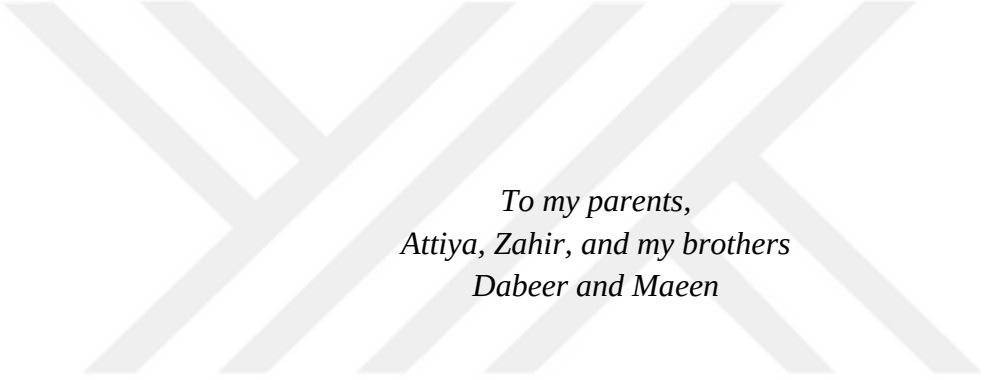


GROUNDED THEORY APPROACH ON AUDIO-VISUAL PERCEPTION OF USERS IN A UNIVERSITY CAFETERIA

A Master's Thesis

by
SHOMAILA FATIMA
SYED

Department of
Interior Architecture and Environmental Design
İhsan Doğramacı Bilkent University
Ankara
May 2024



*To my parents,
Attiya, Zahir, and my brothers
Dabeer and Maeen*

GROUNDING THEORY APPROACH ON
AUDIO-VISUAL PERCEPTION OF USERS IN A
UNIVERSITY CAFETERIA

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

by

SHOMAILA FATIMA
SYED

In Partial Fulfillment of the Requirements for the Degree of
MASTER OF FINE ARTS IN
INTERIOR ARCHITECTURE AND ENVIRONMENTAL DESIGN

THE DEPARTMENT OF
INTERIOR ARCHITECTURE AND ENVIRONMENTAL DESIGN
İHSAN DOĞRAMACI BILKENT UNIVERSITY
ANKARA

May 2024

GROUNDING THEORY APPROACH ON AUDIO-VISUAL PERCEPTION OF USERS IN A
UNIVERSITY CAFETERIA

By Shomaila Syed

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 fine arts.

Semiha Yılmaz

Advisor

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 fine arts.

Çağrı İmamoğlu

Examining Committee Member

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 fine arts.

Ayça Turgay

Examining Committee Member

Approval of the Graduate School of Economics and Social Sciences

Refet S. Gürkaynak

Director

ABSTRACT

GROUNDING THEORY APPROACH ON AUDIO-VISUAL PERCEPTION OF USERS IN A UNIVERSITY CAFETERIA

Shomaila Fatima Syed

MFA., Interior Architecture and Environmental Design

Supervisor: Assist. Prof. Dr. Semiha Yilmazer

May 2024

The study aimed to create a conceptual framework for audio-visual perception in cafeteria environments by comparing four locations with distinct audio-visual characteristics in a cafeteria at Bilkent University, Türkiye. An exploratory study was conducted using ISO 12913-2 Soundscape Method C semi-structured interviews and analyzed via the Grounded Theory (GT) method with ATLAS.ti software. To assess the perceived environment, an ISO 12913-2 Soundscape Method A questionnaire survey was administered, Equivalent Continuous A-weighted Sound Levels (LAeq) were monitored, and signal analysis generated spectrograms and time histories. Additionally, image analysis evaluated the visual environment. These measurements and responses were used to assess the Perceived Affective Quality (PAQ) of the current environment. The resulting conceptual framework revealed a complex interplay between audio-visual

contextual aspects, showing that auditory perceptions are influenced by more than just sound levels. Perceptions of sound level and source varied with different audio-visual contexts. The framework indicated that natural sounds and views reduced negative soundscapes and increased user preference. Negative responses to excessive noise and disruptive sounds highlighted the adverse effects of an unfavorable acoustic environment on comfort and satisfaction. Users employed distraction and coping mechanisms to transform negative responses into neutral or positive perceptions. Participants generally expected visual elements that enhance comfort, such as nature views, indoor plants, fewer crowds, artwork, cheerful socializing, more empty seats, clean surfaces, well-arranged furniture, and larger tables.

Keywords: Cafeteria Environment, Audio-Visual Perception, Restaurant Soundscape, Grounded Theory, Indoor Soundscape.

ÖZET

ÜNİVERSİTE KAFETERYASINDAKİ KULLANICILARIN İŞİTSEL-GÖRSEL ALGISI ÜZERİNE GROUNDED TEORİ YAKLAŞIMI

Shomaila Fatima Syed

İç Mimarlık ve Çevre Tasarımı Yüksek Lisans Programı

Tez Yöneticisi: Dr. Öğr. Üyesi Semiha Yılmaz

Mayıs 2024

Bu çalışma, kafeterya ortamlarında işitsel-görsel algı için bir kavramsal çerçeve oluşturmayı amaçlamış ve farklı işitsel-görsel özelliklere sahip dört konumu karşılaştırmıştır. Yarı yapılandırılmış görüşmeler (ISO 12913-2 Yöntem C) kullanılarak keşif amaçlı bir çalışma yapılmıştır ve veriler ATLAS.ti yazılımıyla Temellendirilmiş Teori (GT) yöntemi kullanılarak analiz edilmiştir. Algılanan ortamı değerlendirmek için katılımcılara ISO 12913-2 Yöntem A anketi uygulanmıştır, Eşdeğer Sürekli A-ağırlıklı Ses Seviyeleri (LAeq) ölçülmüş ve sinyal analizleri ile spektrogramlar ve zaman geçmişleri oluşturulmuştur. Ayrıca, görsel ortamı değerlendirmek için görüntü analizi yapılmıştır. Bu ölçümler ve yanıtlar, mevcut ortamın duygusal kalitesini değerlendirmeye yardımcı olmuştur. Ortaya çıkan kavramsal çerçeve, işitsel-görsel bağlamsal unsurlar arasındaki karmaşık etkileşimi ortaya koyarak, işitsel algıların sadece ses seviyeleriyle

değil, daha fazlasıyla etkilendiğini göstermiştir. Ses seviyesi ve kaynak algıları, farklı işitsel-görsel bağlamlarda değişiklik göstermiştir. Kavramsal Çerçeve, doğal sesler ve manzaraların olumsuz ses işitsel peyzajını azalttığını ve kullanıcı tercihlerini artırdığını belirtmiştir. Aşırı gürültü ve rahatsız edici seslere verilen olumsuz tepkiler, olumsuz bir akustik ortamın konfor ve memnuniyet üzerindeki olumsuz etkilerini vurgulamıştır.

Kullanıcılar, olumsuz tepkileri nötr veya olumlu algılara dönüştürmek için dikkatlerini dağıtma ve başa çıkma mekanizmaları kullandıklarını söylemişlerdir. Katılımcılar, genel olarak, doğa manzaraları, iç mekan bitkileri, az kalabalık, sanat eserleri, neşeli sosyalleşme, daha boş koltuklar, temiz yüzeyler, iyi düzenlenmiş mobilyalar ve daha büyük masalar gibi konforlarını artıran görsel unsurlar beklediklerini belirtmişlerdir.

Anahtar Kelimeler: Kafeterya Ortamı, İşitsel-Görsel Algı, Restoran Ses Manzarası, Grounded Teori, İç Mekan İşitsel Peyzajı.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to Asst. Prof. Dr. Semiha Yılmaz, my advisor. Her guidance and suggestions have been invaluable in shaping my academic pursuits. Her constant encouragement and belief in me gave me the strength to trust myself and persevere.

As members of the thesis defense jury, I am profoundly thankful to Asst. Prof. Dr. Çağrı İmamoğlu and Asst. Prof. Ayça Turgay for their insightful contributions. Their knowledge and perspectives have been essential to the success of this research.

To my beloved parents, Attiya and Zahir, who have been my pillars of strength. Their countless sacrifices have laid the foundation for all my accomplishments. To my dear brothers, Dabeer and Maeen, who always believed in me and inspired me to aim higher academically. They have been my driving force and my source of motivation.

A heartfelt thank you to Iqra, my home away from home, for her unwavering support in every possible way. To Nabiya, for showing me compassion and selflessness. Their emotional support has been a reason I could get back up after every setback.

Lastly, to Amna, whose immense faith in me has been a beacon of hope and motivation. Her belief in my potential has driven me to strive for higher goals and to keep pushing forward.

TABLE OF CONTENTS

ABSTRACT.....	iii
ÖZET	v
ACKNOWLEDGEMENTS.....	vii
TABLE OF CONTENTS.....	viii
LIST OF TABLES.....	x
LIST OF FIGURES	xi
LIST OF ABBREVIATIONS.....	xiii
CHAPTER I INTRODUCTION.....	1
1.1 Aim and Scope	2
1.2 Thesis Structure.....	5
CHAPTER II LITERATURE REVIEW	7
2.1 Soundscapes	7
2.1.1 Previous Studies on Indoor Soundscapes	11
2.1.2 Audio-Visual Perception in Soundscapes.....	15
2.2 Restaurant Acoustic Environments and Soundscapes.....	16
2.3 ISO/TS 12913 Soundscape Standards.....	20
2.3.1 ISO/TS 12913: 2018 Method A: Perceived Affective Quality (PAQ)	21
2.3.2 ISO/TS 12913: 2018 Method C: Grounded Theory (GT)	22
2.3.2.1 Grounded Theory	22
CHAPTER III METHOD	24
3.1 Design of the Study	24
3.1.1 Research Questions.....	25

3.2.1 Site	26
3.2.1.1 Architectural Features	26
3.2.1.2 Acoustic Environment	27
3.2.1.2.1 Equivalent Continuous A-Weighted Sound Level (LAeq) Measurements.....	28
3.2.1.2.2 Signal Processing	29
3.2.1.3 Visual Environment	32
3.2.1.3.1 Image Analysis.....	34
3.2.2 Participants	36
3.2.3 Data Collection and Analysis of the Cafeteria Environment	37
3.2.3.1 Method C- Grounded Theory.....	39
3.2.3.2 Method A- Questionnaire	40
CHAPTER IV RESULTS.....	42
4.1. Method C Grounded Theory (GT) Results	42
4.2. Method A Perceived Affective Quality (PAQ) Results	53
4.2.1 Spearman's Rho Correlation Test.....	53
4.2.2 One-way ANOVA Test	57
4.2.3 Assessment and Appropriateness of Sound and Visual Environments	58
CHAPTER V DISCUSSION.....	63
5.1 Discussion of Grounded Theory (GT) results	66
5.2 Discussion of Perceived Affective Quality (PAQ) results	69
5.3 Outcomes for Cafeteria Design	70
CHAPTER VI	72
CONCLUSION.....	72
REFERENCES	75
APPENDIX A.....	82

LIST OF TABLES

Table 1: The average A-weighted sound Level (μLAeq) of the 4 locations.....	29
Table 2: The area percentages of wall-to-total & outdoor openings of the four locations	35
Table 3: The eight main questions prepared for the semi-structured interview.	39
Table 4: Correlations with Assessment of surrounding sound environment.	55
Table 5: Correlations with Assessment of surrounding visual environment.	56
Table 6: Significant difference in the four locations of cafeteria.	57

LIST OF FIGURES

Figure 1: Brown et al. (2011) Taxonomy of the auditory environment for soundscape research, p. 390.	9
Figure 2: Soundscape Framework created by ISO12913-1(2014)	10
Figure 3: Marmara Cafeteria, Bilkent University, Ankara, Turkey.....	27
Figure 4: Figure 4: Bruel & Kjaer 2230 sound level meter, ZoomH4 sound recorder & Binaural microphone.....	28
Figure 5: Time history of the A-winter garden	31
Figure 6: Time history of the B- Dining hall-left.	31
Figure 7: Time history of the C-dining hall-piano.....	31
Figure 8:Time history of the D-dining hall-Right.....	31
Figure 9: Spectrograms of A, B, C and D.....	32
Figure 10: Panoramic photograph of Locations-A	33
Figure 11: Panoramic photograph of Location-B	33
Figure 12:Panoramic photograph of Location-C	34
Figure 13: Panoramic photograph of Location-D.....	34
Figure 14: Binary Images of Location-A.....	35
Figure 15: Binary Images of Location-B	35
Figure 16: Binary Images of Location-C	36
Figure 17: Binary Images of Location-D.....	36
Figure 18: Visit frequency of participants	37

Figure 19: Gender distribution of the participants.....	37
Figure 20: The procedure of the study.....	38
Figure 21: A summary of the conceptual framework.	43
Figure 22: The detailed conceptual framework for participants' audio-visual perception in the cafeteria environment.....	45
Figure 23: Zoomed in section-A of the frame the framework.	46
Figure 24: Zoomed in section-B of the framework.	47
Figure 25: Perceived affective quality based on mean values.	58
Figure 26: Sound environment assessment in four locations.....	59
Figure 27: Visual environment Assessment in four locations.	60
Figure 28: Audio-visual environment assessment in four locations.....	60
Figure 29: Sound environment appropriateness in four locations.	61
Figure 30: Visual environment appropriateness in four locations.	62

LIST OF ABBREVIATIONS

dB	Decibel
dBA	A-weighted decibels
GT	Grounded Theory
HVAC	Heating, ventilation, and air conditioning
ISO	International Organization for Standardization
kHz	Kilohertz
LA90	A-weighted sound level, just exceeded for 90% of the measurement period.
SPL	Sound Pressure Level
STI	Speech Transmission Index
SEM	Structural Equation Modelling
T30	Reverberation time, the first 30 dB of sound decay
WSP	World Soundscape Project

CHAPTER I

INTRODUCTION

The cafeteria environment is a complex space where various factors contribute to the users' overall experience. A cafeteria with a food court area within the facility has a common area for self-serve meals and multiple seating configurations depending on the layout of the space. Such eateries may be considered a particular type of dining space if their acoustics are considered. Sounds generated by people speaking in closed gatherings are often perceived as annoying since they can be very loud, and conversations may only be possible with a raised voice level and in closed proximity (Piamonte, J. A., Reyes, E. G. A., & Saguibo, K. E. Z., 2022). These research insights can be implied with the restaurant and cafeteria environments as they have a relatively high number of seats compared to other eateries. Due to the raised sound levels and difficulties with the conversation, there is a possibility that the users might leave the place feeling exhausted. Moreover, what we hear while eating or drinking can influence our perception of food and the overall dining experience (Reinoso-Carvalho et al., 2020; Zellner et al., 2017). The audio and visual elements of a restaurant setting significantly influence the user's experience, determining their perception and satisfaction (Wilczek et al., 2019).

According to ISO (2014), a soundscape is the acoustical environment that an individual or group of individuals perceives, experiences, and/or understands within a context.

However, the perception of soundscapes is a multifaceted and intricate phenomenon that includes not only the physical characteristics of sound but also psychological, social, and cultural (Kang et al., 2016). Although soundscape research was first conducted in urban areas, it has recently expanded to include indoor soundscapes (Yilmazer, S. et al., 2023). Numerous studies have been carried out in a variety of settings, including classrooms (Çankaya, S., 2016), open-plan offices (Acun, V., & Yilmazer, S., 2018), mosques (Yilmazer & Acun, 2018), metro stations (Yilmazer & Bora, 2017), museums (Acun & Yilmazer, 2019; Orhan & Yilmazer, 2021), hospitals (Yilmazer S. & Uğurlu Z., 2023), and restaurants (Mistar, N. A., Sulaiman, R., & Che Din, N. B., 2020; Williams, G., & Short, A. E., 2022). Çakır et al. (2021) emphasized the relevance of investigating multi-sensory perceptions in soundscapes. Among those senses, Fiebig (2023), explained that the perception of a space and the feeling of satisfaction felt in it is majorly associated with the auditory and visual senses.

The hearing and visual senses are especially influential in shaping how individuals perceive and feel content with an environment. (Fiebig, A. 2023; Syed, S. F., & Yilmazer, S. 2023).

1.1 Aim and Scope

Noise levels in eateries frequently exceed 110 dBA, with an average of 80 dBA (Williams, G., & Short, A. E., 2022). These sound levels exceed the acoustical comfort threshold in dining areas, which is 64 dBA (Novak et al., 2010). This threshold is necessary for pleasant conversations and other indoor socialization. Cafeteria noise level is an essential

factor to consider since users who find the noise level uncomfortable or unbearable would feel unsatisfied with their experience and might choose not to revisit it in the future.

While the cafeteria soundscape appears significant, its context provides a multi-sensory experience in which multiple auditory and visual elements influence how users interpret their experience.

Surroundings in a cafeteria should thus be created considering the acoustic and visual characteristics. Nonetheless, most research has only examined how people perceive their surroundings by quantitative techniques like surveys and acoustical measurements like sound levels (LAeq). Other factors affecting users' views of an eatery's environment have not been considered (Syed, S. F., & Yilmazer, S. 2023). Thus, an exploratory study could be conducted to better understand cafeteria soundscapes. Furthermore, soundscapes should also be assessed by considering visual perception, as the visual surroundings can also influence one's perception (Syed, S. F., & Yilmazer, S. 2023).

Previous studies on the soundscape in eateries such as restaurants have identified the causes of noise (Mistar et al., 2020; Williams et al., 2022), how soundscape is perceived (Meng et al., 2017; Steffens et al., 2021), and how its spatial characteristics affect soundscape perception (Çakır et al., 2021; Lau et al., 2020). Lindborg (2016) conducted a study on how users are irritated by noise coming from cutlery, furniture, music, human activity, and services. Additionally, previous research has also examined how people perceive noises produced by themselves concerning audio-visual characteristics of altering interiors (Jo et al., 2022; Jo et al., 2019).

On the contrary, the audio-visual interactions that occur among multiple individuals in shared environments remain poorly understood (Jo et al., 2022). Therefore, it is imperative to acknowledge and classify physical and interpersonal design elements to achieve the requirement for spatial distinctiveness in soundscape research and generate a satisfying sound environment (Lindborg, P., 2016).

Consequently, in addition to quantitative study, qualitative research is required to investigate how people perceive the audio-visual characteristics in a cafeteria setting. Further research is necessary to understand how the spatial design of the space and the spectral characteristics of the soundscape impact users' audio-visual experience of the restaurant environment (Syed, S. F., & Yilmazer, S. 2023).

To better understand the differences between users' perceptions and the audio-visual environment, the research investigated how people perceived the sound and visual environments in a cafeteria setting. As a result, the study was carried out at a university cafeteria in four locations (A-Winter Garden, B-Dining Hall Left, C-Dining Hall Piano, and D-Dining Hall), which were chosen based on the user's majority. Using the sound level meter on site, equivalent continuous A-weighted sound level (LAeq) measurements were performed to access the perceived acoustic environment of the cafeteria. To access the perceived visual environment, panoramic photographs were taken of the four locations. These were then visualized with signal and image processing with MATLAB R2021b. Qualitative data was then collected through semi-structured interview responses were then transcribed and analyzed with ATLAS. ti software by employing the analysis methods based on Grounded Theory (GT) techniques. IBM SPSS Statistics were employed on the Method A questionnaire (Appendix A) from the ISO soundscape

standards. These statistical analysis results were used to further support the framework formulated through Grounded Theory (GT).

