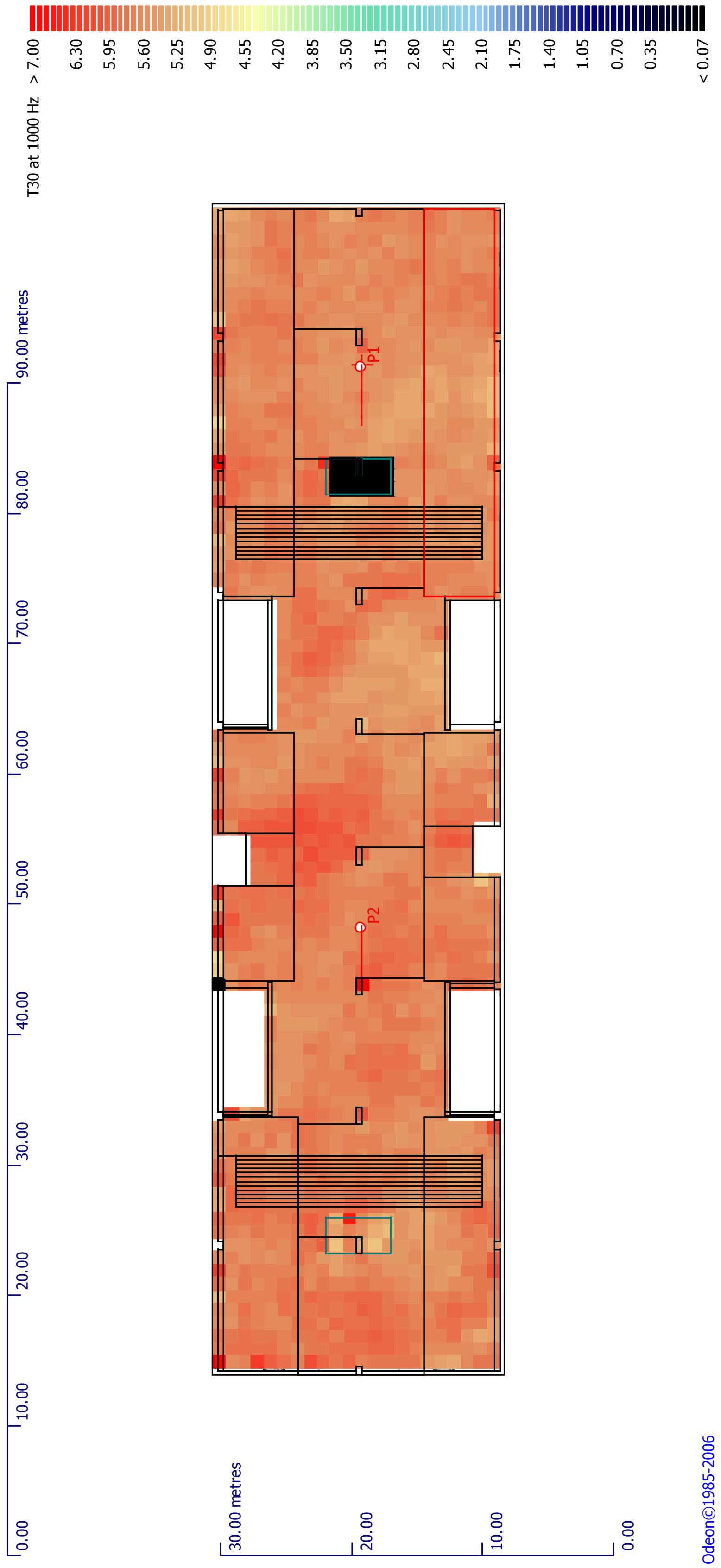


Figure C.1. Grid response of the entrance level at 1000 Hz

