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A qualitative approach to investigate indoor soundscape of the built environment

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ABSTRACT

Soundscape approach takes advantage of both quantitative and qualitative research methods. So far, there have been five main research tools to collect and analyze data. Quantitative ones are consisted of, questionnaire surveys, psychoacoustic measurements and semantic differential scales, while the qualitative ones are observation protocol and interviews. Qualitative methods are mostly used in order to describe and explore the relevant aspects of soundscape especially when there is limited knowledge. Indoor soundscape research has implemented the qualitative approach of Grounded Theory (GT) to identify and define the sound environment. GT is a less frequently used but a more user-centered method that can systematically analyze individual's subjective perception of the soundscape in the built environment. This paper presents the way of Grounded Theory (GT) applications and findings of indoor soundscape researches conducted by the authors which took place in four different indoor spaces: Museum, Historical religious space, High school environment and Open-plan office. The results indicate that core categories of the framework, such as the context of sound, are similar with others, while some categories are different, possibly due to the function of the indoor space.

1 INTRODUCTION

Soundscape approach was introduced in late 1960's, by R.M. Schafer and it reached peak popularity within the last decade¹. Soundscape is concerned with the perception of sound rather than the transfer of sound energy. ISO 12913-1 defined soundscape as "the acoustic environment

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perceived or experienced and/or understood by a person or people, in context”². Soundscape approach takes advantage of both quantitative and qualitative research methods.

Great majority of the soundscape research has focused on urban environment, with very little attention to the indoor environments. However, there are various types of indoor environments that serve different functions and completely different sound environments. Mackrill et al., used Grounded Theory (GT) to conceptualize the lived in experience of a hospital ward and found that patients are coping with the aspects of soundscape by accepting and habituating to the soundscape³. Similarly, Acun and Yilmazer also found that individuals are coping with the negative aspects of the soundscape by using earphones, physically or verbally interfering to the sound source and/or through adaptation⁴.

This paper presents the way of Grounded Theory (GT) applications and findings of indoor soundscape researches conducted by the authors which took place in four different indoor spaces: *Museums, Historical religious space, High school environment and Open-plan office*. In this study, GT’s procedure used three phases of coding and relied on theoretical saturation and constant comparison. At the beginning, interview transcriptions undergone sentence by sentence *open coding* which separated the data into pieces by labelling each significant event. After the data is broken down into pieces, that held the essence of the significant events, the data are grouped back together based on their association with each other by using the *axial coding*. This procedure created categories. Based the relation between the categories, such as causal relationship, a framework is created to visualize the emerging theory. In the last phase, the selective coding, a category which reflects the core of the phenomenon is chosen. Its relation to other categories are explored which creates the theory to explain the phenomenon.

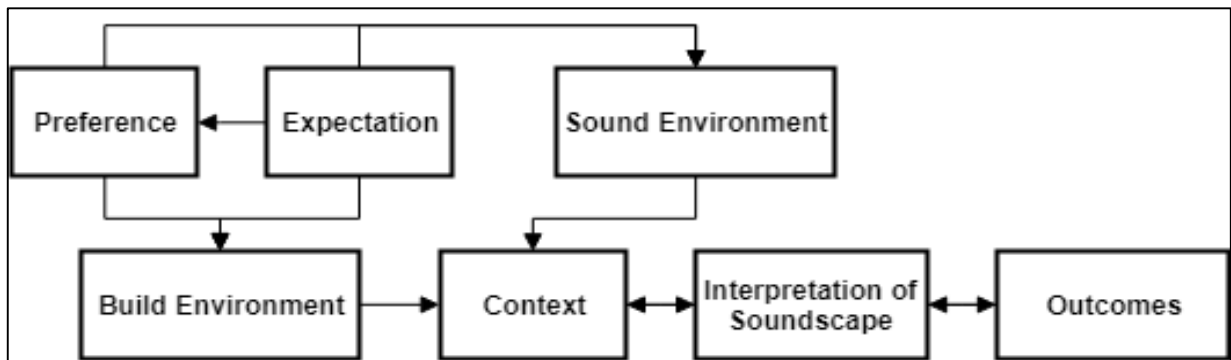


Fig. 1 – The conceptual framework that is created after GT analysis⁴.

Grounded theory analysis of the interview data resulted in a conceptual framework with 7 categories (Figure 1). These categories are Sound Environment, Build Environment, Context, Preference, Expectation, Interpretation of Soundscape, and Outcomes. The key phenomenon in this framework is the Interpretation of the Soundscape. Conceptual framework represents how this process works.

2 GROUNDED THEORY APPROACH TO EXPLORE INDOOR SOUNDSCAPE OF BUILT ENVIRONMENT

2.1 Indoor soundscape of historical spaces: The case study of Çengelhan Caravanserai

This study investigates visitors’ subjective perception of the museum soundscape and how it effects the visitor experience^{5,6}. Also, we seek to identify the associations between the

soundscape, function and the historic characteristics of the museum. With this regard, qualitative approach of grounded theory is used to explore the phenomenon.