1.2 Thesis Structure

This thesis is organized into six chapters. The first chapter, 'Introduction,' provides essential background information on acoustics and soundscapes, emphasizing the importance of the current study. It outlines the research objectives and scope and presents the overall structure of the thesis.

The second chapter, 'Literature Review,' explores the concept of soundscapes, briefly explaining the existing research on indoor soundscapes and the role of audio-visual perception. It examines cafeteria environments and their soundscapes and reviews the ISO/TS 12913 Soundscape standards, particularly Methods A and Method C. The chapter also covers the Grounded Theory approach as an analysis method employed on method C, discusses measurements such as the Equivalent Continuous A-Weighted Sound Level (LAeq), and explains audio signal analysis and image analysis techniques.

Chapter three, 'Method,' details the research design and methodology. It includes the formulation of research questions and mentions the assessed hypothesis for the thesis' exploratory study, a description of the study site with its architectural and acoustic characteristics, and the visual environment. The chapter explains the procedures for measuring LAeq, signal processing, and image analysis to study the existing site auditory and visual conditions. It also provides information on the participants and describes the data collection and analysis methods for understanding perceived acoustic and visual environments, including the use of questionnaires and the Grounded Theory approach.

The fourth chapter, 'Results,' presents the findings in the form of a framework from semi-structured interviews conducted using the Grounded Theory method and the results of the questionnaire survey. It includes statistical analyses such as Spearman's Rho correlation test and one-way ANOVA test, along with an evaluation of the perceived affective quality (PAQ) of the acoustic and visual environments.

Chapter five, 'Discussion,' provides a critical analysis and comparison of the research findings with earlier studies on indoor soundscapes. It addresses the three research questions posed at the start of the research, considering the hypothesis. The chapter is divided into two sections. It initially discusses the framework created through grounded theory and further discusses perceived acoustic and visual perception results achieved through the questionnaire. This chapter also compares user perceptions of the four cafeteria locations with existing research and offers outcomes for cafeteria design.

The final chapter, 'Conclusion,' serves as the thesis' conclusion, summarizing the research findings, discussing the limitations faced during the study, and offering recommendations for further investigations in the research area.

CHAPTER II

LITERATURE REVIEW

This chapter provides an overview of the soundscape literature. It provides details on soundscape evaluation methods and existing research in indoor soundscape environments. Further, the existing research on soundscapes of restaurant environments with the significance of their audio-visual perception is discussed.

2.1 Soundscapes

The word "soundscape," developed by composer R. M. Schafer, has received much attention in research regarding how people perceive the acoustic environment, especially in indoor settings. Schafer's classification of sound into keynote sounds, signals, and soundmarks gave insight into the many auditory experiences in an environment (Schafer, 1977). As defined by Schafer, Keynote sounds integrate seamlessly with ambient noise, often remaining undetected yet contributing to the environment. On the other hand, signals are prominent sounds that attract attention, such as conversation or kitchen noises at a cafeteria. Soundmarks are distinctive sounds that define a particular location, such as clinking dishes in a cafeteria. Schafer's pioneering work resulted in the founding of the

World Soundscape Project (WSP) in 1969, which focused on acoustic design, perception, and noise pollution (Schafer, 1977; Truax et al., 2014).

Before 2011, the word "soundscape" lacked an internationally acknowledged meaning, prompting Brown et al. (2011) to describe it as "existing through human perception of the acoustic environment of a place" (p. 388), paving the way for the taxonomy of the acoustical environment (Figure 1). It divided acoustic environments into internal and external settings, each having distinctive characteristics (Brown et al., 2011). Urban, rural, wilderness, and underwater environments were the four classifications of the external acoustic environment, as were the indoor or internal acoustic environment classifications.

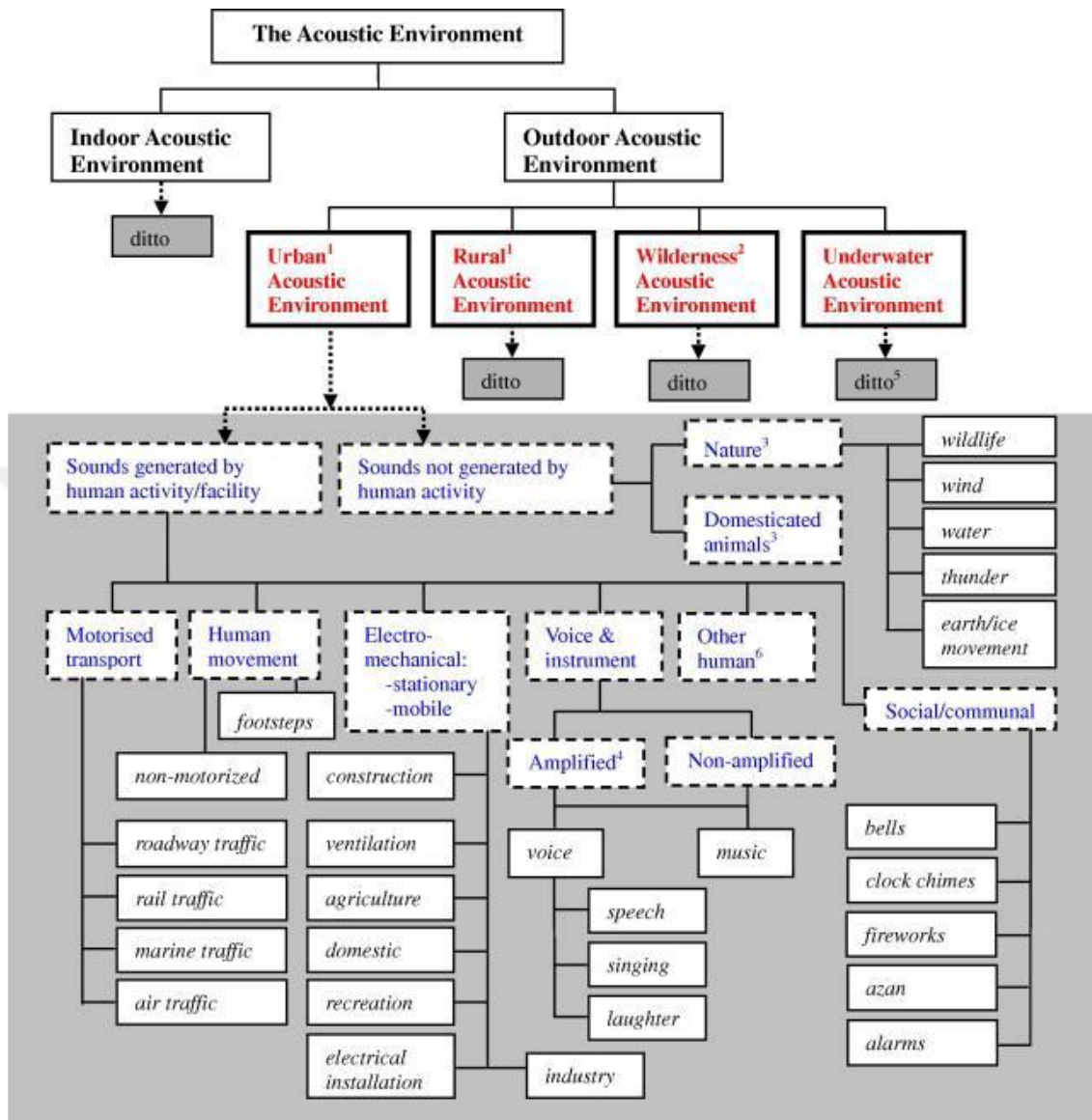


Figure 1: Brown et al. (2011) Taxonomy of the auditory environment for soundscape research, p. 390.

Soundscape, as defined by the International Organization for Standardization (ISO), is the "Acoustic environment as perceived, experienced, and/or understood by a person or people, in context" (ISO, 2014, p. 1). This concept highlights how subjective the soundscape is and how people's perception and the auditory environment are interrelated with each other (Brooks et al., 2014; Aburawis & Dokmeci Yorukoglu, 2018; Kang et al.,

2017; Yang & Kang, 2013). ISO 12913-1 (2014) outlines this relationship in the context of a soundscape framework (Figure 2).

ISO's framework has seven components: context as being the main category and then sound sources, acoustic environment, auditory sensation, interpretation of auditory sensation, responses, and outcomes, all being interconnected around context (ISO/TS 12913-1, 2014). There are numerous assessments of these elements within the cafeteria setting. The primary category that governs the interaction between sound sources and the acoustic environment is *context*. For example, the clatter of utensils and individuals' conversations may create a vibrant environment in a particular location, while in another, it may be considered disturbing. Auditory sensations, impacted by ceiling height and table layout characteristics, are important in how users perceive the cafeteria soundscape. Interpreting their sensations determines the responses and outcomes, including joy, discomfort, or behavioral changes. Understanding the intricacies of cafeteria soundscapes would allow researchers to customize the surroundings to improve users' auditory and visual experiences.

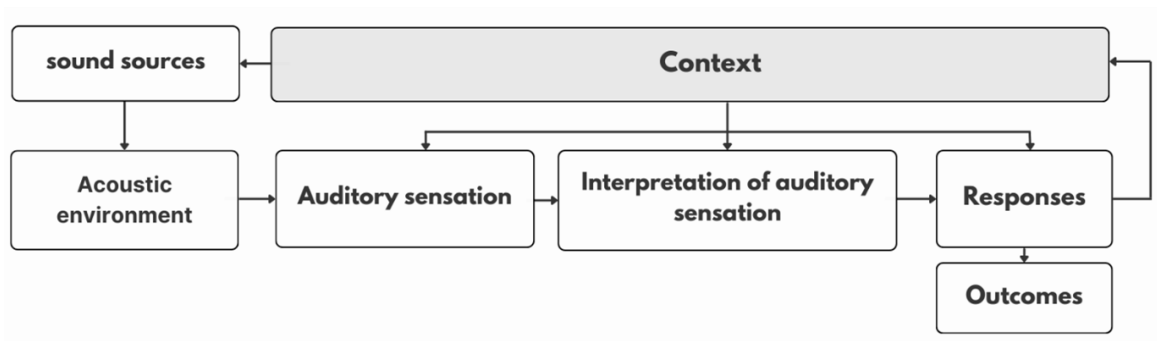


Figure 2: Soundscape Framework created by ISO12913-1(2014)

2.1.1 Previous Studies on Indoor Soundscapes

Urban contexts were largely focused on the previous year on scope of soundscape settings, but recent years have seen an emergence in indoor soundscapes as well (Torresin et al., 2020). Indoor environments differ from outdoor ones due to the presence of various surfaces with different shapes, materials, and functions. Therefore, it is essential to consider indoor soundscapes within their broader context (Syed, S. F., & Yilmazer, S. 2023). Context can refer to a place or its function. Indoor soundscape research has explored various contexts, including classrooms, open-plan offices, museums, mosques, metro stations, and hospitals (Syed, S. F., & Yilmazer, S. 2023).

Acun and Yilmazer (2018a) examined the soundscapes of four open study areas at Bilkent University: the arts and science faculty building, the library, and the dormitories. Users' satisfaction, coping strategies, and perceptual dimensions were evaluated in these locations. 120 students filled out a survey questionnaire in this area, and LAeq measurements were taken. The results indicated that the soundscape satisfaction of the participants remained unchanged with the change in sound levels in the four areas. The most common noises in all four areas were walking, laughing, and speaking, which students found most disturbing. Additionally, these noises moderately impacted their ability to focus. To cope, students employed strategies such as removing themselves from the area, wearing earphones to maintain concentration, or moving to a quieter location.

In 2022, Çankaya and Yilmazer based their research on Bilkent High School to compare students' auditory perceptions between a classroom and a computer lab. They measured the Speech Transmission Index (STI), Equivalent Continuous A-Weighted Sound Level (LAeq), and Reverberation Time (T30). The study employed semi-structured interviews as

a qualitative method and a questionnaire survey as a quantitative approach. Out of 117 students who completed the questionnaire, 50 were interviewed. Grounded Theory analysis techniques were used on the data collected by the interviews, while the questionnaire results underwent statistical analysis with SPSS v.20. The findings revealed that students' responses to their surroundings varied depending on the background of the sound source, suggesting that noise levels were not the sole factor influencing perception. The results produced a conceptual framework illustrating the dynamic between student perception, the built environment, and the acoustical surroundings.

In another study, Acun and Yilmazer (2018b) explored acoustic environments in two open offices, one engineering office and one architectural office, by interviewing staff members. They used Odeon Room Acoustics Software for acoustic simulations and collected LAeq measurements. The Grounded Theory method was applied to interviews with 49 employees, resulting in a conceptual framework that highlighted how context, activity type, and surrounding elements shape perceptions. It was found that both the context and personnel attributes influenced preferred sounds. Employees developed coping strategies such as eliminating the sound source, tolerating it, or using headphones to maintain concentration. Interestingly, employees expressed a dislike for both excessive noise and silence but found motivation in the sounds produced by keyboards and mouse.

Jo and Jeon (2022) investigated soundscape perception in open-plan office environments through two studies conducted in four virtual office settings with varying audio-visual characteristics. In the first study, they explored the relationship between work performance and satisfaction to visual complexity and acoustic diversity. Thirty-four

participants were exposed to 24 audio-visual stimuli and completed a questionnaire on job satisfaction. The second study examined how different sound sources impacted employees' emotional and work-related quality. Forty-one participants experienced 36 visual and auditory stimuli and provided feedback via a questionnaire. The findings indicated that specific visual and auditory elements could enhance both productivity and enjoyment. Additionally, employee satisfaction and productivity improved when they felt comfortable and content in their environment.

In a study by Acun and Yilmazer (2019) of the Museum Rahmi Koç, the responses of visitors to the museum's acoustic environment were investigated. Data were collected through a questionnaire completed by 113 visitors, interviews with 15 visitors, and LAeq measurements. Using the GT approach, a conceptual framework was developed, and Structural Equation Modeling (SEM) was applied to analyze the relationships among the framework's categories. Despite expectations, SEM analysis did not find the anticipated correlations, suggesting that specially designed soundscapes can enhance the museum experience in ways not initially predicted.

Orhan and Yilmazer (2021) compared visitor perceptions of built and auditory environments in the Erimtan Archaeology and Arts Museum, with its modern setting and the historic Rahmi M. Koç Museum. Sixty visitors completed surveys, and LAeq measurements were taken. Additionally, interviews with 13 visitors using the Grounded Theory method revealed that visitors preferred historical settings for historical displays and appreciated acoustic environments that complemented these settings. Positive feedback was given to the interactive exhibition sounds, which enriched the auditory environment.

Yilmazer and Acun (2018) examined the soundscape perceptions and expectations of users at the Hacı Bayram Mosque, a place of prayer and worship. Using Odeon Room Acoustics Software, LAeq measurements, T30, and STI values were collected. Semi-structured interviews with 15 users led to the development of a conceptual framework using the Grounded Theory method. Findings indicated that despite high surrounding noise levels, participants did not consider these disturbances due to the mosque's religious significance. Participants identified the mosque's identity through its acoustic characteristics, which significantly influenced their soundscape expectations and perceptions.

Soundmarks of the Akköprü metro station and its surroundings were examined by Yilmazer and Bora (2017). They conducted LAeq measurements and audio recordings at eight locations, followed by a listening test where 60 participants evaluated the sound samples. The spatial functions of the sounds heard were identified by half of the participants. Natural soundmarks, as well as those at the metro station entrance and inside the metro, helped participants associate the sounds with their locations. Notably, outdoor sounds received more positive ratings than indoor sounds. Additionally, females and younger individuals efficiently identified the sound sources compared to males and older adults.

By examining these various contexts and their impacts on soundscape perceptions, these studies underscore the complex interplay between environmental factors and human responses, highlighting the importance of tailored acoustic management strategies in different settings.

2.1.2 Audio-Visual Perception in Soundscapes

Like the auditory environment, one aspect that helps evaluate the context is the visual environment. The interactions between these settings should be considered for a well-perceived audio and visual environment (Syed, S. F., & Yilmazer, S. 2023). For instance, the visual surroundings or sense of sight may also affect how one perceives a soundscape (Li & Lau, 2020; Liu et al., 2013). Since the audio-visual elements can enhance the soundscape, it is essential to simultaneously assess the sound and visual surroundings (Hong & Jeon, 2013). The acoustic and visual components of an environment should be assessed concerning their impact on people's perceptions.

The auditory and visual interactions between many individuals in shared places are barely researched (Syed, S. F., & Yilmazer, S. 2023). Offices, hospitals, urban residential outdoors, and interiors are the contexts that have all been subjected to research on the audio-visual perception of soundscape (Syed, S. F., & Yilmazer, S. 2023).

According to research by Davies et al. (2013), our perception of noise annoyance is greatly influenced by the kind and the quantity of sound sources present in a soundscape. It recognized that other senses, such as perceptions of sight, can also influence our experience of noise discomfort. For instance, noise may become less annoying when looking at nature, such as trees or water. The study proposed that a comprehensive strategy that considers both auditory and visual characteristics might be helpful when planning urban areas to reduce noise nuisance. However, the spatial arrangement of the space and how spectral soundscape characteristics influence users' audio-visual perceptions of the eateries need to be further researched (Syed, S. F., & Yilmazer, S. 2023). This chapter investigated soundscape evaluation methodologies and prior research

on soundscapes in the literature. It also looked at audio-visual perception and soundscapes in eateries. The study methodology will be explained in the chapter that follows.

2.2 Restaurant Acoustic Environments and Soundscapes

Most research in the scope of restaurant environments has focused on sound levels without considering other elements influencing users' perceptions of these environments. Existing studies on soundscapes in restaurant environments have addressed noise and its contributing factors (Mistar et al., 2020; Williams et al., 2022), the perception of soundscapes (Meng et al., 2017; Steffens et al., 2021), and the impact of spatial characteristics (Çakır et al., 2021; Lau et al., 2020). A taxonomy for perceived sound sources in restaurants was proposed by Lindborg (2016). Yet not much is known about how the spatial arrangement of the space and the spectral characteristics of the soundscape influence users' audio-visual perceptions of the dining area.

Mistar et al. (2020) did a literature study that included 1,191 publications from various fields. They created a database of related research and put it through a multi-step screening procedure to find the main variables that determine acoustic comfort. The study reviewed the literature to offer a framework for classifying acoustic comfort in dining establishments. It emphasized how important a comfortable listening atmosphere is to increase customer satisfaction and willingness to return. It was demonstrated that the physical environment, restaurant design, and noise levels are essential factors influencing acoustic comfort. These components significantly influenced participants' opinions of a restaurant's ambiance and overall perceptions.

The study suggests a framework based on the six factors that were found: types of restaurants, physical environment, noise source, layout and arrangement, density, and demography. It emphasizes the importance of considering these factors to enhance the overall dining experience and acoustic comfort for customers. The framework is meant to be a reference for acoustic design in the food and beverage industry, emphasizing the need to balance environment and noise levels to provide a comfortable eating experience.