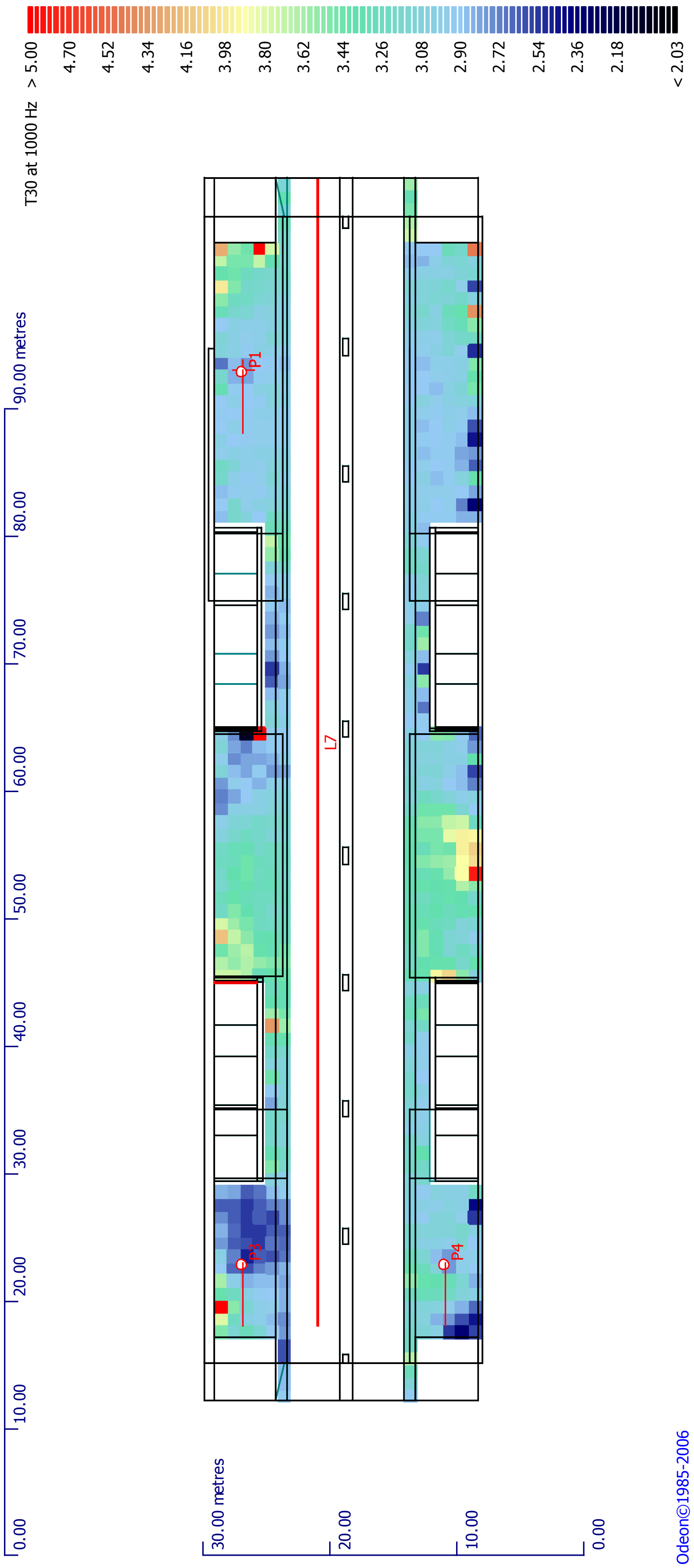


Figure C.2. Grid response of the platform level at 1000 Hz