Fig. 2 – The inner courtyard (left) and the ground floor plan (right) of Çengelhan

Historic building is currently used by the Rahmi Koç Museum, an institution concerned with collecting, researching, preserving and exhibiting of industrial and engineering object from all countries and periods up to present day. Building is located in front of the main gate of Ankara Castle. It is constructed at the first quarter of sixteenth century as caravanserai, and used for various different purposes until its comprehensive restoration and conversion into a museum at the beginning of twenty first century. The single storey building has an inner courtyard and a basement. The courtyard at the middle is surrounded with vaulted stone cloisters. The inner courtyard is covered with a glass roof during the restoration (Figure 2).

Table 1 – The conceptual framework that is created after GT analysis⁵

Categories						
Expectation	Preference	Build Environment	Sound Environment	Context	Interpretation of Soundscape	Outcomes
		<ul style="list-style-type: none"> • Physical Aspects • Perceptual Aspects 	<ul style="list-style-type: none"> • Sound Sources 	<ul style="list-style-type: none"> • Consistency • Inconsistency 	<ul style="list-style-type: none"> • Positive Interpretation • Neutral • Negative Interpretation 	

2.2 Indoor soundscape in historic religious spaces of Anatolian spaces: A case study on Hacı Bayram Mosque

This study presents a research that is concerned with the indoor soundscape in historical mosque⁷. Hacı Bayram Mosque and its surroundings area of Hamamönü has been selected as the research site due to being the historical center of Ankara. Although there are studies concerned with the acoustical characteristics of mosques, there isn't enough research focusing on user's expectation and interpretation of the indoor soundscape within a historical space.

Hacı Bayram Mosque is located on a hill at the historic Ulus district of Ankara. Religious history of the location dates back more than 2000 years. During the ancient times, this site was used to worship the Anatolian deities, Cybele and Men. After Roman conquest, Temple of Augustus (Monumentum Ancyranum) was built on its place. Temple was converted into a church during the Byzantine rule and with the Turkish conquest it was used as a madrassah. Hacı Bayram Mosque was constructed right adjacent to the temple at 1427. Mosque has the characteristics of early Ottoman era architecture. South-eastern corner of the mosque touches the western wall of the temple with approximately 40 degrees of angle (Figure 3). Mausoleum of Hacı Bayram-I Veli is attached to the southern wall of the mosque. Mausoleum is a domed structured that is constructed shortly after the mosque, with the death of Hacı Bayram (Figure 3). The minaret of the mosque is attached to the south-eastern corner of the mausoleum. Even though both of these structures are attached to the mosque they are independent structures which cannot be accessed from inside the mosque. Over the centuries the mosque has undergone many restorations and some parts were added to the original mass during these restorations.



Fig. 3 – Hacı Bayram Mosque and the Temple of Augustus (left) and interior view of the Mosque (right)

The mosque was the central part of an Islamic social complex (Külliye) with buildings spread around the site asymmetrically, most of which are non-existent today. The main mass of the mosque that survived until today has a rectangular stone foundation, brick walls with wooden girders, wooden cassette ceiling and a hipped roof. Mosque has two storeys. On the first floor, the main prayer hall is located after narthex (Figure 3). This hall is two storey high and oriented towards the plaster mihrap. The upper floor has a cantilevered slab, facing the mihrap. First floor has rectangular windows while the second floor has pointed arch windows. In the main prayer hall, inner surface of the walls are covered with glazed tiles up to the top of the first row of windows. Upper portion of the walls are painted plainly. After the renovation efforts of 2011, the mosque has a floor area of 2500 m².

Sample group consists of fifteen males. Prayer sessions are dominated by male population. Because of this, it is very hard to find any female that leaves the mosque after a prayer. The very small amount of females that we found did not prefer to participate in the survey. Age of the sample group vary between the ranges of thirty six to sixty. Three different days are chosen to conduct Semi-structured interviews. Tuesday is chosen as a work day, in which the participants are mostly those living or working in the area. Friday is considered as a holy day in the Muslim world. Due to this, Friday afternoon prayers are more crowded than any other prayer period. Being the

weekend, Saturdays has a more diverse community then week days has increased number of tourists and those living in further districts of Ankara visits the mosque.

Table 2 – Categories and subcategories generated at the end of data analysis ⁶

Categories and Subcategories					
Spatial Function	Soundscape Expectation	Sound Preference	Interpretation of Soundscape	Place Identity	Outcomes
1.Social Function				1. Mystique	1. Preference
2.Religious Function				2. Spiritual	
				3. Tranquil	
				4. Peaceful	
				5. Impressive	

2.3 The effect of indoor soundscape on the students’ perception in high school environment

This study represents the existing high school acoustic environment and examines the interpretation of auditory sensation towards it ⁸. To create a conceptual framework between them, grounded theory (GT) approach is used. Lastly, this research intends to express the soundscape perception differences between selected areas in high school environment.