In their 2022 study, Williams, G., and Short, A. E. investigated how noise affected participants' anxiety levels in indoor restaurant environments, considering individual variances in noise sensitivity, irritation threshold, and personality factors. The study, which focused on a randomly selected sample of people ($n = 274$) above 18, used a mixed-methods survey with validated measures. The data was collected using an online platform, and the predictive ability of the parameters on reported anxiety levels was investigated using hierarchical multiple regression. It was demonstrated that increased degrees of annoyance and sensitivity to noise relate to anxiety. All of these are factors that restaurant owners could consider to minimize the impact of noise on users. The study examined the potential effects of restaurant layout and acoustics on noise levels and customer satisfaction. It emphasizes the importance of understanding how noise impacts mental health and social interactions in public settings like restaurants, underscoring the need for more public awareness and noise management. This study provides valuable design suggestions for restaurants that will improve users' dining experience and provide information on the psychological effects of noise in public spaces.

Meng et al., J. (2017) investigated the effects of different table layouts on users' speech behaviors and perceptions of acoustics in Chinese restaurants. The three dining styles—

centralized, separate, and dispersed—are compared, with aspects such as background music and crowd density taken into consideration. The experiment includes a questionnaire survey at typical eateries and acoustic measurements. It measures the frequency of conversations, sound pressure levels, and acoustic comfort by accounting for the number of users at each table and the presence of background music. The findings suggest that dining patterns might significantly influence sound pressure level and acoustic comfort. While the separate style efficiently lowers sound pressure levels, especially in quieter areas, centralized dining increases the frequency of conversations. The degree of acoustic comfort increases in more scattered dining areas with lower crowd densities as the density of people decreases. It was discovered that background music had no adverse effect on conversational levels. However, users prefer background music at lower crowd densities for improved comfort, which impacts acoustic comfort. The study offered insights into how restaurant design and management might carefully consider acoustic elements and dining patterns to maximize dining experiences.

Research conducted by Steffens et al. (2021) examined the effects of room acoustics, particularly sound pressure level and reverberation time, on the assessment of the soundscape and overall customer satisfaction in restaurants. Research in the field was carried out with 142 volunteers in 12 different Berlin eateries. In addition to rating acoustical and non-acoustical aspects associated with restaurant quality, participants provided feedback on the A-weighted sound pressure level and reverberation time. The findings suggest that the sound pressure level and reverberation time significantly impact how pleasant and eventful the soundscape is. The study suggests that restaurant acoustics must balance liveliness and comfort depending on the desired ambiance. Since the A-

weighted sound pressure level (LAeq) impacts the restaurant's overall quality and the soundscape's pleasantness, it must be controlled. Controlling the reverberation time (T20, occ) is essential since it reduces the influence of the sound pressure level, changing the soundscape. The study highlights the complex interactions between acoustical and non-acoustical factors and recommends more research to comprehend their combined influence on restaurant quality completely.

Çakır et al. (2021) employed psychoacoustic parameters such as loudness, sharpness, roughness, and fluctuation intensity to assess the acoustic comfort in various restaurants. Their methodology involved a combination of surveys, on-site measurements, and laboratory hearing tests to gather both objective and subjective data across different dining establishments. The study revealed that enhanced acoustic comfort was associated with higher sharpness, lower loudness, shorter reverberation times, and lower roughness values. This model suggests that it is possible to manage restaurant acoustics effectively without needing structural changes, potentially guiding future acoustic design decisions.

In a related study, Lau et al. (2020) examined the impact of restaurant acoustic environments on customer satisfaction and word-of-mouth communication in Singapore, Macao SAR, and Hong Kong SAR. They measured noise levels and conducted a questionnaire survey during lunchtime at various restaurants in these regions. The study also considered factors such as restaurant layout, size, and customer behavior. Results indicated that restaurants in Singapore were generally louder than those in Macao SAR and Hong Kong SAR. The loudness from restaurant services negatively affected the acoustic environment and users' subjective emotions. Additionally, the study found that

the acoustic environment, including service-related noise, significantly influenced customer satisfaction and their willingness to recommend the restaurant to others.

Lindborg (2016) examined noises from people, tables, cutlery, music, and activities in restaurants that might irritate participants. The study suggests a system of classification that links sound units to Likert scales for perceived sound sources in restaurants. Data on perceptual evaluations, sound remarks, and environment-specific terms were gathered from 40 restaurants. Through cladistic analysis, a classification was created. The created classification, SSR, emphasizes the significance of context in soundscape perception and has proven helpful for field research, simulation design, and sound perception theory. Additionally, the research could help with simulation design and enhance comprehension of how users hear sounds in restaurants. This study demonstrates how our perceptions of sounds may be influenced by their circumstances, such as being in a restaurant. Additionally, it highlights a potential positive bias in sound perception that might change with careful listening.

2.3 ISO/TS 12913 Soundscape Standards

ISO/TS 12913-1, published by the International Organization for Standards (ISO) in 2014, provides a definition and conceptualization of soundscapes. Nevertheless, the establishment of criteria for data collection or evaluation in soundscape research was absent. As a result of ISO/TS 12913-2, guidelines were established in 2018 for the collection and assessment of environmental research data. This standard provided information on methodologies for individual, environmental, and acoustic assessments, along with reporting guidelines for study participants and acoustic data. Therefore, three data collection methods were incorporated into the ISO/TS 12913-2 standards: Method A

(questionnaire), Method B (soundwalk), and Method C (semi-structured guided interviews), in addition to minimum reporting criteria for the research sample and the auditory environment.

2.3.1 ISO/TS 12913: 2018 Method A: Perceived Affective Quality (PAQ)

Among the three approaches, the Method A questionnaire approach is divided into four parts to capture the opinions of individuals on sound in different contexts. It is often used in soundscape research (Erdoğu & Yilmazer, 2021; Şahin, 2020). These sections cover identifying sound sources, evaluating the appropriateness of the acoustic environment, and assessing perceived affective quality, among other topics. According to ISO/TS (2018), the questionnaire can be expanded to include more detailed questions related to the study's context. Participants should be informed about the study's purpose from the outset, participation should be voluntary, and they should have the option to withhold information if they feel uncomfortable.

The first part of the survey is dedicated to the classification of distinct categories of sounds within the context of the study: "sounds of technology," "sounds of nature," and "sounds of humans" (ISO/TS, 2018, p. 14). Participants assess which noises are more dominant. Section two asks them to indicate how much they agree with eight adjectives that characterize the surrounding's sound. The third and fourth sections utilize a five-point Likert scale to evaluate and determine the suitability of the auditory environment. To interpret the questionnaire data, ISO/TS 12913-3 (2019) recommends statistical analysis techniques such as correlation analysis, linear regression, and ANOVA. Due to the correlation between attributes, the results of the perceived affective quality section can also be represented using a two-dimensional model.

2.3.2 ISO/TS 12913: 2018 Method C: Grounded Theory (GT)

As described in ISO soundscape standards, Method C- semi-structured interviews are used for gathering research data. The GT technique, also recommended in ISO/TS 12913-3 (2019), can be used to analyze the interviews. Compared to the other two methods, method C offers greater flexibility due to the lack of strict guidelines. Researchers pre-determine questions related to the auditory environment in a specific setting; however, additional questions may arise spontaneously during the interviews. ISO standard provides example questions for soundscape research, suggesting that these be adapted based on the study's context. Nonetheless, ISO/TS (2018) notes that not all questions are suitable for every scenario, and new questions may emerge as conversations progress. Grounded Theory (GT) method, as outlined in ISO/TS 12913-3(2019) and Strauss (2010), is used to analyze the interview data. According to Bhattacharjee (2012), GT allows researchers to derive insights from participants without introducing bias.

2.3.2.1 Grounded Theory

Glaser and Strauss introduced grounded theory (GT) in 1967 as part of their sociological research program (Charmaz, 2014; Walker & Myrick, 2006). According to Dey (1999) and Walker and Myrick (2006), GT is the most often used method of exploratory study analysis. It involves gathering data and then presenting a researcher's hypothesis. This provides the researcher with the flexibility to simplify and enhance the information, an aspect that was disregarded before the collection of data. According to Corbin and Strauss (1990), interviews might be methodically evaluated if the Grounded Theory method's protocols were followed. The protocol specifies that gathering and analyzing data must be completed simultaneously. Data analysis can begin as soon as the initial interview

responses are gathered. Three levels of coding analysis will be applied to the answers: open, axial, and selective coding. The first step in this procedure would be to extract the main themes. These ideas come from the unprocessed interview data, and continual comparison is used in the analysis to create categories (Corbin & Strauss, 1990). Some of the concepts would then come together to form categories. After that, a theory is developed, and the link between the categories is defined.



CHAPTER III

METHOD

The methodology of the study in this chapter includes details on the research objectives, hypothesis, and methodology, in addition to describing the site along with its architectural, acoustic, and visual features and the participants. This chapter also explains the data collection and analysis procedures used for the study.

3.1 Design of the Study

The objective of this study was to examine how participants perceive the audio-visual environment in a university cafeteria through a comparison of four different locations, each with its own set of audio-visual characteristics. To attain a complete understanding of the correlation between the participants' experience and the audio-visual environment, an exploratory study was conducted through semi-structured interviews. From the data collected by conducting interviews with participants at each of the four locations, a conceptual framework for the cafeteria environment was constructed utilizing the Grounded Theory (GT) method. Before conducting the study, a pilot study was done with six participants and a hypothesis for the study was assessed from the information

collected. The semi-structured interviews were then conducted keeping in mind the assessed hypothesis. To investigate the current perceived environment, a survey questionnaire was provided to the participants, Equivalent Continuous A-weighted Sound Levels (LAeq) were monitored, and signal analysis were carried out to create spectrograms and time histories. Furthermore, image analysis was performed to evaluate the perceived visual environment. These measurements and questionnaire responses assisted in assessing the current environment in terms of its perceived affective quality. This integrated approach resulted in a thorough understanding of the different manners in which the cafeteria's users experience the audio-visual environment.

3.1.1 Research Questions

This study focuses on answering the following research questions.

1. How does the acoustic environment affect the participants in the cafeteria?
2. How does the visual environment affect the participants in the cafeteria?
3. Is there any relation between the spectral characteristics of the acoustical environment and the user's auditory perception in the cafeteria?

From a pilot study of six people, a hypothesis was assessed for this exploratory study. It was assumed that the users preferred sitting next to the windows, and they also avoided sitting in the areas around the buffet counter. Furthermore, it was assumed that the user preferred silence or music from the piano as a preferred background sound environment rather than the background noise coming from the cafeteria services as it provoked the negative soundscape among the users.

3.2 Method

The method of the study includes the architectural and acoustic characteristics and the visual characteristics of the site. To define the acoustical environment, it is essential to include details about sound sources, wind and weather conditions, measurements from the sites, the time of year, and metrics such as LAeq and LCeq. ISO/TS 12913-3 (2019) recommended integrating multiple approaches for triangulating studies. In Addition to data collection and evaluation techniques like using Methods A, B, and C, ISO standards also established criteria for other techniques such include using signal processing and image analysis to represent data from both visual and auditory environments.

3.2.1 Site

The study was carried out in Bilkent University's Marmara Cafeteria. The cafeteria is designed in a rectangular shape and uses the concept of self-service. Students and teachers are drawn by its reasonably priced meal options, and they typically visit for meals such as lunch and dinner. There are acoustic and visual differences between the areas in the cafeteria due to distinct finishes and roof elevations, the distance between tables and the buffet counter, and windows that provide views of the outdoors. To examine the auditory and visual sensations of the participants, measurements were obtained from four different locations on the ground floor level of the cafeteria, with the highest frequency of participants present.

3.2.1.1 Architectural Features

As shown in Figure 3, the four locations were A-Winter Garden, B-Dining Hall left, C-Dining Hall piano, and D-Dining Hall right. Despite being in a similar setting, these

spaces have different visual and acoustic components, which alters participants' experiences with the cafeteria's soundscape. Floor tiles made of marble, walls covered with ceramic tiles, floor-length windows made of glass, and columns made of exposed cement plaster were some of the materials used. The ceilings are partly exposed with HVAC, partly made of wood, and vary in height. Point A has a wood-finished suspended ceiling made of micro-perforated panels (MPPs).



Figure 3: Marmara Cafeteria, Bilkent University, Ankara, Turkey

3.2.1.2 Acoustic Environment

Like most eateries, the sounds were produced by multiple sources. In-situ measurements were taken (see Figure 4) at 150 cm height using a ZoomH4 sound recorder and a Binaural microphone. The Bruel & Kjaer 2230 sound level meter was used to measure the equivalent continuous A-weighted sound level (L_{Aeq}). The primary sound sources in the four locations were from human-based activities, such as the unintelligible and intelligible speech of both male and female users and service staff, footsteps, eating sounds, laughing, and pouring of water. All the sound sources included sounds from the utensils' collision, furniture dragging, piano playing, the noise of electrical appliances, and the echo of these

sounds. The overall acoustic environment of the restaurant was expected to be noisier, with higher sound levels during peak rush hours. Moreover, the frequently heard noise was of the metal utensils being washed. The speech and footsteps of the service staff at the buffet counter and service area were also part of the auditory environment. The farther ends of the cafeteria were expected to be quieter than the main dining hall as it was away from the primary source of the sound, which was the buffet counter.



Figure 4: Figure 4: Bruel & Kjaer 2230 sound level meter, ZoomH4 sound recorder & Binaural microphone.

3.2.1.2.1 Equivalent Continuous A-Weighted Sound Level (LAeq) Measurements

According to Brüel and Kjaer (n.d.), the Equivalent Continuous A-weighted Sound Level (LAeq) is the pressure level (SPL) of the sound that is measured using a filter setting called an A-weighting at a certain moment in time. A sound level meter can be used to determine this measurement, which is given in decibels (dB). Since LAeq successfully filters out low-frequency noises that the human ear normally does not perceive, it is

commonly used in soundscape studies (Egan, 1988; Orhan, 2019). As a result, sound pressure levels with different weightings do not align as closely with human perception as LAeq does.

To begin with, according to ISO/TS 12913-2 (2018), the Equivalent Continuous A-Weighted Sound Level (LAeq) is a physical characteristic of the acoustic environment. On Tuesday, November 1, 2022, between 12:00 and 14:00, during the interview hours, five minutes were spent at every location taking the LAeq measurements. This timeframe was chosen since it represented peak hours. The afternoon hours were avoided due to the absence of certain university day scholars. At each of the four locations, a Brüel & Kjaer Hand-held Analyzer Type 2230 sound level meter was used to measure LAeq. As per ISO/TS 12913-3 (2019), the device was positioned at a height of 150 cm in the center of every location. The Equivalent Continuous A-Weighted Sound Level (μ LAeq) mean for each of the four locations throughout the interview hours is shown in Table 1. The difference was expected based on changes in visual and auditory features across locations.

Table 1: The average A-weighted sound Level (μ LAeq) of the 4 locations

Locations	A	B	C	D
LAeq	75	85	80	78

3.2.1.2.2 Signal Processing

Moura (2009) defines a signal as a physical parameter encompassing speech, images, videos, audio, or sensory data. Time and frequency are two domains in which audio signals may be displayed. These signals are defined by characteristics like frequency and loudness. These signals are analyzed using signal processing methods, which allow for

various interpretations and the extraction of information (Abraham, 2017; MATLAB, n.d.). To do this, the signal must be coded, filtered, reproduced, and formatted to the required output (MATLAB, n.d.; Moura, 2009).

Digital tools like MATLAB, Python, and GNU Octave are frequently used for signal analysis (Smith, 2022). In audio signal processing, the primary focus is on filtering the signal, with MATLAB being particularly powerful for processing and visualizing audio signals (MATLAB, n.d.). By isolating the relevant data, the processed signal becomes more comprehensible. Visualizing an audio file in the time domain, which reflects how humans perceive sound over time, is ideal. This includes displaying the signal's frequency and amplitude or its amplitude and intensity (dB) against the time domain. The short-time Fourier transform (STFT) is especially useful for this purpose, as it generates a spectrogram that visualises the audio signal in a frequency-time graph domain (Smith, 2011; Acun, 2021).

After the binaural audio recordings were taken at the four locations using a binaural microphone, MATLAB R2021b was used for signal processing. The most effective 30-second sound clips from each recording were chosen to depict each distinct sound environment. Spectrophotograms and time histories were acquired to examine variations in frequency and amplitude across time. Time histories (Figure 5-8) display the variations in the sound's amplitude over time, while spectrograms illustrate the variations in frequency and amplitude over time. During the analysis of the spectrogram peak points, each peak point was assigned a corresponding sound source from the 30-second clip.

Visualizations were made of the four locations' binaural audio recordings. First, their time histories were recorded. The amplitude range for each of the four locations was set at 0 to 55 to simplify comparisons. Of the four locations, Location D has the largest amplitude.

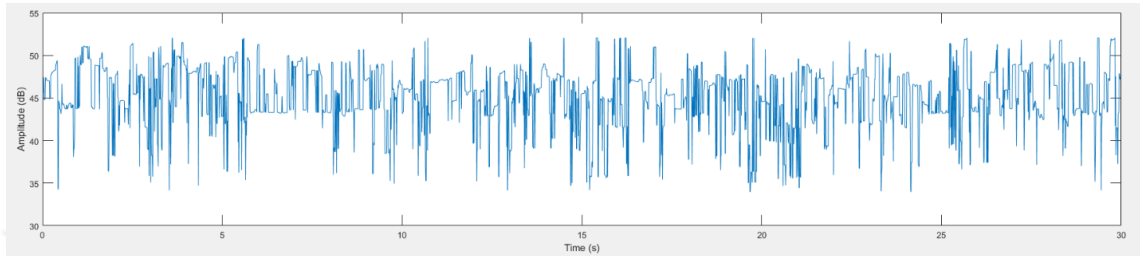


Figure 5: Time history of the A-winter garden.

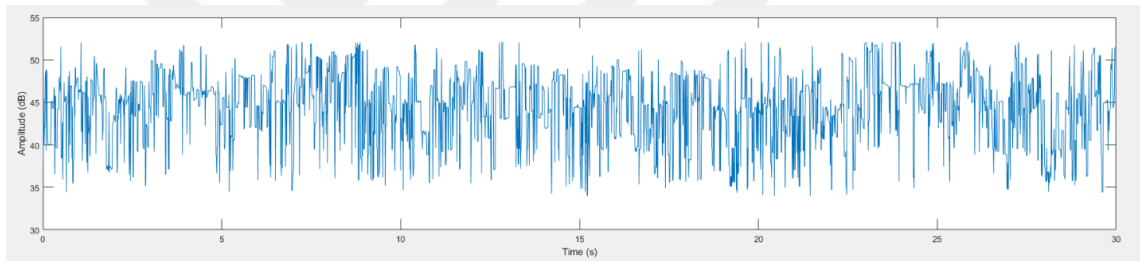


Figure 6: Time history of the B- Dining hall-left.