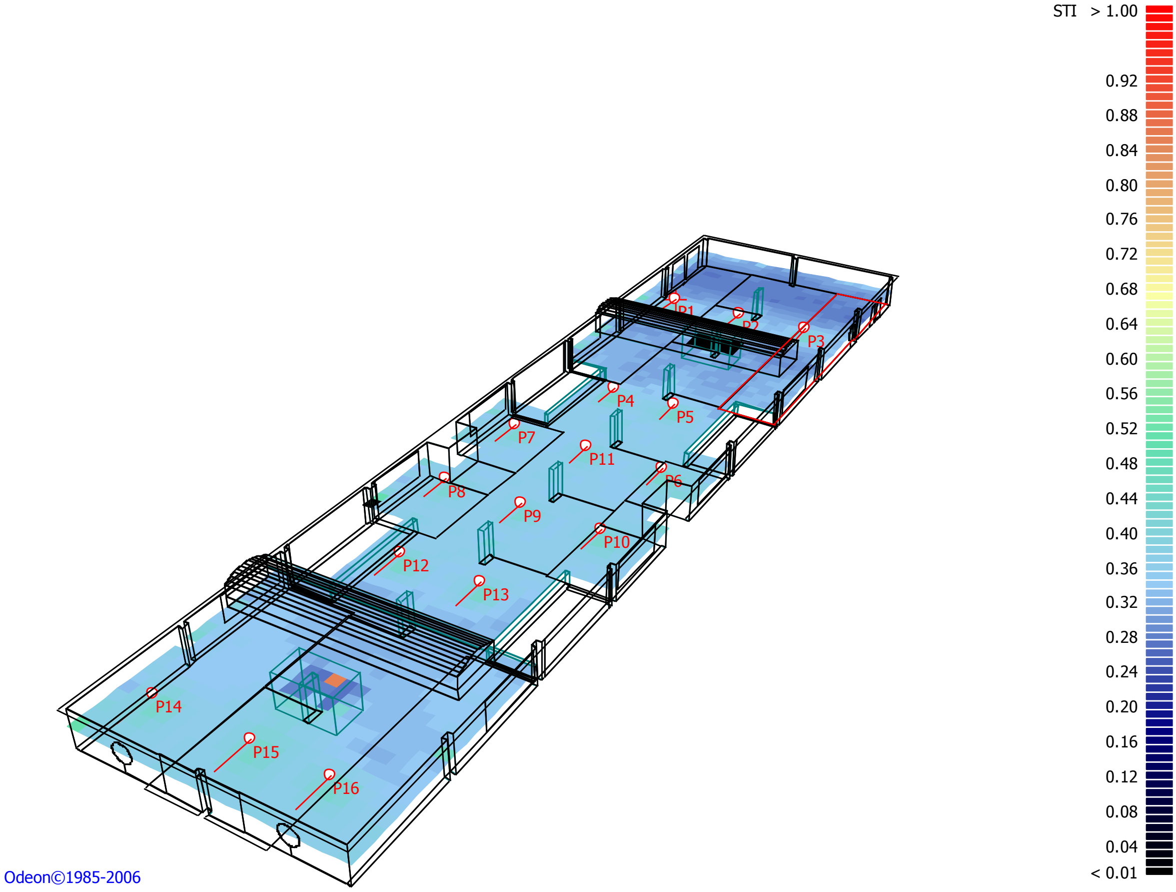


Figure C.3. Speech Transmission Index (STI) distributions of the station entrance level