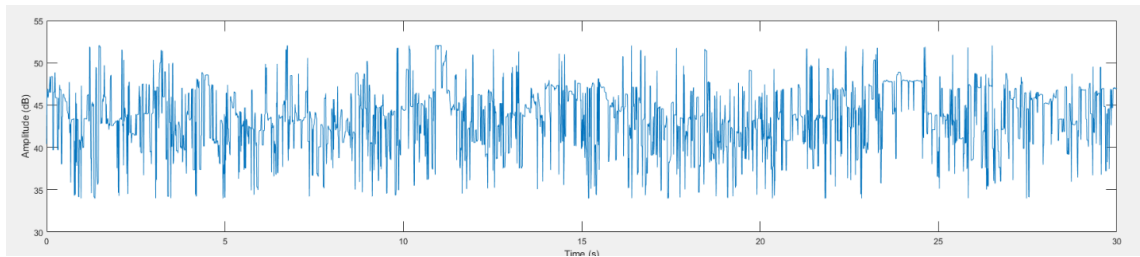


Figure 7: Time history of the C-dining hall-piano.

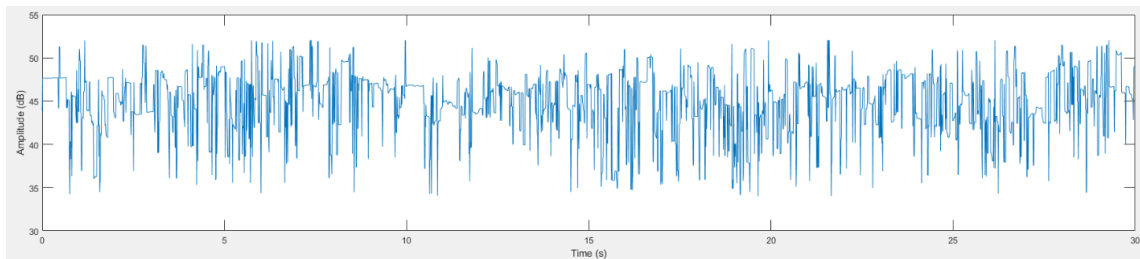


Figure 8: Time history of the D-dining hall-Right.

To fully understand the behavior of amplitude and frequency in the time domain, spectrograms were obtained for each of the four locations (Figure 9). The frequency range for these locations was set between 0 and 22 kHz to facilitate comparison and focus on the greater amplitudes in the recordings. These representations of the sound environments enabled the identification of various distinct sounds. Spectrograms distinctly showed conversations as continuous background noise in all locations.

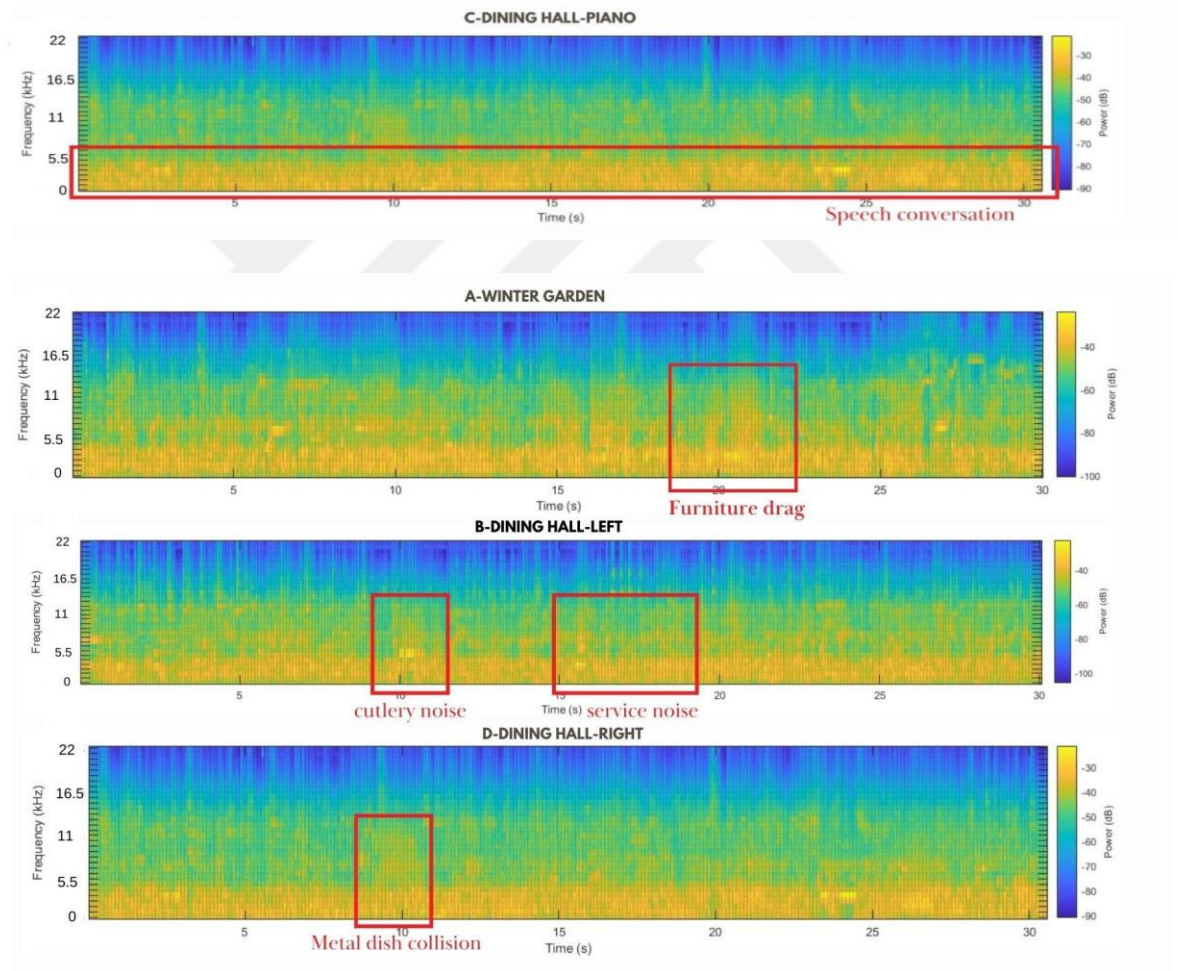


Figure 9: Spectrograms of A, B, C and D

3.2.1.3 Visual Environment

Four different locations were analyzed in this study because of the difference in their visual characteristics. 360° panoramic photos of the four locations were taken and

analyzed. There are outdoor openings in all four locations, including fixed windows or walkout windows and glass doors. The location A-Winter Garden has an outdoor opening on all three sides and a low wooden ceiling (Figure 10). The windows look out to the campus landscape, and the walkout windows open into the balcony, which has seasonal outdoor seating. Location B-Dining hall left has an outdoor opening on one side as fixed windows that look out the campus landscape; the other three sides have interior characteristics (Figure 11). Like location B, there is an outdoor opening with large windows on one side in locations C and D as well (Figure 12 & Figure 13). Locations B, C, and D all experience crowdedness, especially Location D, which has long queues of users who are waiting at the buffet counter. Location C is next to the piano with a double-height ceiling. Location B has an exposed ceiling and large windows on one side.

Location B has an exposed ceiling and large windows on one side.



Figure 10: Panoramic photograph of Locations-A



Figure 11: Panoramic photograph of Location-B



Figure 12: Panoramic photograph of Location-C



Figure 13: Panoramic photograph of Location-D

3.2.1.3.1 Image Analysis

Like audio signal analysis MATLAB can be employed for image analysis, where coding procedures break down images into their constituent parts. MATLAB's Image Segmenter and Color Thresholder applications aid in this process by automatically segmenting images to produce grayscale outputs, with options for manual adjustments (MathWorks, n.d.-c). By leveraging these tools and techniques, both audio and image signals can be effectively analyzed and visualized, contributing to a deeper comprehension of their inherent characteristics and behaviors. Like the Image Segmenter program, the Color Thresholder app automatically segments colored images and permits manual segmentation adjustments (MathWorks, n.d.-a). MathWorks (MathWorks, n.d.-b) helps in determining the percentages of white or black regions in these segmented images, which can be accomplished using custom-written codes.

MATLAB R2021b's color threshold software was used to convert each picture into a binary image for image analysis. The percentages of the white regions in the whole picture

were calculated using the newly segmented images. First, the percentages of the wall to total area in each of the four sites were compared. The findings (Table 2) show that the wall area at site A was 16.7% of the total area, the wall area at location B was 15.2% of the total area, the wall area at location C was 19.5% of the total area, and the wall area at location D was 9.6% of the total area. Next, percentages of the total area of these four locations that comprised windows and outside openings were also acquired. The A's windows and outside openings comprised 46% of the area's visual environment. The area occupied by B accounted for 15.6%, C for 29%, and D for 15.7% of the location's visual environment.

Table 2: The area percentages of wall-to-total & outdoor openings of the four locations

Area percentages	A	B	C	D
Wall-to-total	16.7%	15.2%	19.5%	9.6%
Outdoor openings	46%	15.6%	29%	15.7%



Figure 14: Binary Images of Location-A



Figure 15: Binary Images of Location-B



Figure 16: Binary Images of Location-C

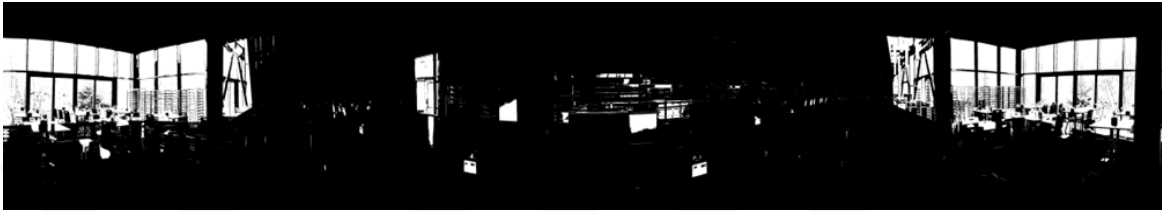


Figure 17: Binary Images of Location-D

3.2.2 Participants

A convenience sample method was used to choose the participants. Forty-four participants in all who gave consent to take part in the research. The questionnaire was completed by twenty male and twenty female participants, whose ages ranged from eighteen to thirty-five (μ age = 22.73; SD age = 4.048 years). In addition, 43 out of 44 consumers took part in the semi-structured interview. Twenty men and twenty-three women were present (Figure 19). Interviews took place on weekdays between 12:00 and 14:00 at four different locations during lunch. The length of the interviews ranged from 6 to 8 minutes.

Participants' visits varied in frequency, but among the 44 participants in the study, the group that visited "frequently" had the highest number of visits (Figure 18).

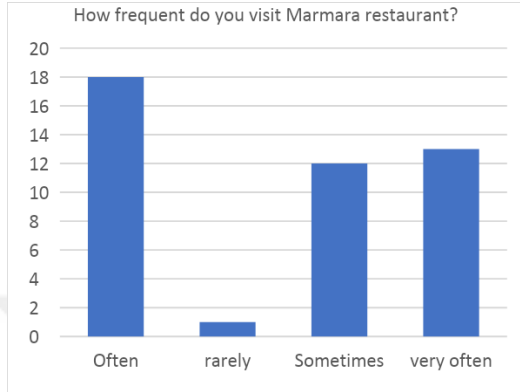


Figure 18: Visit frequency of participants.

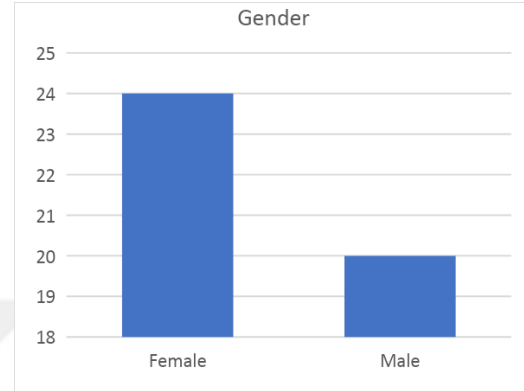


Figure 19: Gender distribution of the participants.

3.2.3 Data Collection and Analysis of the Cafeteria Environment

This research assessed user perceptions of the visual and acoustic environments in a university cafeteria by conducting an exploratory study. Semi-structured interviews were conducted, guided by the GT method. Eight key questions were asked to gather in-depth insights. To study the perceived audio-visual environment, measures such as binaural audio recordings, 360° photos of the four locations, and Equivalent Continuous A-Weighted Sound Level (LAeq) measurements were also taken to support and assist the results of the qualitative study. Soundscape Standards (ISO12913-2) Method A questionnaire was also administered, with three additional items focusing on the visual environment. Both the questionnaire and the interviews were conducted in English. The study's methodology is illustrated in Figure 20.

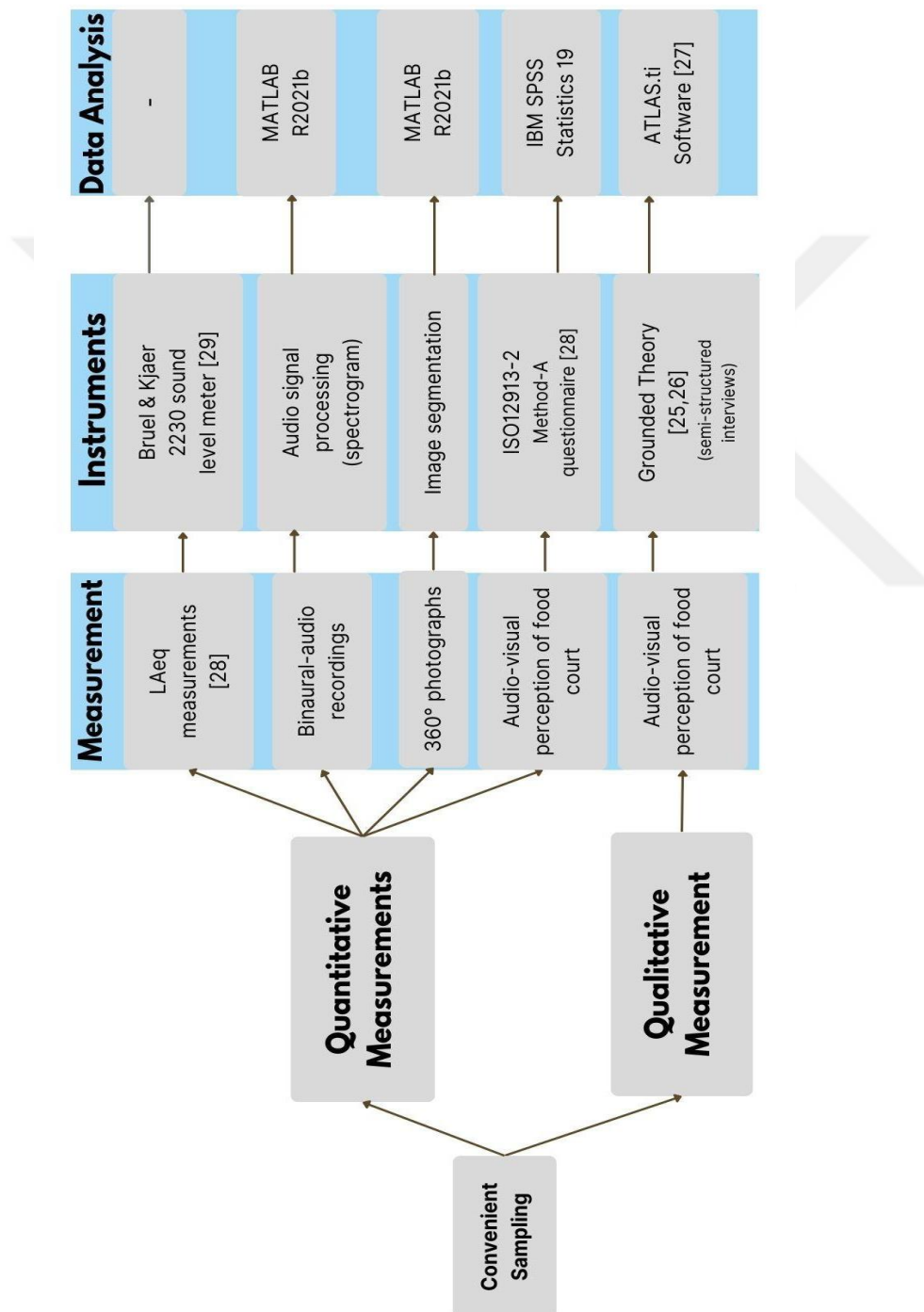


Figure 20: The procedure of the study.

3.2.3.1 Method C- Grounded Theory

This study's main objective is to conduct qualitative research to investigate how participants perceive the soundscape visually and acoustically. Semi-structured interviews were thus the main method used to gather GT data. The interview comprised eight primary questions that explored how people perceive their acoustic and visual surroundings (Davies et al., 2013) (Table 3). Two of the questions were more generic, while three asked about the perception of the sound, and three inquired about the visual environments.

Table 3: The eight main questions prepared for the semi-structured interview.

1. What do you hear?
2. What do you want to hear?
3. What do you expect to hear?
4. What do you see?
5. What do you want to see?
6. What do you expect to see?
7. How do you cope with an auditory or a visual factor that you do not like?
8. How do you feel in this environment?

Participants at locations A, B, C, and D were selected through convenience sampling. As the interviews progressed, additional questions arose organically. Eager was expressed by participants in sharing their thoughts on topics beyond the main questions, such as the smell of the environment and their perception of the food. A brief overview of the interview's content was provided to participants, and audio recordings were initiated. Each

interview lasted approximately 6 to 8 minutes. Following the recommendation of the grounded theory technique, interviews ceased when theoretical saturation of the data was achieved (Strauss, 2010). Each interview was subsequently transcribed, and the coding process started after the transcription of the audio files. Data were entered into a Microsoft Word document and then transferred to the ATLAS.ti coding program, a qualitative data analysis software that facilitates efficient coding of extensive data (ATLAS.ti, n.d.).

Three primary coding phases—open coding, axial coding, and selective coding—are involved in the grounded theory method (Strauss, 2010). Key concepts were derived from the raw data and utilized in open coding. These key concepts were then organized into categories for axial coding. Additionally, main categories and subcategories were established for selective coding. Connections between these categories were subsequently developed, and a core category was identified along with its connections to other categories. Finally, the acoustic and visual aspects of the cafeteria environment were explained, and a conceptual framework was formulated.

3.2.3.2 Method A- Questionnaire

Lastly, participants were asked to fill out a questionnaire based on Method A (2018). The research was briefly explained to the participants at the start of the questionnaire. They were told that participation was entirely voluntary, the data would only be used for scientific purposes, and their identity would not be questioned. Lastly, a contact email was provided in case they had more queries.

It consisted of two primary parts: Personal demographics and a survey. The demographics part gathered data on the participant's age, gender, cultural background, and rate of visits.

The questionnaire had seven components, which focused on the identification of sound sources, the perceived affective quality, assessments and appropriateness of the surrounding sound and visual environment, and the assessment of the overall audio-visual environment. The students answered the questionnaire in English, which they could speak fluently. The participants' opinions were assessed with a Likert scale based on five points. Forty-four participants participated in the survey, and the results were analyzed using IBM SPSS Statistics. A one-way ANOVA test was used to compare the four locations (A, B, C, and D).