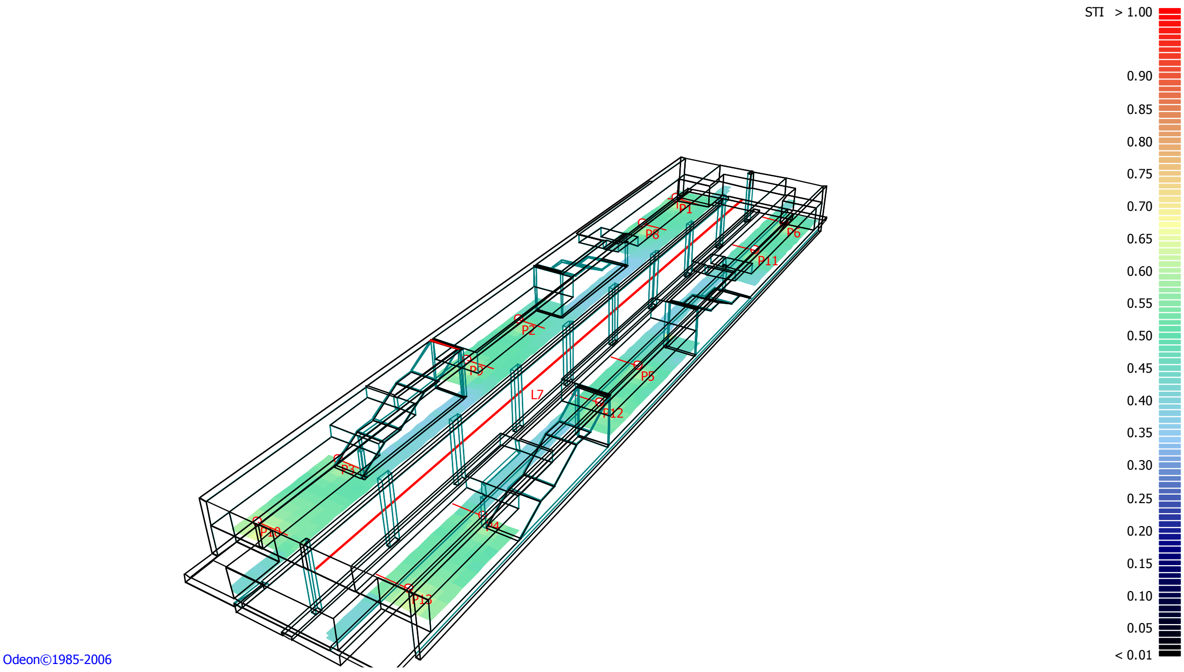


Figure C.4. Speech Transmission Index (STI) distributions of the station entrance level