An overview of the research methodology, the characteristics of the participants, the location of the case study, the auditory and visual conditions, and the methods used for data collection and analysis are provided in this section. The research findings will be discussed in the next chapter.

CHAPTER IV

RESULTS

The findings of this study are examined in this chapter. Information is offered on the findings of semi-structured interviews conducted as part of the study. Details are provided on the results of the data analysis from questionnaire surveys that were conducted to study the perceived affective quality of the environment.

4.1. Method C Grounded Theory (GT) Results

To explore the audio-visual perceptions of participants at the Marmara Cafeteria, semi-structured interviews were conducted. The data from these interviews were analyzed using grounded theory methodology with the aid of ATLAS. ti software. The findings are presented within a conceptual framework (see Figure 21), which emphasizes the audio-visual assessments provided by frequent cafeteria participants. The semi-structured nature of the interviews facilitated the collection of candid opinions while minimizing interviewer bias. The coding process employed open, axial, and selective coding techniques to classify key phrases into core, main, and sub-categories, culminating in the conceptual framework.

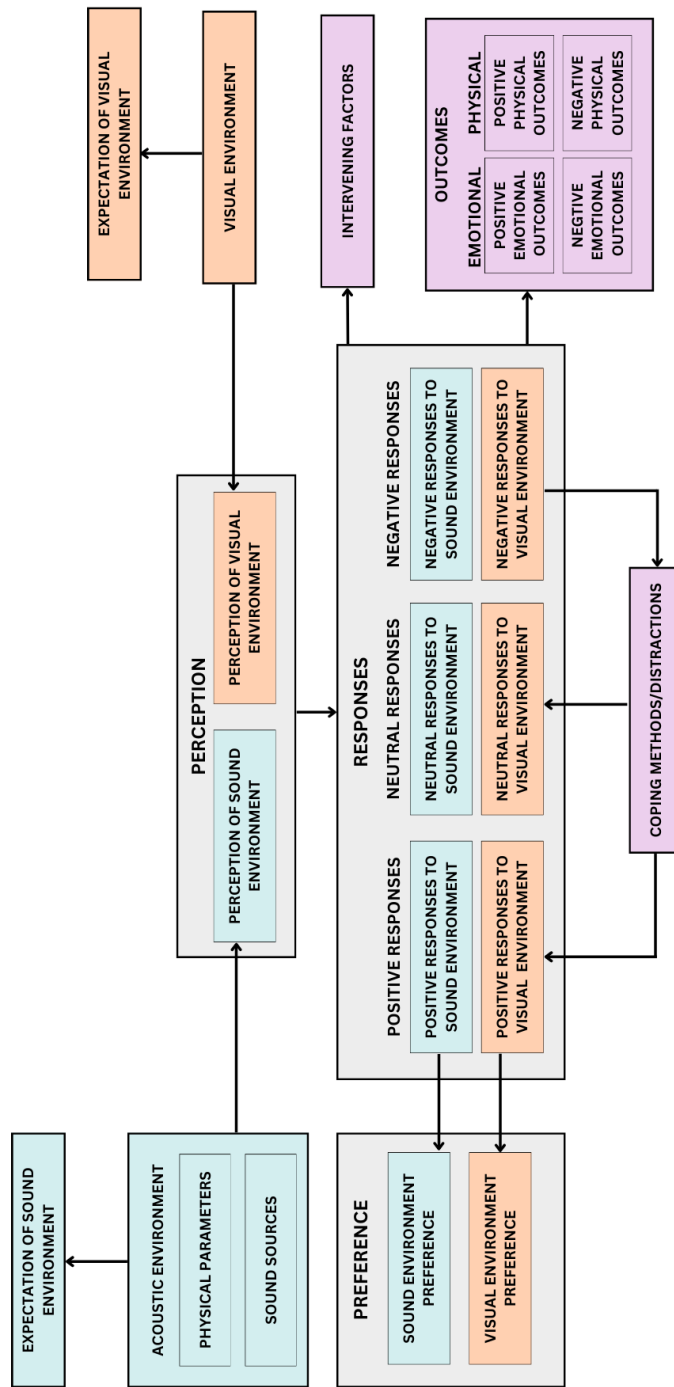


Figure 21: A conceptual framework of Audio-visual perception in a Cafeteria environment

Each interview sentence was analyzed and coded using ATLAS.ti software. Key phrases were extracted and systematically categorized. The transcriptions were divided into key phrases corresponding to significant events, resulting in the identification of 594 key phrases during the initial coding phase. For example, feelings such as 'anxious' and 'stressful' were classified under 'negative emotional outcomes,' whereas feelings like 'good' and 'safe' were categorized under 'positive emotional outcomes.' These subcategories were part of the main category 'Emotional outcomes.' After identifying all main and subcategories, they were connected to the core category 'outcomes'. The relationships among the core category, main categories, and subcategories were mapped out. Further emotional and physical outcomes of the audio-visual environments were grouped under the main category 'Outcomes' as they were related.

The conceptual framework was developed to include categories related to the acoustic environment, and the visual environment, and categories relevant to both. The analysis revealed that the acoustic environment influences participants' expectations and perceptions of the soundscape. Similarly, the visual environment affects participants' expectations and perceptions of visual elements. Participants' responses are shaped by their simultaneous perception of both acoustic and visual environments. Coping mechanisms were identified as ways to transform negative responses into neutral or positive ones. Positive responses also indicate user preferences. An overall evaluation of Marmara cafeteria across all four locations (A, B, C, & D) was provided by participants. Consequently, the framework does not differentiate between these four areas. The framework comprises ten main categories and sixteen subcategories, which are illustrated in detail in Figure 22, with zoomed-in sections shown in Figures 23 and 24.

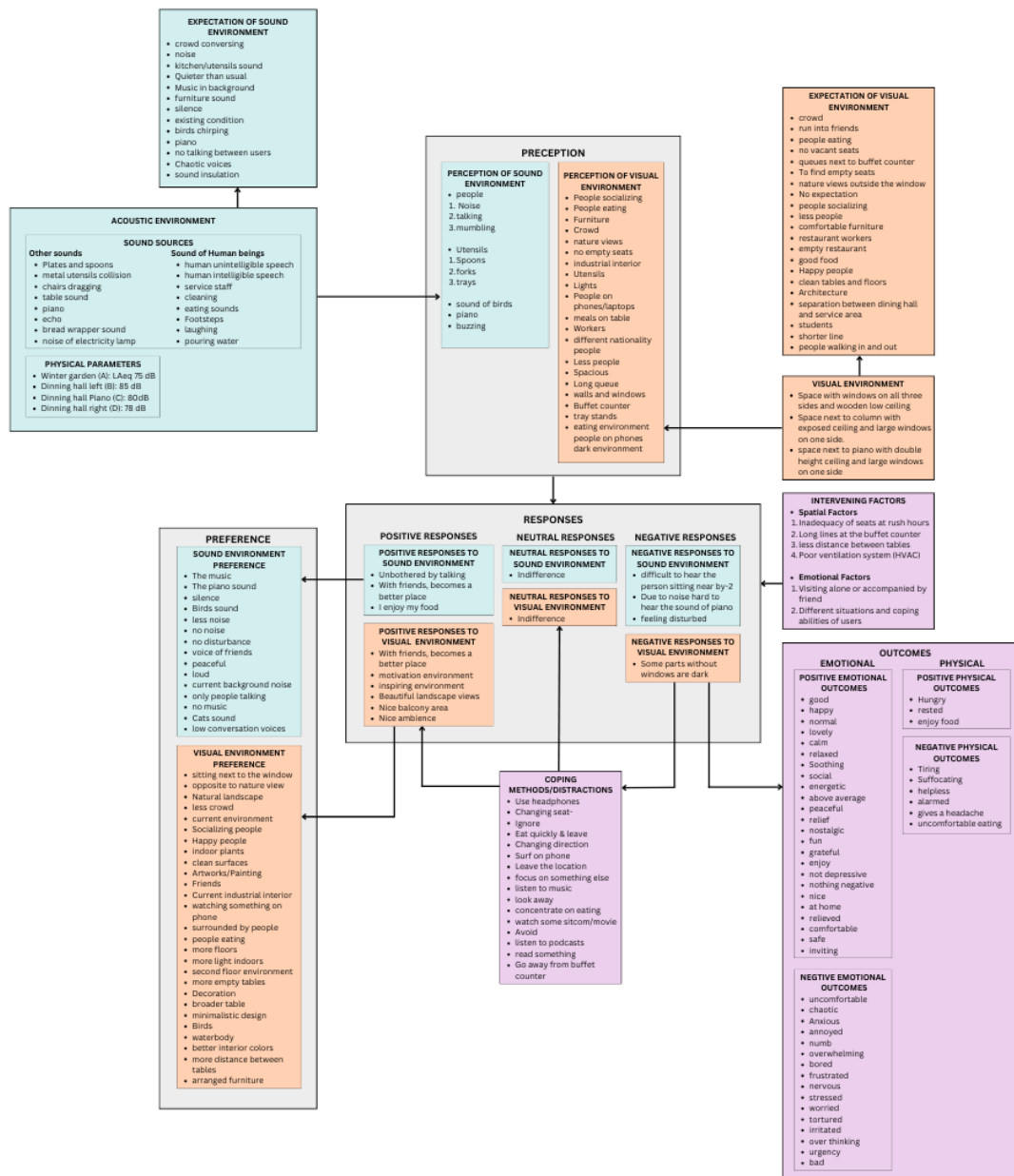
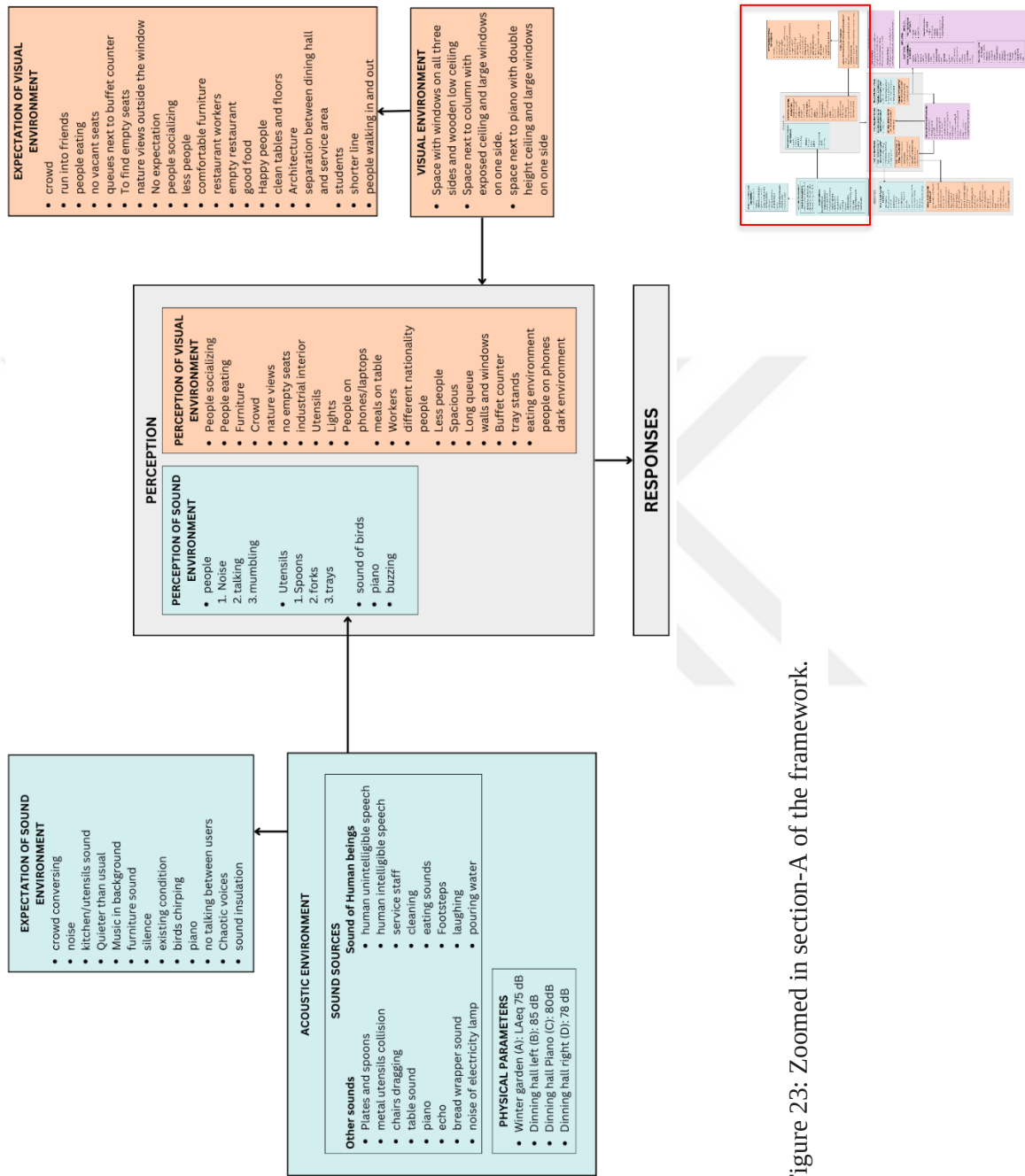


Figure 22: The detailed conceptual framework for participants' audio-visual perception in the cafeteria environment.



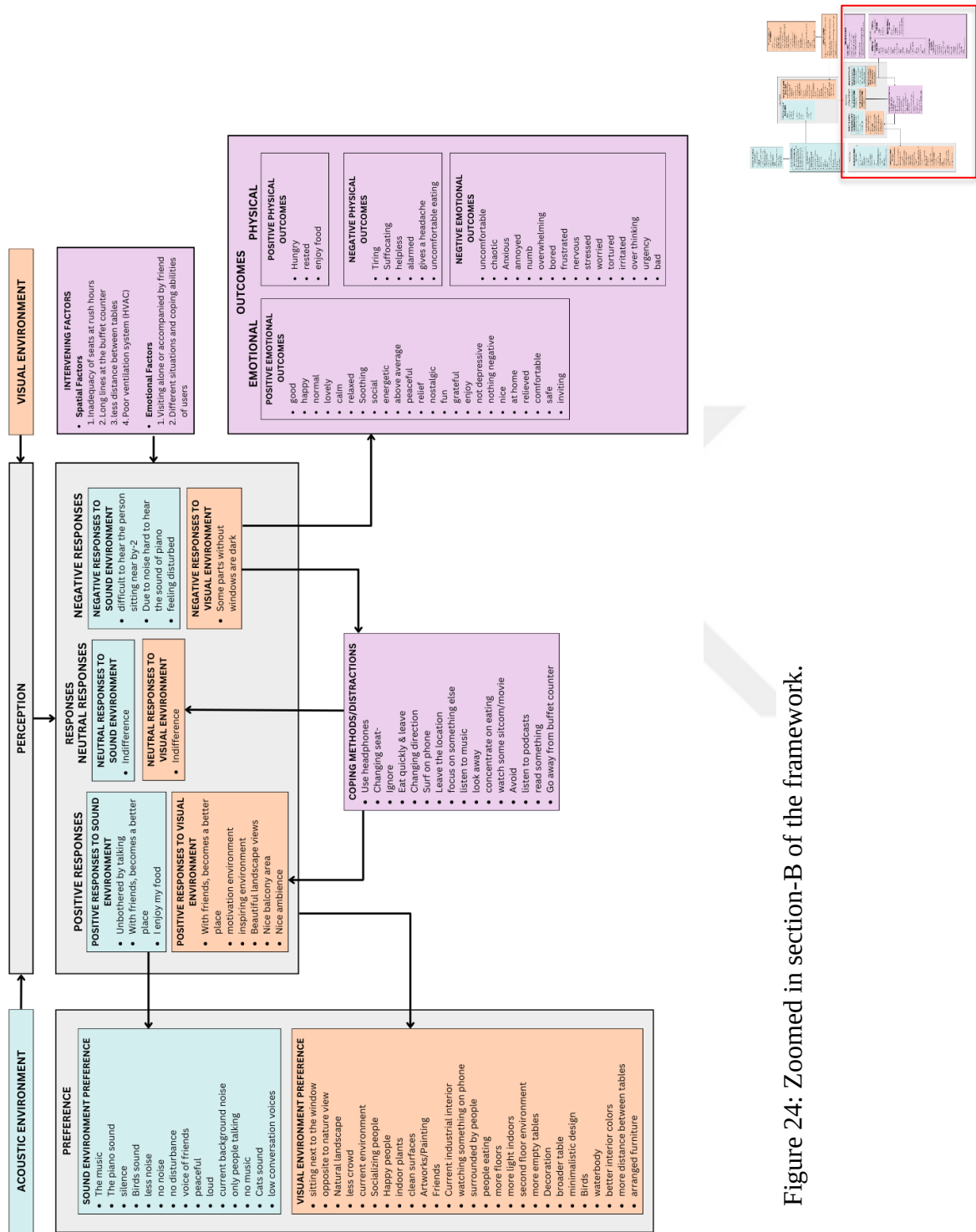


Figure 24: Zoomed in section-B of the framework.

Acoustic Environment & Expectation and Perception

The 'Acoustic Environment' category was divided into two subcategories: 'Physical Parameters' and 'Sound Sources.' These subcategories outlined the objective characteristics of the sound environment. The acoustic environment was found to influence how participants perceived the sound environment and their expectations of it. Therefore, the acoustic environment was intrinsically linked to the 'Expectation of Sound Environment' and 'Perception of Sound Environment' categories.

It was observed that participants' perceptions often differed from the actual acoustic environment. Their perceptions sometimes omitted elements present in the actual environment, such as footsteps, eating sounds, cleaning noises, laughter, water pouring, and service staff sounds. Additionally, human sounds were often generalized as people talking, without distinguishing between unintelligible (female/male) and intelligible (female/male) speech. Sound perception also included bird sounds, which were not part of the actual acoustic environment. Many participants expected to hear conversational noise and kitchen utensil sounds. Some participants anticipated bird chirping or background music, while fewer expected furniture noises, piano music, or a quieter environment. Conversely, some participants preferred complete silence while eating, linking their preference to sound insulation.

A: “When people talk loudly, I really feel uncomfortable. The quiet place actually can be good.”

B: “A crowded cafeteria is also okay. As long as it's not too noisy.”

Furthermore, it was found that the perception of the sound environment was related to the visual environment, as participants often experienced them together. For instance, they

saw people and heard them talking simultaneously. Thus, both sound and visual perception fall under the main category of 'Perception.'

Visual Environment & Expectation and Perception

The 'Visual Environment' category outlined the objective parameters of the visual environment, based on the cafeteria's layout and openings. How users perceived their environment and responded to it was dependent upon the auditory and visual aspects of the environment. Therefore, the visual environment was connected to the 'Expectation of Visual Environment' and 'Perception of Visual Environment' categories.

Participants' perceptions often differed from the actual visual environment. Instead of evaluating the visual environment, they focused on individual elements, such as people socializing, eating, using phones, furniture, crowds, nature views through windows, industrial interiors, meals on the table, long queues, and lighting. Participants mostly expected visual elements that enhanced comfort, such as nature views, more indoor plants, decorations, fewer crowds, artworks, cheerful socializing people, birds, more empty seats, clean surfaces, arranged furniture, and broader tables.