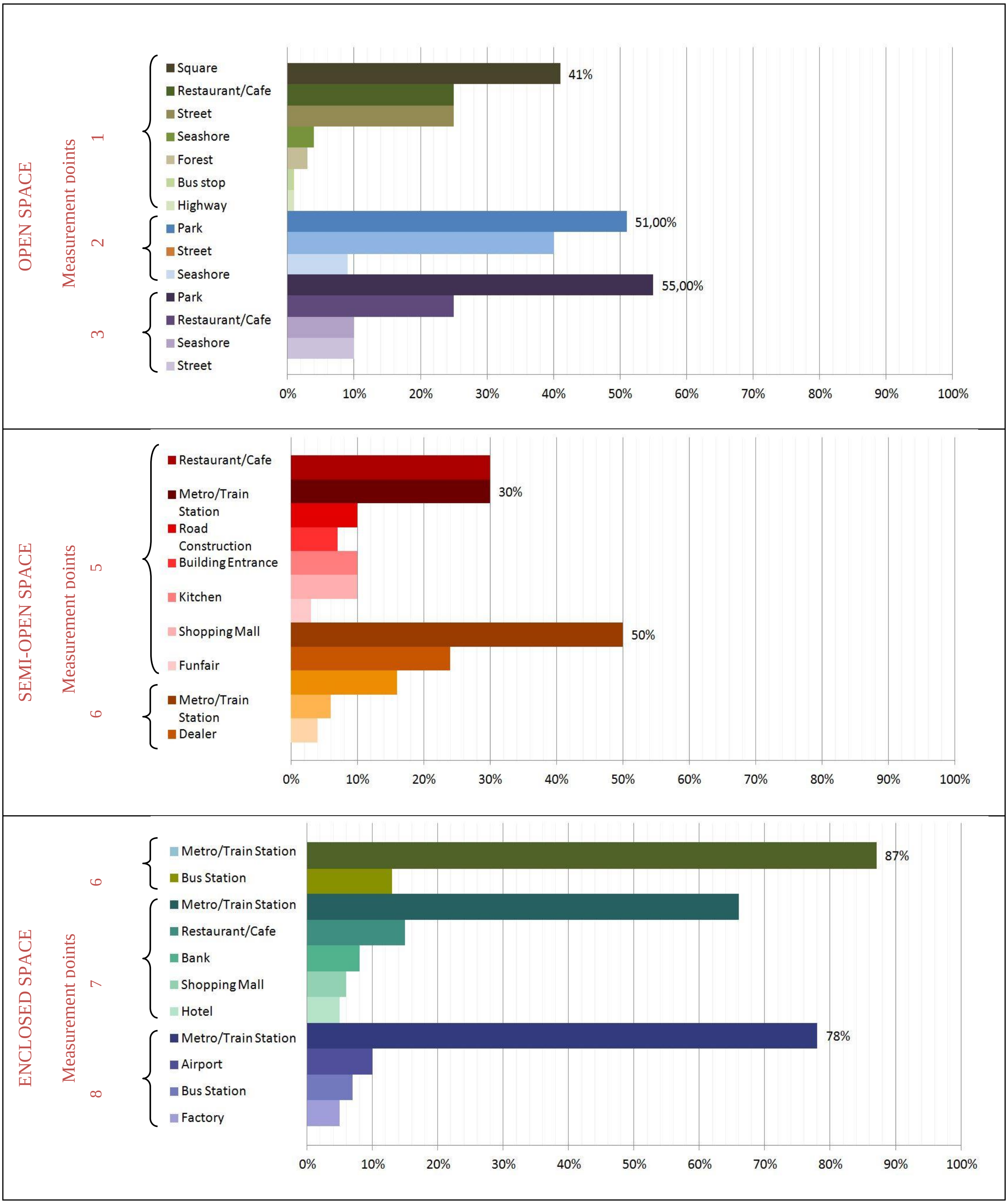


Figure C.5. Listening Test results - Subjects' verbalism of the recorded spaces (see table 14 for measurement points)

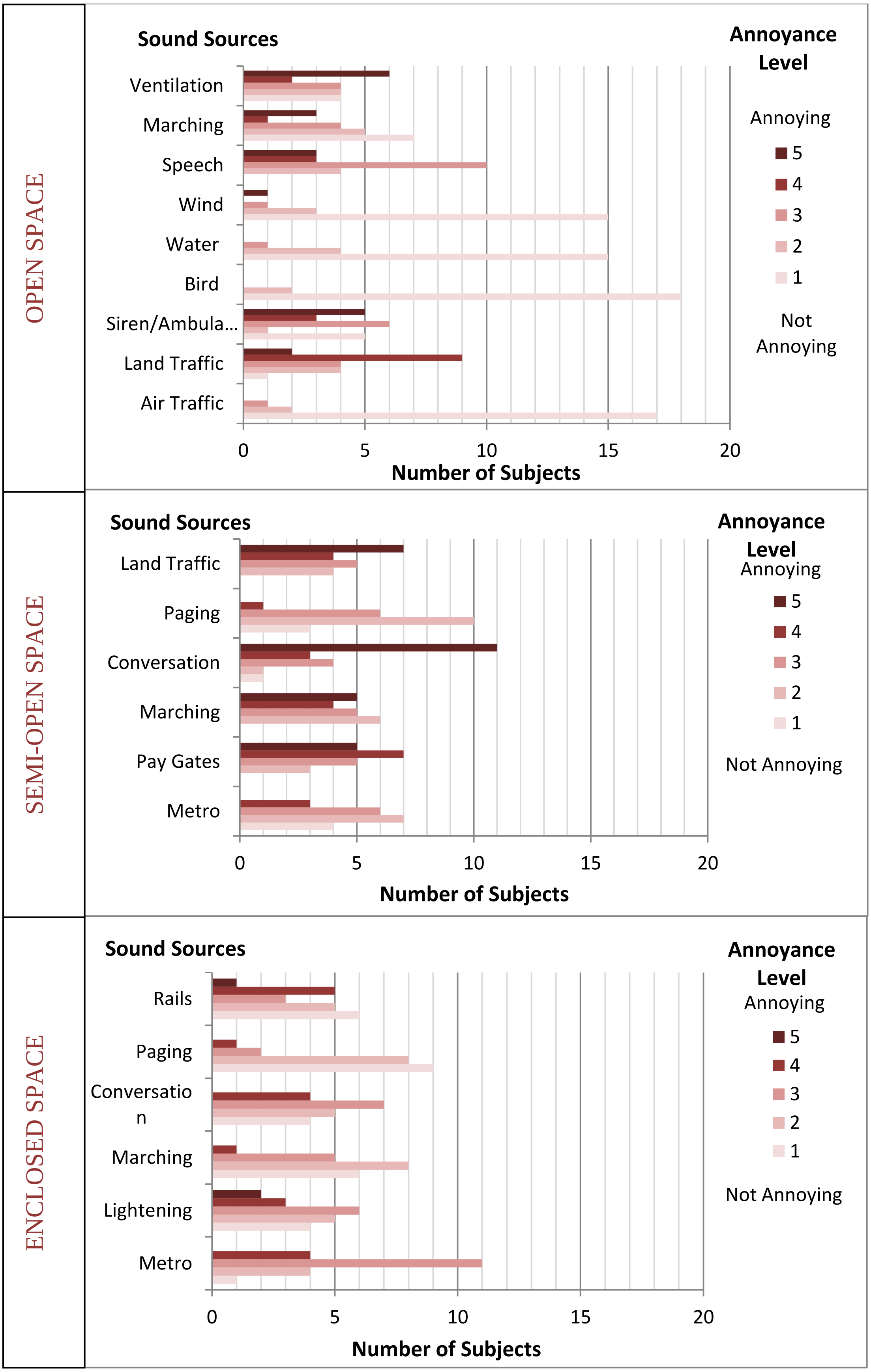


Figure C.6 . Noise annoyance ratings of the subjects on specified sound sources (see table 14 for measurement points)

APPENDIX D

1) Measurement Spot 1 (from park, see figure 14 for measurement poimts)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	doğru tahmin	90	100,0	100,0	100,0

Figure D.1.1. Results showing the percentage of intelligibility of space types)open-semiopen-enclosed)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yanlış tahmin	40	44,4	44,4	44,4
	doğru hatmin	50	55,6	55,6	100,0
	Total	90	100,0	100,0	

Figure.D.1.2. Results showing the percentage of space recognitions

2) Measurement Spot 2 (from park, see figure 14 for measurement poimts)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	doğru tahmin	90	100,0	100,0	100,0

Figure D.2.1. Results showing the percentage of intelligibilityof space types)open-semiopen-enclosed)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yanlış tahmin	44	48,9	48,9	48,9
	doğru hatmin	46	51,1	51,1	100,0
	Total	90	100,0	100,0	

Figure.D.2.2. Results showing the percentage of space recognitions

3) Measurement Spot 3 (from park, see figure 14 for measurement poimts)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yanlış tahmin	2	2,2	2,2	2,2
	doğru tahmin	88	97,8	97,8	100,0
	Total	90	100,0	100,0	

Figure D.3.1. Results showing the percentage of intelligibilityof space types)open-semiopen-enclosed)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yanlış tahmin	53	58,9	58,9	58,9
	doğru tahmin	37	41,1	41,1	100,0
	Total	90	100,0	100,0	

Figure D.3.2. Results showing the percentage of space recognitions

4) Measurement Spot 4 (from entrance level of the station, see figure 14 for measurement poimts)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yanlış tahmin	84	93,3	93,3	93,3
	doğru tahmin	6	6,7	6,7	100,0
	Total	90	100,0	100,0	

Figure D.4.1. Results showing the percentage of intelligibilityof space types)open-semiopen-enclosed)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yanlış tahmin	45	50,0	50,0	50,0
	doğru tahmin	45	50,0	50,0	100,0
	Total	90	100,0	100,0	

Figure D.4.2. Results showing the percentage of space recognitions

5) Measurement Spot 5 (from entrance level of the station, see figure 14 for measurement poimts)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yanlış tahmin	86	95,6	95,6	95,6
	doğru tahmin	4	4,4	4,4	100,0
	Total	90	100,0	100,0	

Figure D.5.1. Results showing the percentage of intelligibilityof space types)open-semiopen-enclosed)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yanlış tahmin	64	71,1	72,7	72,7
	doğru tahmin	24	26,7	27,3	100,0
	Total	88	97,8	100,0	
Missing	System	2	2,2		
Total		90	100,0		