C: "I would like to see flowers, nature, color, actually."

D: "I always love to see the view of trees, the Industrial shape of buildings, like walls and everything."

Intervening Factors

Participants' responses and perceptions of the elements in their were influenced by 'Intervening Factors.' These factors were categorized into 'Emotional Factors' and 'Spatial Factors.' User responses varied based on their coping abilities and whether they were

alone or with friends. Spatial factors affecting responses included inadequate seating, long buffet lines, congested table settings, and poor ventilation (HVAC). Many participants also mentioned the time spent searching for empty seats during peak hours.

E: "I wish there were no long lines, and not try to look for a place to sit for ten minutes."

F: "The environment is not very comfortable, technically. But, when I'm with people that I like it becomes a better place."

Responses & Outcomes

'Responses' constitute the core category, as other categories are centered around it.

Participants' perceptions of the sound and visual environments, along with intervening factors, result in 'Positive Responses,' 'Neutral Responses,' or 'Negative Responses.'

Responses to the sound and visual environments differ but are interconnected, and thus, are categorized under positive, neutral, and negative responses.

Positive responses to the sound environment included soothing sounds and a moderate level of conversational noise. Positive visual environment responses included a peaceful, motivating ambiance and a better experience with friends. Neutral responses indicated no desire for change from existing conditions. Negative sound environment responses included descriptions of being too noisy, very crowded, and annoying noises like furniture dragging or metal dishes clashing. Negative visual environment responses included crowded spaces, long queues, disorganized furniture, and insufficient seating.

G: "Sometimes it can be overwhelming, I want to see less crowd."

H: *“I mostly look through the windows because the view is amazing. And I like the design of the place.”*

I: *“There are lots of people and it's too crowded. Maybe the distance between the tables could be arranged again because it's too near and sometimes all the voices from the nearby table are coming on ours.”*

Following participants' expression of their perceptions of the environment, they proceeded to evaluate the 'Outcomes' of these responses. Consequently, 'Emotional Outcomes' and 'Physical Outcomes' were identified. Positive emotions reported by participants included feelings of gratitude, calmness, comfort, and relief, while negative emotions primarily encompassed discomfort, chaos, anxiety, stress, and urgency. Participants also described positive and negative physical outcomes such as feeling rested, enjoying eating, experiencing headaches, and feeling physically tired.

J: *“I feel tired because of the view of a lot of people.”*

K: *“It's not like a home environment, but I am used to it. Maybe like recess, I come here between breaks. So, I feel rested.”*

Coping Methods/Distractions

As participants provided negative responses, they also identified 'Coping Methods/Distractions' to mitigate adverse outcomes. To transform negative responses into neutral or positive ones, participants primarily opted to wear headphones and listen to music or were relocated to different seats in response to uncomfortable sounds or views.

Other coping methods/distractions included eating quickly and leaving, changing direction, diverting their focus, and using the telephone.

Preferences

The positive responses from participants define their 'Preferences' regarding the cafeteria environment into two subcategories: 'Sound Environment Preference' and 'Visual Environment Preference.' Participants responded positively to the sound environment when it was peaceful, preferring minimal or no noise. They also favored the visual environment with elements such as nature views, artworks or paintings, clean surfaces, arranged furniture, and indoor plants, along with more empty seats. The sound and visual environment preferences were interconnected, as participants desired fewer crowds and less crowd noise.

Participants preferred sitting next to windows to enjoy the landscape view in the visual environment, paired with a calm auditory setting featuring silence or soft music (piano or instrumental). Additional sound environment preferences included birdsong, the voices of friends, and low conversation levels. Other visual environment preferences included more space between tables, indoor water features, decorative elements, and views of happy, socializing people. While fewer people preferred the current sound and visual environment, the following user quotes highlight their preferences:

L: "I like the piano sound that sometimes they play."

M: "Maybe relaxing music. Music will be really good while we are eating and talking. But the music should be not too noisy."

N: "I really like the view over here. That's why I mostly sit next to the window. It's better than sitting in the center because I don't like people around me. I have

anxiety because of that."

4.2. Method A Perceived Affective Quality (PAQ) Results

The questionnaire was sent out to 43 willing participants from the cafeteria's locations: A (n=13), B (n=12), C (n=9), and D (n=10). The program IBM SPSS Statistics was used to analyze the data. The one-way ANOVA test, Spearman's rho correlation, and questionnaire reliability were evaluated. Bar charts were created to evaluate the appropriateness of the visual and auditory environments. The Cronbach's alpha value was used to determine the questionnaire's reliability. Since the result is more than 0.70, the questionnaire was considered reliable, as indicated by the value of 0.723.

4.2.1 Spearman's Rho Correlation Test

The Spearman's rho correlation test yielded significant correlations between various survey questions related to the assessment of the surrounding sound and visual environments across all four locations: A-Winter Garden, B-Dining hall left, C-Dining hall piano, and D-Dining hall right. Notably, positive significant correlations were observed with moderate to strong relationships in vibrant ($r_s=0.589$, $p=0.034$), assessment of the Audio-visual environment ($r_s=0.551$, $p=0.051$), and sounds produced by Human activity ($r_s=0.648$, $p=0.017$) in Location A. Conversely, significant negative correlations were noted with strong relationships in calm ($r_s=-0.698$, $p=0.008$) and annoying ($r_s=-0.624$, $p=0.023$) in the same location.

Similar significant correlations were found in Locations B, C, and D, indicating the impact of sound attributes on users' perceptions across different areas of the cafeteria. For instance, positive significant correlations were identified between specific sound attributes, such as annoying sounds and human activity, and the overall assessment of the surrounding sound environment in all locations. Additionally, negative significant correlations were observed between attributes like calmness and pleasantness and users' assessments of the sound environment, suggesting that certain sound characteristics influenced users' perceptions in all areas of the cafeteria.

Similarly, significant correlations were observed in the assessment of the surrounding visual environment, with positive correlations between attributes like monotonous sounds and the overall assessment of the Audio-visual environment across all locations. Negative correlations were found between attributes like pleasantness and natural sounds and users' assessments of the visual environment, indicating the influence of specific visual attributes on users' perceptions across all locations.

These findings underscore the importance of considering both sound and visual attributes in assessing users' perceptions of the cafeteria environment, as well as the need to address specific sound and visual characteristics to enhance users' overall experience. The significant correlations for the assessment of the surrounding sound and visual environments are shown in Table 4 and Table 5.

Table 4
Items that have significant correlations with the Assessment of the surrounding sound environment

Items	Location A			Location B			Location C			Location D		
	rs	p	n	rs	p	n	rs	p	n	rs	p	n
pleasant	-0.207	0.497	13	-0.266	0.404	12	-0.790	0.011	9	-0.675	0.032	10
Chaotic	0.425	0.148	13	-0.044	0.891	12	0.655	0.056	9	0.660	0.038	10
Vibrant	0.589	0.034	13	-0.645	0.024	12	-0.355	0.348	9	-0.488	0.152	10
Calm	-0.698	0.008	13	-0.084	0.796	12	-0.725	0.027	9	-0.540	0.107	10
Annoying	-0.624	0.023	13	0.521	0.089	12	0.919	0	9	0.720	0.019	10
Eventful	-0.180	0.555	13	-0.033	0.186	12	0.599	0.088	9	0.575	0.082	10
Monotonous	-0.028	0.928	13	0.186	0.563	12	0.630	0.069	9	0.134	0.712	10
Appropriateness of the surrounding sound environment	-0.225	0.459	13	-0.426	0.168	12	-0.582	0.100	9	-0.191	0.597	10
Appropriateness of the surrounding visual environment	-0.027	0.930	13	-0.342	0.277	12	-0.783	0.013	9	-0.429	0.216	10
Assessment of visual environment	0.000	1.000	13	0.446	0.146	12	0.767	0.016	9	0.509	0.133	10
Assessment of Audio-visual environment	0.551	0.051	13	0.831	0.001	12	0.889	0.001	9	0.765	0.01	10
Background activity Sound	0.104	0.736	13	0.365	0.243	12	0.530	0.142	9	0.474	0.166	10
Natural sounds	-0.056	0.856	13	-0.266	0.404	12	-0.730	0.025	9	-0.261	0.467	10
Human Activity Sounds	0.648	0.017	13	0.469	0.124	12	0.486	0.185	9	0.124	0.733	10

Table 5
Items that have significant correlations with Assessment of surrounding visual environment

Items	Location A				Location B				Location C				Location D			
	rs	p	n	rs	p	n	rs	p	rs	p	n	rs	p	n	rs	p
Pleasant	0.474	0.102	13	-0.423	0.171	12	-0.450	0.224	9	-0.298	0.403	10				
Chaotic	-0.139	0.652	13	0.267	0.401	12	0.337	0.318	9	0.627	0.053	10				
Vibrant	0.171	0.577	13	0.168	0.601	12	-0.493	0.177	9	-0.090	0.805	10				
Calm	0.129	0.674	13	-0.261	0.413	12	-0.401	0.285	9	-0.477	0.163	10				
Annoying	0.231	0.448	13	-0.211	0.362	12	0.827	0.006	9	0.598	0.068	10				
Eventful	0.093	0.763	13	-0.692	0.013	12	0.436	0.241	9	0.738	0.015	10				
Monotonous	-0.412	0.162	13	-0.004	0.446	12	0.860	0.003	9	0.062	0.866	10				
Appropriateness of the surrounding sound environment	-0.305	0.311	13	-0.004	0.990	12	-0.529	0.143	9	0.212	0.557	10				
Appropriateness of the surrounding visual environment	-0.337	0.261	13	-0.135	0.676	12	-0.601	0.087	9	-0.139	0.703	10				
Assessment of Sound environment	0.000	1.000	13	0.446	0.146	12	0.767	0.016	9	0.509	0.133	10				
Assessment of Audio-visual environment	0.070	0.821	13	0.729	0.007	12	0.932	0	9	0.901	0	10				
Background Activity Sounds	-0.374	0.209	13	0.237	0.458	12	0.384	0.308	9	0.050	0.891	10				
Natural Sounds	0.497	0.084	13	-0.633	0.027	12	-0.801	0.008	9	-0.390	0.265	10				
Human activity Sounds	-0.195	0.524	13	0.680	0.015	12	0.446	0.229	9	0.370	0.293	10				

4.2.2 One-way ANOVA Test

A one-way ANOVA and post-hoc Scheffe tests were used to compare the four locations. Differences between these locations were identified using a one-way ANOVA test. The post-hoc Scheffe test showed the location which was different from the others. Table 6 presents the results, which indicate a significant difference in annoyance ($F(3) = 5.64$, $p = 0.03$) among all four locations. Location B and D were perceived to be more annoying than Location A. The remaining variables did not show significant differences, which means the perceived sound was almost the same in the remaining four areas.

Table 6: Significant difference in the four locations of the cafeteria.

Items	df	F	p	Locations	Mean	n
Annoying	3	5.640	0.003	A	2.00	13
				B	3.67	12
				C	3.00	9
				D	3.40	10

To evaluate the perceived affective quality across all four locations, mean values were computed and depicted in a radar chart (See Figure 25). Notably, Location A exhibited higher levels of perceived pleasantness and calmness compared to the other three locations, attributed to its distance from significant noise sources. Conversely, Location B was characterized by higher levels of annoyance and chaos relative to the other locations. Location C emerged as the most eventful and vibrant among the four, whereas Location D displayed values like those of Locations B and C. Furthermore, participants consistently perceived the cafeteria environment as eventful across all locations, with a tendency towards monotony rather than vibrancy. These findings provide insights into the perceived

affective quality of the cafeteria environment, highlighting variations across different locations and aspects such as noise levels and eventfulness.

Perceived Affective Quality (based on mean values)

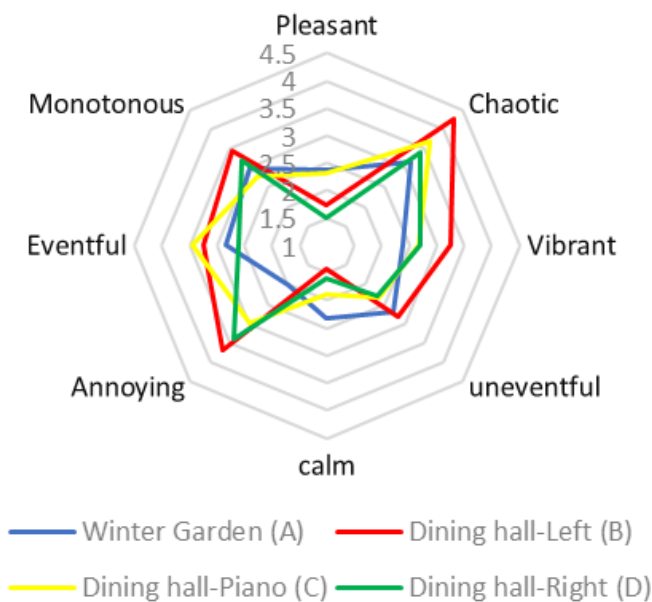


Figure 25: Perceived affective quality based on mean values.

4.2.3 Assessment and Appropriateness of Sound and Visual Environments

There are still some modifications in terms of the evaluation and appropriateness of the surrounding visual and auditory environments, even though the one-way ANOVA findings did not reveal any significant differences among the four locations. Figures 26, 27, and 28 provide assessments of the visual, audio-visual, and auditory environments. While some participants in location D evaluated the acoustic environment from Good to extremely terrible, many participants in locations A, B, and C regarded it as neither good nor bad.

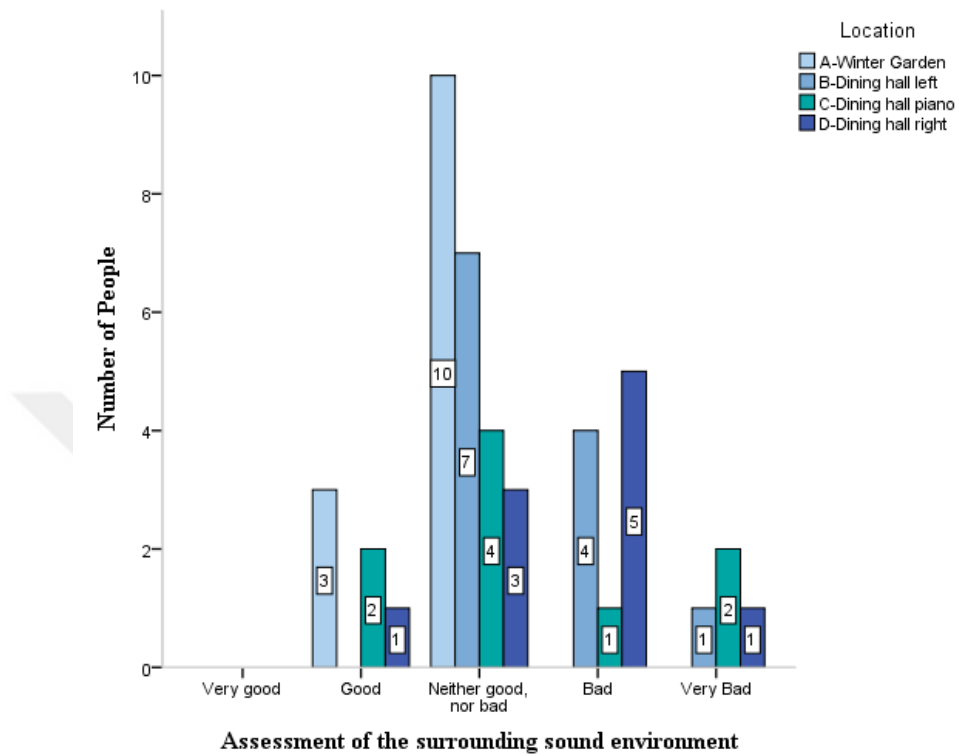


Figure 26: Sound environment assessment in four locations.

Many participants in locations A, B, and C gave the visual environment high ratings, whereas those in location D gave it low ratings.

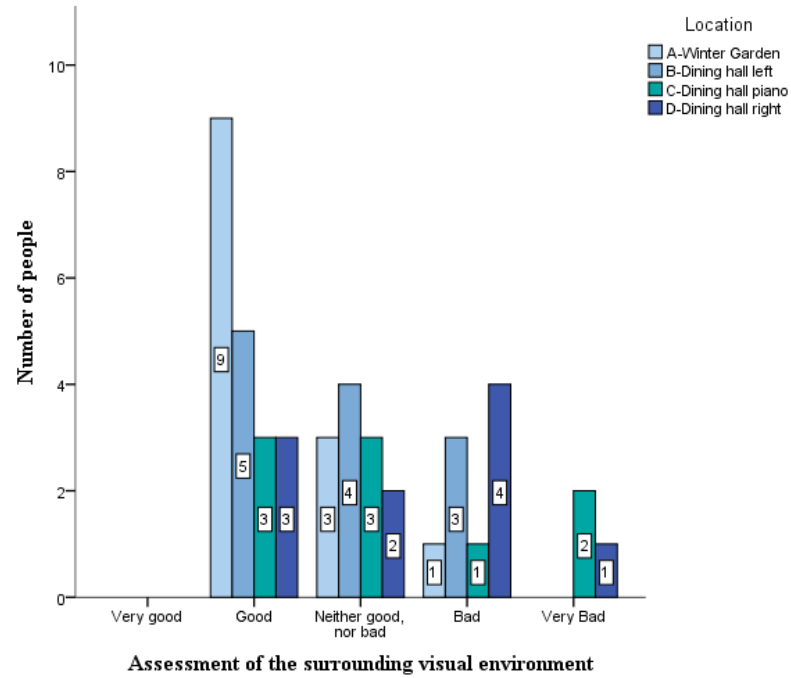


Figure 27: Visual environment Assessment in four locations.

Most participants in the four locations rated the audio-visual environment from good to bad.

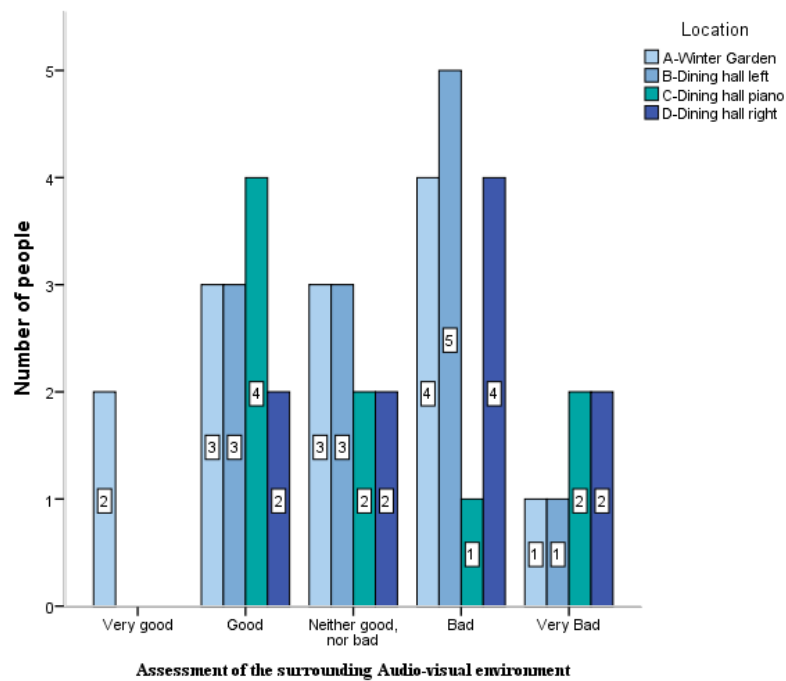


Figure 28: Audio-visual environment assessment in four locations.

Figures 29 and 30 show how appropriate the surrounding visual and acoustic environments were. While participants in locations B, C, and D assessed the acoustic environment's appropriateness between slightly and very appropriate, most participants in location A perceived it between moderate and very.

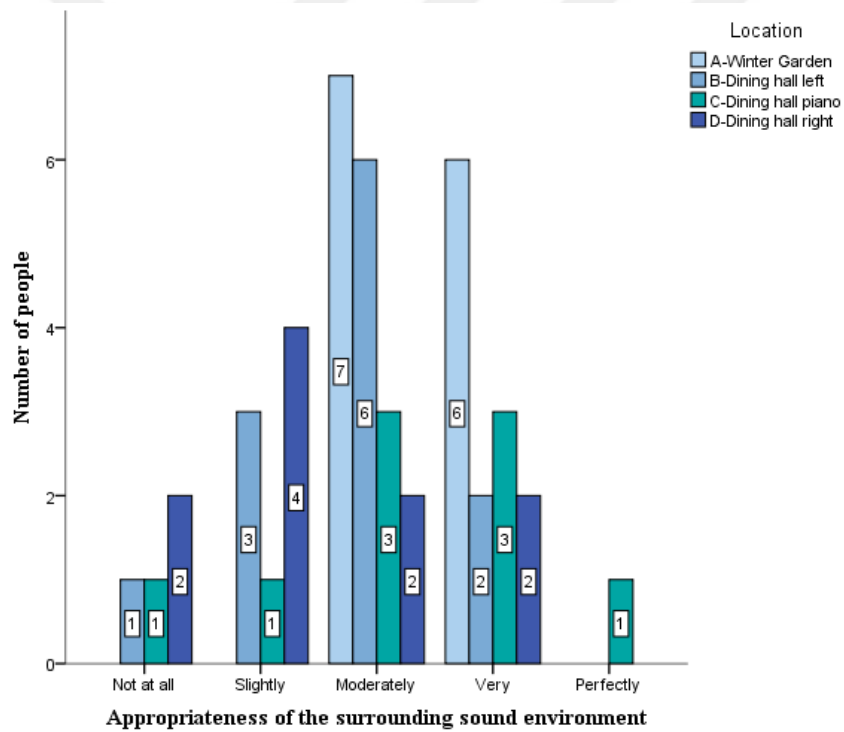


Figure 29: Sound environment appropriateness in four locations.

Whereas participants in locations B, C, and D ranked the visual environment's appropriateness between not at all and to perfectly, most participants in location A rated it between moderate and very. Table 8 displays all the item mean values.

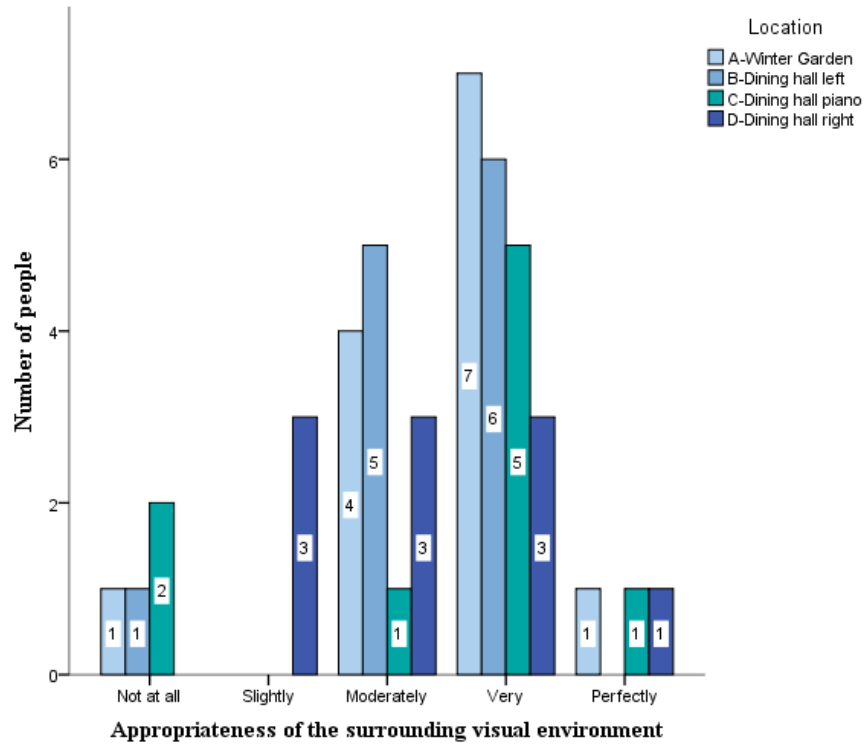


Figure 30: Visual environment appropriateness in four locations.

CHAPTER V

DISCUSSION

This thesis employed an exploratory study approach to investigate the auditory and visual environments within a cafeteria setting. Furthermore, to assist the qualitative study, quantitative measurements were utilized to gain a comprehensive understanding of participants' perceptions. The research aimed to examine the impacts of visual and auditory environments and the correlation between the spectral characteristics of the soundscape and user perception. The results derived from interview responses along with the measurements taken and analyzed through signal analysis, image segmentation, and sound level measurements provide valuable insights into the cafeteria environment at Bilkent University, and its users' experiences. Questionnaire responses were also analyzed, and they assisted in studying the assessment, and appropriateness of the cafeteria. Participants reported high sound levels (L_{Aeq}) in the four locations: A = 75 dB, B = 85 dB, C = 80 dB, and D = 78 dB. These findings stood consistent with a previous study by Lau et al. (2020), which also identified high sound levels in cafeteria settings.

Most of the sounds came from background activity and human-intelligible and unintelligible speech, especially around the buffet counter. Other sounds were chairs being dragged and cutlery clattering, as seen in the spectrograms (Figure 9) and identified by the participants in their responses. Although there was similar noise in the remaining locations as well, the intensity decreased as they moved away from the buffet counter. Negative responses to excessive noise and disruptive sounds highlighted the adverse effects of an unfavorable acoustic environment on participants' comfort and satisfaction, hence supporting the hypothesis that was assessed after conducting the pilot study and identifying the patterns of the user's perception.

On the other hand, some participants thought a moderate amount of background noise was appropriate and enhanced the lively atmosphere. Participants identified that key sound sources included human-generated chatter and background activity, contributing to the bustling ambiance of the cafeteria. Through method C grounded theory analysis, participants' perceptions of the acoustic environment, physical parameters, and their expectations of the sound environment revealed that the acoustic environment of Marmara cafeteria significantly influenced the user's experience. The disparity of responses emphasizes how crucial sound-level management is for achieving a balance between comfort and liveliness. This also answered the first research question which aimed at investigating the auditory environment of the cafeteria.

The second research question aimed to investigate the impact of the visual environment of the Marmara cafeteria on participants. The visual environment of the cafeteria featured various openings providing different views, such as windows overlooking the outdoor greenery and plain concrete walls, and deficiencies, such as inadequate seating units

during rush hours, were noted. Some participants desired more indoor natural elements and improved aesthetics, suggesting preferences to enhance the visual environment to promote comfort and satisfaction (Syed, S. F., & Yilmazer, S. 2023).

Participants preferred the natural view and the sunlight that entered via the windows, especially in Location A, where external openings (see Figure 14) and windows accounted for 46% of wall to the total. The visual environment was positively assessed by most people in the three locations besides Location D. The unfavorable view at Location D was due to its proximity to the cafeteria entrance and the buffet queues during peak times, resulting in a disorganized environment for users. Furthermore, spatial elements such as the organization of seats and the density of the crowd had a substantial impact on people's perceptions of the environment. These findings emphasize the need to consider the emotional and spatial aspects of cafeteria design to improve user satisfaction and comfort. Meng et al. (2017) have also researched that dining styles had a significant effect on sound pressure levels and acoustic comfort which aligns with this study as participants expressed issues with the availability of seating and the extended waiting times at the buffet counter during peak hours, indicating possible areas for improvement in spatial layout.

Additionally, participants generally expected visual elements that enhance their comfort, such as nature views from windows, more indoor plants and decorations, fewer crowds, artworks/paintings, cheerful socializing people, birds, more empty seats, clean surfaces, well-arranged furniture, and larger tables. This also supports the hypothesis indicating that tables adjacent to or facing windows with an outside view were preferred among

participants in the cafeteria. Conversely, tables adjacent to or facing the buffet counter were avoided by the participants.

The third research question explored the correlation between the spectral characteristics of the acoustical environment and the user's auditory perception in the cafeteria.

Spectrograms showed that human activity noises, such as chair dragging and utensil clattering, incredibly close to the buffet counter, contributed significantly to the recorded sounds and human speech, as seen in the spectrograms (Figure 16). High-frequency, high-amplitude sounds evoked negative responses from participants, supporting the assessed hypothesis that loud background noise created a negative soundscape in the cafeteria. This also highlighted how spectral features contribute to a negative soundscape, emphasizing the importance of addressing specific sound sources to enhance the acoustic environment.

5.1 Discussion of Grounded Theory (GT) results

While this study answered the research questions, its main goal was to create a detailed framework of users' perceptions in a university cafeteria setting. People's perceptions of environments vary depending on the context (Syed, S. F., & Yilmazer, S. 2023). The conceptual framework developed from the interviews identified "Responses" as the core category, capturing various parameters such as user preferences and expectations in the cafeteria environment.

Participants reported that intervening factors, such as crowding during rush hours and ambient noise, led to negative responses. Many expressed feelings anxious and overwhelmed, struggling to find a place to sit, with noise significantly affecting their comfort. Emotional factors, such as coping abilities and social context, shaped their

experiences. To mitigate negative responses, participants adopted coping strategies like wearing headphones, changing seats, and redirecting focus, highlighting proactive approaches to managing environmental stresses (Syed, S. F., & Yilmazer, S. 2023). Participants also felt more comfortable and at ease when accompanied by friends, indicating the social dimension of the dining experience.

Existing research on restaurant environments has primarily focused on sound levels and their impact on users' perceptions. Studies by Mistar et al. (2020) and Williams et al. (2022) emphasize the importance of creating a comfortable listening atmosphere to enhance user satisfaction. Similarly, Meng et al. (2017) and Steffens et al. (2021) explored the effects of spatial characteristics and room acoustics on users' experiences, highlighting the need to balance liveliness and comfort in restaurant environments. These findings align with the current study, which also emphasizes the significance of acoustic factors and spatial layout in shaping users' perceptions of the cafeteria environment.

The framework proposed by Mistar et al. (2020) for classifying acoustic comfort in eateries resonates with the "Responses" category identified in this study's conceptual framework. Both frameworks highlight the multifaceted nature of users' experiences and the importance of considering various factors, such as noise levels, layout, and demography, in optimizing environments in eateries. Moreover, the coping mechanisms adopted by participants, such as wearing headphones and changing seats, reflect proactive approaches to managing environmental stresses, as suggested by Williams et al. (2022).

Participants' preference for calm soundscapes and natural views aligns with findings from previous research. Studies by Meng et al. (2017) and Çakır et al. (2021) emphasize the

importance of creating pleasant auditory and visual environments in restaurants, which can positively influence users' perceptions and overall satisfaction. Additionally, the influence of social context on users' experiences, as expressed by participants' reported comfort when accompanied by friends, resonates with the social dimension of eateries highlighted by Lau et al. (2020).

This study's framework also provided direction for cafeteria design and management, aiming to optimize dining experiences by carefully considering acoustic factors and layout styles. For instance, increasing the distance between adjacent tables could mitigate negative impressions such as discomfort, chaos, anxiety, and stress, leading to emotional outcomes like feeling overwhelmed, frustrated, and annoyed. To decrease these negative effects, participants adopted coping techniques to overcome unpleasant responses to the cafeteria environment. Their responses to auditory and visual stimuli indicated a preference for calm soundscapes with ambient noise and calming music, as well as visual aspects such as natural views and clean, well-organized areas.

In summary, the findings align with previous research, highlighting the importance of considering acoustic and spatial factors in cafeteria design to enhance user satisfaction. The proactive coping strategies and preferences for calm environments observed among participants further emphasize the need for thoughtful design and management in dining settings.

5.2 Discussion of Perceived Affective Quality (PAQ) results

The observed variations in the assessment of visual and auditory environments across the four locations offer significant insights that align with and expand upon the existing literature. Figures 26, 27, and 28 demonstrate that the cafeteria was perceived as more eventful rather than uneventful and often more monotonous than vibrant, highlighting a need to adjust the cafeteria environment to better align with users' audio-visual preferences. Participants rated the auditory environment in Locations A, B, and C as neutral, whereas Location D received more polarized responses, indicating a broader range of auditory perceptions. According to Figure 25, Locations B and D were perceived as more annoying compared to Location A, which was viewed as more pleasant and peaceful, supporting the hypothesis that proximity to noise sources significantly impacts user perception. Conversely, Location C was noted for its liveliness and vibrancy, while Location D shared characteristics with both Locations B and C. These findings suggest that adjustments to the cafeteria environment, including seating arrangements, noise management, and visual enhancements, could improve user experience by catering to diverse preferences.

Mistar et al. (2020) emphasized the importance of a comfortable listening atmosphere in eateries, our findings from method A questionnaire support this by demonstrating that participants' perceptions of the cafeteria's auditory environment varied significantly across different locations, indicating that noise management is critical for enhancing user experience.

Williams et al. (2022) found that noise levels significantly impact anxiety and customer satisfaction, emphasizing the need for effective noise management in restaurant design.

The polarized responses in Location D from our study indicate that poor acoustic conditions can lead to negative perceptions, supporting the notion that noise levels must be carefully controlled to prevent user discomfort and dissatisfaction.

Meng et al. (2017) showed that different table layouts influence users' speech behaviors and perceptions of acoustics. Our study's findings that Location A was perceived as more peaceful due to its distance from main noise sources align with Meng et al.'s conclusions that spatial arrangement and crowd density significantly impact acoustic comfort. Adjusting the cafeteria layout to create quieter zones could enhance the overall dining experience, as suggested by Meng et al.'s research.

Lindborg (2016) proposed a taxonomy for perceived sound sources in restaurants, emphasizing the contextual influence on soundscape perception. The consistent perception of the cafeteria as eventful rather than uneventful in our study aligns with Lindborg's findings, suggesting that the context significantly influences how users perceive sound environments. Incorporating elements to balance eventfulness and vibrancy with tranquility could better meet user preferences.

5.3 Outcomes for Cafeteria Design

For designers aiming to create environments that align with users' visual and auditory preferences, the findings of this study offer valuable insights. The research identified several key outcomes that influence the cafeteria environment.

Participants responded positively to visual elements such as views of nature, artwork, paintings, clean surfaces, arranged furniture, and indoor plants, and preferred more empty seats. Davies et al. (2013) also discuss how natural visual stimuli can mitigate the

annoyance caused by a negative soundscape. Additionally, participants desired less crowd visibility and noise. The ideal environment combined a landscape view from windows with a calm auditory setting featuring silence or soft music (e.g., piano or instrumental).

Statistical analysis revealed that Location A was perceived as having the most appropriate visual and acoustic environment for a cafeteria compared to the other three sites (Figures 29 and 30). This preference was attributed to its distance from the buffet counter and primary noise sources, as well as its low-height micro-perforated panel (MPP) suspended ceiling, which acted as a sound insulator. Visually, Location A featured outdoor views on three sides, accounting for 46% of its visual environment (see Table 3). Thus, Location A was determined to have the most favorable acoustic and visual environment due to its extensive outdoor views and surrounding landscape.

Incorporating elements of nature into both the visual and auditory settings can enhance the dining experience. This includes adding indoor plants, providing views of the outdoors, playing soothing music, or recreating natural sounds to mask background noise, such as birdsong or flowing water. Cafeteria environments are perceived through the combined influence of auditory and visual stimuli, so designers must consider these elements together rather than in isolation. Creating a consistent audio-visual environment can significantly improve user satisfaction and create a positive soundscape experience, benefiting both participants and staff.

CHAPTER VI

CONCLUSION

As spaces where people gather to eat and socialize, eateries play an essential part in society. While acoustic measurements were the main emphasis of previous research on restaurant soundscapes, this thesis did an exploratory study on participants' audio-visual perceptions. The results emphasized how crucial it is to consider users' subjective experiences while designing eateries such as cafeterias. Within the cafeteria setting, participants' experiences are impacted not only by the quality of the food but also by the visual and auditory characteristics of the environment. Poor environmental conditions can negatively influence participants' overall dining experiences in cafeterias. The research findings indicated that adding natural elements to audiovisual settings may enhance the overall dining experience and create a more relaxing environment, as nature also makes one feel at ease. This study also highlighted the need for a triangulation method in analyzing the environment, demonstrating the value of quantitative and qualitative measurement techniques.

This study highlighted the significant impact of visual and auditory environments on participants' perceptions and experiences, presenting a detailed response to the research

objectives. The assessed hypothesis, which was predicted while the research continued, was supported by the results, highlighting how important it is to manage background noise, enhance aesthetics, and consider customer preferences while designing cafeterias.

Analyzing their auditory and visual environment demonstrated how people perceive and respond to their surroundings, emphasizing the critical role that audio-visual design plays in increasing participants' satisfaction and well-being. While participants' responses may differ, it might be useful to correlate participants' expectations and preferences with the responses to improve the overall dining experience. Providing appropriate audio-visual environments and a pleasant soundscape in cafeterias may benefit participants as they develop coping mechanisms and create preferences based on their perceptions.

Limitations of the Study

Thoroughly evaluating every component of an indoor environment is crucial. However, when assessing the multi-sensory interaction in a cafeteria, it is essential to acknowledge that additional senses, such as smell, taste, and tactile sensations, also play a role in shaping the overall perception of the setting. Regardless of the setting, these additional sensory elements should be considered in any contextual research.

Another important aspect of the cafeteria environment was its significant outdoor opening on most of the surroundings, which were enclosed by glass windows and doors. Glass, as a reflective material, can impact the reverberation time of the sound present in the environment. It is highly likely that the ambient sound in the cafeteria was amplified by the presence of glass. This potential amplification and its effects on the auditory

environment were not explored in this study, representing a limitation that should be addressed in future research.

Recommendations for Future Research

It was evident in this study that participants preferred a combination of both audio-visual sensory features. According to Alvarsson et al. (2010), nature has healing properties that can be experienced both visually and acoustically. Zhao et al. (2018) and Davies et al. (2013) further support the idea that harmonizing sounds and sights can enhance an environment's healing capabilities. Future investigations should explore deeper into the spectral properties of sounds and demographic variables to better understand participants' perceptions of users in cafeteria settings.