Figure D.5.2. Results showing the percentage of space recognitions

6) Measurement Spot 6 (from platform level of the station, see figure 14 for measurement poimts)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yanlış tahmin	24	26,7	26,7	26,7
	doğru tahmin	66	73,3	73,3	100,0
	Total	90	100,0	100,0	

Figure D.6.1. Results showing the percentage of intelligibilityof space types)open-semiopen-enclosed)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yanlış tahmin	20	22,2	22,2	22,2
	doğru hatmin	70	77,8	77,8	100,0
	Total	90	100,0	100,0	

Figure D.6.2. Results showing the percentage of space recognitions

7) Measurement Spot 7 (from platform level of the station, see figure 14 for measurement poimts)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	doğru tahmin	90	100,0	100,0	100,0

Figure D.7.1. Results showing the percentage of intelligibilityof space types)open-semiopen-enclosed)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yanlış tahmin	36	40,0	40,0	40,0
	doğru tahmin	54	60,0	60,0	100,0
	Total	90	100,0	100,0	

Figure D.7.2. Results showing the percentage of space recognitions

8) Measurement Spot 8 (from platform level of the station, see figure 14 for measurement poimts)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yanlış tahmin	20	22,2	22,2	22,2
	doğru tahmin	70	77,8	77,8	100,0
	Total	90	100,0	100,0	

Figure D.8.1. Results showing the percentage of intelligibilityof space types)open-semiopen-enclosed)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yanlış tahmin	12	13,3	13,3	13,3
	doğru hatmin	78	86,7	86,7	100,0
	Total	90	100,0	100,0	

Figure D.8.3. Results showing the percentage of space recognitions

Correlations	Loud quiet	Unplea. Pleas.	Disturb. Comfor.	Stress. relaxing	Artific. natural	Agitat. calming	Boring exciting	Not pref. preferr.	Crowd. Uncrow	Disorg. Org.	Unstea. steady	Calming eventful	Diserted lively	Empty joyful	Gloomy exciting	Dark light	Strange Comm.
Loud - quiet	1,000	0,545	0,652	0,288	0,157	0,191	0,17	0,53	0,612	0,252	0,277	-0,51	-0,23	-0,27	0,032	0,401	0,158
Unpleasant - pleasant		1,000	0,715	0,122	0,246	0,008	0,277	0,563	0,218	0,208	0,232	-0,29	0,036	0,111	0,279	0,451	0,297
Disturbing- comfortable			1,000	0,352	0,094	0,226	0,436	0,626	0,349	0,25	0,234	-0,56	-0,17	0,076	0,196	0,478	0,203
Stressing - relaxing				1,000	0,102	0,676	0,522	0,27	0,207	0,005	0,087	-0,22	-0,09	-0,05	0,041	0,361	0,241
Artificial - Natural					1,000	0,188	-0	-0,1	0,097	0,245	-0,19	-0,08	-0	0,053	-0,14	-0	-0,03
Agitating - calming						1,000	0,394	0,14	0	0,176	0,026	-0,2	-0,04	-0,25	-0,06	0,196	0,101
Boring - exciting							1,000	0,475	0,125	0,441	-0,07	-0,28	-0,17	0,451	0,512	0,6	0,037
Not preferred-preferred								1,000	0,231	0,115	0,282	-0,23	-0,09	0,126	0,276	0,391	0,168
Crowded -uncrowded									1,000	0,411	0,236	-0,43	-0,45	0,034	0,041	0,148	-0,18
Disorganized - organized										1,000	0,138	-0,46	-0,29	0,146	0,156	0,282	-0,09
Unsteady - steady											1,000	-0,25	-0,11	-0,26	-0,09	-0,05	-0
Calming - eventful												1,000	0,608	0,122	-0,04	-0,46	0,038
Diserted - lively													1,000	0,042	0,193	-0,04	0,301
Empty - joyful														1,000	0,641	0,194	-0,28
Gloomy - exciting															1,000	0,629	-0,1
Dark - light																1,000	0,259
Strange - common																	1,000

Figure D.9. Correlation Matrix