Given the limitations of this study, including the significant influence of glass as a reflective material that can amplify ambient sound, it is crucial to address the impact of different surfaces and their varying materials as they impact the absorption and reverberation time. Additionally, participants expressed a desire for well-thought-out audio-visual environments that include pleasant sounds, visual elements, and calming effects. Future research should expand to include other sensory perceptions, such as taste and smell, to provide a more comprehensive understanding of the cafeteria experience. By exploring multisensory perceptions, researchers can develop more holistic guidelines for designing cafeteria spaces that effectively enhance user experience.

REFERENCES

- Acun, V. (2021). *An Approach Based on Sound Classification To Predict Soundscape Perception Through Machine Learning* (thesis).
- Acun, V., & Yilmazer, S. (2018). A grounded theory approach to investigate the perceived soundscape of open-plan offices. *Applied Acoustics*, 131, 28-37.
- Acun, V., & Yilmazer, S. (2018a). Understanding the indoor soundscape of study areas in terms of users' satisfaction, coping methods and Perceptual Dimensions. *Noise Control Engineering Journal*, 66(1), 66–75. <https://doi.org/10.3397/1/37667>
- Acun, V., & Yilmazer, S. (2018b). A grounded theory approach to investigate the perceived soundscape of open-plan offices. *Applied Acoustics*, 131, 28–37. <https://doi.org/10.1016/j.apacoust.2017.09.018>
- Acun, V., & Yilmazer, S. (2019). Combining grounded theory (GT) and Structural Equation Modelling (SEM) to analyze indoor soundscape in historical spaces. *Applied Acoustics*, 155, 515–524. <https://doi.org/10.1016/j.apacoust.2019.06.017>
- Alvarsson, J. J., Wiens, S., & Nilsson, M. E. (2010). Stress Recovery during Exposure to Nature Sound and Environmental Noise. *International Journal of Environmental Research and Public Health*, 7(3), 1036–1046. <https://doi.org/10.3390/ijerph7031036>
- Abraham, D. A. (2017). Signal Processing. *Applied Underwater Acoustics*, 743–807. <https://doi.org/10.1016/b978-0-12-811240-3.00011-4>
- ATLAS.ti. (n.d.). *Why atlas.ti*. ATLAS.ti - The Qualitative Data Analysis & Research Software. Retrieved Dec 28, 2022, from <https://atlasti.com/why-atlas-ti>

- Brown, A. L., Kang, J., & Gjestland, T. (2011). Towards standardization in soundscape preference assessment. *Applied Acoustics*, 72(6), 387–392.
<https://doi.org/10.1016/j.apacoust.2011.01.001>
- Brooks, B. M., Schulte-Fortkamp, B., Voigt, K. S., & Case, A. U. (2014). Exploring our sonic environment through soundscape research & theory. *Acoustics Today*, 10(1), 30–40. <https://doi.org/10.1121/1.4870174>
- Brüel & Kjær. (n.d.). Knowledge. Leq - LAE/SEL - When To Choose What? | Brüel & Kjær. Retrieved March 31, 2022, from
<https://www.bksv.com/en/knowledge/blog/sound/leq-lae-sel>
- Bhattacharjee, A. (2012). Qualitative Analysis. In *Social Science Research: Principles, methods, and practices*. essay, Anol Bhattacharjee.
- Charmaz, K. (2014). *Constructing grounded theory*. SAGE.
- Çankaya, S. (2016). A comparative study on soundscape in a high school environment (Doctoral dissertation, Bilkent Üniversitesi (Turkey)).
- Çakır, O., & İlal, M. E. (2021, September). Utilization of psychoacoustic parameters for occupancy-based acoustic evaluation in eating establishments. In *Building Simulation* (pp. 1-11). Tsinghua University Press.
- Corbin, J. M., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative Sociology*, 13(1), 3–21.
<https://doi.org/10.1007/bf00988593>
- Çankaya Topak, S., & Yılmaz, S. (2022). A comparative study on indoor soundscape assessment via a mixed method: A case of the High School Environment. *Applied Acoustics*, 189, 108554. <https://doi.org/10.1016/j.apacoust.2021.108554>
- Chen, X., & Kang, J. (2017). Acoustic comfort in large dining spaces. *Applied Acoustics*, 115, 166-172.
- Davies, W. J., Adams, M. D., Bruce, N. S., Cain, R., Carlyle, A., Cusack, P., ... & Poxon, J. (2013). Perception of soundscapes: An interdisciplinary approach. *Applied acoustics*, 74(2), 224-231.
- Dokmeci Yorukoglu, P. N., & Kang, J. (2017). Development and testing of Indoor Soundscape questionnaire for evaluating contextual experience in public spaces. *Building Acoustics*, 24(4), 307–324. <https://doi.org/10.1177/1351010x17743642>

- Egan, M. D. (1988). *Architectural acoustics (J. Ross Publishing Classics)*. J. Ross Publishing.
- Erdoğu, İ., & Yilmazer, S. (2021). Understanding the Effect of Geometric Forms on Indoor Soundscape Assessment: A Case Study in CSO Concert Halls in Ankara, Turkey. *INTER-NOISE and NOISE-CON Congress and Conference Proceedings*, InterNoise21, Washington, D.C., USA., 1963-1969. <https://doi.org/10.3397/IN-2021-2015>
- Fiebig, A. (2023). Soundscape: A Construct of Human Perception. In *Soundscapes: Humans and Their Acoustic Environment* (pp. 23-48). Cham: Springer International Publishing.
- Glaser, B. G., & Strauss, A. L. (1967). *The discovery of Grounded Theory: Strategies for qualitative research*. Aldine Publishing.
- Hong, J. Y., & Jeon, J. Y. (2013). Designing sound and visual components for enhancement of urban soundscapes. *The Journal of the Acoustical Society of America*, 134(3), 2026–2036. <https://doi.org/10.1121/1.4817924>
- Hong, J. Y., Lam, B., Ong, Z. T., Gupta, R., Gan, W. S., Chong, S. H., & Feng, J. (2017, July). Suitability of natural sounds to enhance soundscape quality in urban residential areas. In *Proceedings of the 24th international congress on sound and vibration; London, UK*.
- Hasegawa, Y., & Lau, S. K. (2021). Audiovisual bimodal and interactive effects for soundscape design of the indoor environments: a systematic review. *Sustainability*, 13(1), 339. Chicago,
- International Organization for Standardization. (2014). ISO 12913-1: 2014 Acoustics- Soundscape-part 1: definition and conceptual framework. *ISO, Geneva*.
- International Organization for Standardization. (2018). ISO/TS 12913-2: 2018 Acoustics - soundscape-Part 2: Data collection and reporting requirements. *ISO, Geneva*.
- International Organization for Standardization. (2019). ISO/TS 12913-3:2019. Acoustics – Soundscape – Part 3: Data analysis. *ISO, Geneva*.
- Jo, H. I., & Jeon, J. Y. (2022). Influence of indoor soundscape perception based on audiovisual contents on work-related quality with preference and perceived productivity in open-plan offices. *Building and Environment*, 208, 108598.

- Jo, H. I., & Jeon, J. Y. (2019). Downstairs resident classification characteristics for upstairs walking vibration noise in an apartment building under virtual reality environment. *Building and Environment*, 150, 21-32.
- Kang, J., & Schulte-Fortkamp, B. (Eds.). (2016). *Soundscape and the built environment* (Vol. 525). Boca Raton, FL, USA:: CRC press.
- Kang, J., Schulte-Fortkamp, B., Brown, A. L., Gjestland, T., & Dubois, D. (2017). Acoustic Environments and Soundscapes. In *Soundscape and the Built Environment* (pp. 1–17). essay, CRC Press.
- Li, H., & Lau, S.-K. (2020). A review of audio-visual interaction on Soundscape assessment in urban built environments. *Applied Acoustics*, 166, 107372. <https://doi.org/10.1016/j.apacoust.2020.107372>
- Liu, J., Kang, J., Luo, T., & Behm, H. (2013). Landscape effects on soundscape experience in City Parks. *Science of The Total Environment*, 454-455, 474–481. <https://doi.org/10.1016/j.scitotenv.2013.03.038>
- Lau, S. K., To, W. M., & Chung, A. W. (2020, May). A comparative study of restaurant sonic environments in Singapore, Macao SAR, and Hong Kong SAR. In *Proceedings of Meetings on Acoustics 174ASA* (Vol. 31, No. 1, p. 015007). *Acoustical Society of America*.
- Lindborg, P. (2016). A taxonomy of sound sources in restaurants. *Applied Acoustics*, 110, 297-310.
- Ma, H., & Shu, S. (2018). An experimental study: The restorative effect of soundscape elements in a simulated open-plan office. *Acta Acustica United with Acustica*, 104(1), 106-115.
- Mistar, N. A., Sulaiman, R., & Che Din, N. B. (2020). A Conceptual Framework for Acoustic Comfort Classification in Eatery Places: Critical Reviews of the Determining Factors. *Acoustics Australia*, 48(3), 337-348.
- Meng, Q., Zhang, S., & Kang, J. (2017). Effects of typical dining styles on conversation behaviors and acoustic perception in restaurants in China. *Building and Environment*, 121, 148-157.
- Moura, J. (2009). What is signal processing? [president's message. *IEEE Signal Processing Magazine*, 26(6), 6–6. <https://doi.org/10.1109/msp.2009.934636>

- MathWorks. (n.d.-b). *Help center*. Documentation - MathWorks. Retrieved May 28, 2023, from <https://ch.mathworks.com/help/releases/R2021b/index.html>.
- MathWorks. (n.d.-c). *Image Segmenter*. Image Segmenter - Segment an image by refining regions. Retrieved May 28, 2023, from <https://ch.mathworks.com/help/images/ref/imagesegmenter-app.html>.
- MATLAB. (n.d.). *Signal Analysis Made Easy with the Signal Analyzer App*. MathWorks. Retrieved May 28, 2023, from <https://ch.mathworks.com/videos/signal-analysis-made-easy-with-the-signal-analyzer-app-1604485876749.html>.
- Novak, C. C., La Lopa, J., & Novak, R. E. (2010). Effects of sound pressure levels and sensitivity to noise on mood and behavioral intent in a controlled fine dining restaurant environment. *Journal of Culinary Science & Technology*, 8(4), 191-218.
- Orhan, C. (2019). *A Comparative Study On Indoor Soundscape In Museum Environments* (thesis).
- Orhan, C., & Yilmazer, S. (2021). Harmony of context and the built environment: Soundscapes in museum environments via GT. *Applied Acoustics*, 173, 107709.
- Reinoso-Carvalho, F., Gunn, L., Molina, G., Narumi, T., Spence, C., Suzuki, Y., ... & Wagemans, J. (2020). A sprinkle of emotions vs a pinch of crossmodality: Towards globally meaningful sonic seasoning strategies for enhanced multisensory tasting experiences. *Journal of Business Research*, 117, 389-399.
- Smith, G. M. (2022). *What is signal processing?* Dewesoft. Retrieved March 28, 2022, from <https://dewesoft.com/daq/what-is-signal-processing>.
- Smith, J. O. (2011). *Spectral Audio Signal Processing*. W3K. Retrieved from <https://ccrma.stanford.edu/~jos/sasp/>.
- Şahin, Z. (2020). *A Comparative Study On Soundscapes In Real And Virtual Open Office Environments* (thesis).
- Strauss, A. L. (2010). *Codes and coding*. In *Qualitative analysis for social scientists* (pp. 55–81). essay, Cambridge University Press.
- Strauss, A. L. (2010). *Qualitative analysis for social scientists*. Cambridge University Press.

- Steffens, J., Wilczek, T., & Weinzierl, S. (2021), Junk Food or Haute Cuisine to the Ear? – Investigating the Relationship Between Room Acoustics, Soundscape, Non-Acoustical Factors, and the Perceived Quality of Restaurants. *Frontiers in Built Environment*, 7, 676009.
- Schafer, R. M. (1977). *The Soundscape our sonic environment and the tuning of the world*. Destiny Books.
- Syed, S. F., & Yilmazer, S. (2023, November). Grounded theory approach on audio-visual perception of users in the restaurant environment. In INTER-NOISE and NOISE-CON Congress and Conference Proceedings (Vol. 268, No. 1, pp. 7487-7497). Institute of Noise Control Engineering.
- Truax, B., Westerkamp, H., Woog, A., & Kallmann, H. (2014). World Soundscape Project. In *The Canadian Encyclopedia*. Retrieved from <https://www.thecanadianencyclopedia.ca/en/article/world-soundscape-project>
- Torresin, S., Aletta, F., Babich, F., Bourdeau, E., Harvie-Clark, J., Kang, J., Lavia, L., Radicchi, A., & Albatici, R. (2020). Acoustics for supportive and Healthy Buildings: Emerging themes on indoor soundscape research. *Sustainability*, 12(15), 6054. <https://doi.org/10.3390/su12156054>
- Williams, G., & Short, A. E. (2022). Effects of noise on anxiety related to the experience of dining in restaurants. *Music and Medicine*, 14(1), a806.
- Wilczek, T., Steffens, J., & Weinzierl, S. (2019). *Room Acoustics, Soundscapes and Customer Satisfaction in Restaurants-a Field Study*. Universitätsbibliothek der RWTH Aachen.
- Walker, D., & Myrick, F. (2006). Grounded theory: An exploration of process and procedure. *Qualitative Health Research*, 16(4), 547–559. <https://doi.org/10.1177/1049732305285972>
- Yilmazer, S et al (2023). There is a way to differently define the acoustic environment, 184th Acoustical Society of America (ASA) Meeting Lay Language Paper, 8-12 May, Chicago, USA

- Yilmazer, S., & Acun, V. (2018). A grounded theory approach to assess indoor soundscape in historic religious spaces of Anatolian culture: A case study on hacı bayram mosque. *Building Acoustics*, 25 (2), 137-150.
- Yilmazer, S., & Bora, Z. (2017). Understanding the indoor soundscape in public transport spaces: A case study in Akköprü metro station, Ankara. *Building Acoustics*, 24 (4), 325-339.
- Yilmazer, S., & Uğurlu, Z. (2023, February). A Qualitative Approach to Explore Audio-Visual Interaction in a Hospital Environment. In *INTER-NOISE and NOISE-CON Congress and Conference Proceedings* (Vol. 265, No. 6, pp. 1451-1458). Institute of Noise Control Engineering.
- Yilmazer, S., & Uğurlu, M. Z. (2022). A qualitative approach to explore auditory and visual perception in a hospital environment. *ASA 182nd Meeting, Acoustical Society of America*, Denver, Colorado, USA. <https://doi.org/10.1121/10.0010794>
- Yang, M., & Kang, J. (2013). Psychoacoustical evaluation of natural and urban sounds in soundscapes. *The Journal of the Acoustical Society of America*, 134(1), 840–851. <https://doi.org/10.1121/1.4807800>
- Zhao, J., Xu, W., & Ye, L. (2018). Effects of auditory-visual combinations on perceived restorative potential of urban green space. *Applied Acoustics*, 141, 169–177. <https://doi.org/10.1016/j.apacoust.2018.07.001>
- Zellner, D., Geller, T., Lyons, S., Pyper, A., & Riaz, K. (2017). Ethnic congruence of music and food affects food selection but not liking. *Food Quality and Preference*, 56, 126-129.

**RESEARCH ON AUDITORY AND VISUAL PERCEPTION OF USERS IN MARMARA RESTAURANT,
BILKENT UNIVERSITY, ANKARA, TURKEY**

This survey is carried out within the scope of the perceived sound and visual environment research prepared at Bilkent University, Department of Interior Architecture and Environmental Design. Your identity is not asked in the survey. The data obtained from all the participants is entirely voluntary.

For more information: fatima.syed@bilkent.edu.tr

A. Personal information

1. Age
2. Education
 - ☐ Undergrad
 - ☐ Masters
 - ☐ PHD
3. Gender
 - ☐ Female
 - ☐ Male
 - ☐ Other
4. Please specify your ethnicity.
 - ☐ White
 - ☐ Mixed/ Multiple ethnic groups
 - ☐ Asian/ British-Asian
 - ☐ Black/ African/ Caribbean/ Black-British
 - ☐ Middle Eastern
 - ☐ Rather not say
 - ☐ Another ethnic group

Please specify "Another ethnic group"

.....

APPENDIX A

Questionnaire Survey

5. Purpose of visit
 - ☐ Breakfast Other
 - ☐ Lunch
 - ☐ Dinner
 - ☐ Other
6. How frequent do you visit Marmara restaurant?
 - ☐ Never
 - ☐ rarely
 - ☐ Sometimes
 - ☐ Often
 - ☐ Very Often
7. How long do you stay in Marmara Restaurant at every visit?
 - ☐ 15-20 mins
 - ☐ 30-45 mins
 - ☐ more than 1 hour

B. Questionnaire Part

B1. Sound source identification

What are the different sounds that you're presently hearing in the Marmara restaurant while you fill this survey? To what extent do you hear those sounds?

Please tick off one response alternative each sound.

Sound sources	Not at all	A little	Moderately	A lot	Dominates completely
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐

To what extent do you presently hear the following four types of sounds?

Please tick off one response alternative per type of sound

	Not at all	A little	moderately	A lot	Dominates completely
Sound from human activity (e.g., conversations, laughter, footsteps, piano playing in background)	☐	☐	☐	☐	☐
Sounds from background activity (e.g., service noises, furniture drags, cutlery clutter, piano playing in background, HVAC)	☐	☐	☐	☐	☐
Natural sounds (e.g., singing birds, wind, rain)	☐	☐	☐	☐	☐

B2. Perceived affective quality

For each of the 8 scales below, to what extent do you agree or disagree that the present surrounding sound environment is ...

	Not at all	A little	moderately	A lot	Dominates completely
pleasant	☐	☐	☐	☐	☐
Chaotic	☐	☐	☐	☐	☐
Vibrant	☐	☐	☐	☐	☐
uneventful	☐	☐	☐	☐	☐
Calm	☐	☐	☐	☐	☐
Annoying	☐	☐	☐	☐	☐
Eventful	☐	☐	☐	☐	☐
Monotonous	☐	☐	☐	☐	☐

B3. Assessment of the surrounding sound environment

Overall, how would you describe your experience in the present surrounding sound environment?

Very good	Good	Neither good, nor bad	Bad	Very Bad
☐	☐	☐	☐	☐

B4. Appropriateness of the surrounding sound environment

Overall, to what extent is the present surrounding sound environment appropriate to the present place?

Not at all	Slightly	Moderately	Very	Perfectly
☐	☐	☐	☐	☐

What are the annoying sounds you are hearing while you fill this survey?

.....

What is the most annoying sound you are hearing while you fill this survey?

.....

B5. Assessment of the surrounding visual environment

Overall, how would you describe the present surrounding visual environment?

Very good	Good	Neither good, nor bad	Bad	Very Bad
☐	☐	☐	☐	☐

B6. Appropriateness of the surrounding visual environment

Overall, to what extent is the present surrounding visual environment appropriate to the present place?

Not at all	Slightly	Moderately	Very	Perfectly
☐	☐	☐	☐	☐

B7. Assessment of the surrounding Audio-visual environment

Overall, how would you describe the present surrounding?

Very good	Good	Neither good, nor bad	Bad	Very Bad
☐	☐	☐	☐	☐