Bilkent High School is chosen which is located in east side of Bilkent University Campus in Ankara. Two different functional spaces are defined as classroom and computer laboratory. Number of sound sources and the content of lesson are main criteria to select these study areas because computer laboratory class has more interactive lesson content than regular classroom lesson. Moreover, they have different sound source environment when compared their lesson requirements.

To minimize the spatial differences, classroom and computer laboratory are selected similarly in terms of area sizes and location of spaces in the plan of the school. Computer laboratory is located between corridors without connection with outside and classroom is also located among three corridors and lateral façade. Computer laboratory has 55 m² area having around 15 students whilst classroom has 49 m² area having around 15-18 students.



Fig. 4 – The interior view of the classroom (left) and computer laboratory (right)

All measurements and interviews are conducted after obtaining required permissions from the relevant authority of school. 16 classroom and 14 computer laboratory students were interviewed during class hours in two school days. Interviews ranged from 4 to 14 minutes in duration. Semi-structure interview questions are covering some topics as identification of recognized sound, an indication of positive and negative sound sources, sound preferences, sound perception and satisfaction. The data are recorded and transcribed verbatim. Transcriptions were later coded to derive themes and categories related to each space.

Table 3 –Results of classrooms laboratory in selected categories ⁸

Categories	Classroom	Computer Laboratory
Sound Sources & Sound Levels	Speech	Computer fan sound
Acoustic Environment	LAeq = 62.6 db RT > 0.6 STI = 0.63	LAeq = 64.9 db RT > 0.6 STI = 0.61
Soundscape Preference	Music – wanted sound	Music – wanted sound
Soundscape Perception	Birds singing- positive Speech - negative	Laughter - positive Speech - negative

2.4 A grounded theory approach to investigate the perceived soundscape of open-plan offices

This study presents the findings of a user focused soundscape survey, that took place in a visual task based and a computational task based open-plan office spaces ⁴. Aim of this study is to conduct a grounded theory (GT) survey which captures individuals’ subjective response to the soundscape and creating a conceptual framework in the end.

The offices are chosen taking the slight differences between the work tasks they are performing into account. One of the chosen offices is used by an architecture company and the other one is by an engineering company that specializes in structural and mechanical design. Both of them are performing computer based tasks the architects are concerned with spatial function and aesthetics visual attention based tasks while engineers are more concerned with computational tasks.

Both offices are located in Ankara/Turkey. Data collections are held at the architecture company first. This company occupies the first 3 floors of a residential building which is located at the city centre of Ankara, close to the main roads but within a secluded area. Research has taken place in the design and accounting departments, and in a few private offices. The main office area takes up 215 m² space at the ground floor. About one third of this area has a very low plaster suspended ceiling (h= 2.40m) and it is mostly dedicated to meeting rooms and private offices for the senior employees. Rest of the space has almost twice the ceiling height (h=5.79m) and it is dedicated for the open office area. This part has linear metal ceiling panels with some degree of acoustical treatment. Through the office space vinyl is used as the floor material and paint on plaster is used for the walls. There also large windows on the walls which take up 19.8 m² area. Employees’

workstations have screen partitions covered with fabric which are not only used for acoustical purposes but also used by employees to attach visual material, memos, etc.

Table 4 –Core categories and subcategories created by the end of the coding ⁴

Coping Methods	Task Type	Physical Attributes of Space	Task Performance	Sound Preference	Activity
<ul style="list-style-type: none"> ▪ Adaptation ▪ Isolation ▪ Intervention 	<ul style="list-style-type: none"> ▪ Routine Task ▪ Concentration required task 	<ul style="list-style-type: none"> ▪ Heating ▪ Lighting ▪ Office Layout ▪ Proximity 	<ul style="list-style-type: none"> ▪ Positive ▪ Negative ▪ Neutral 	<ul style="list-style-type: none"> ▪ Task Dependent ▪ Mood Dependent ▪ Personal Preference 	<ul style="list-style-type: none"> ▪ Length of Exposure ▪ Activity
Employee Characteristics	Environmental Factors	Sound Sources & Sound Levels	Interpretation of Soundscape		
			Positive	Neutral	Negative
<ul style="list-style-type: none"> ▪ Behavioural Tendency ▪ Mood ▪ Health ▪ Experience 	<ul style="list-style-type: none"> ▪ Crowdedness ▪ Tension ▪ Relaxation ▪ Workload ▪ Privacy 	<ul style="list-style-type: none"> ▪ Human ▪ Mechanical ▪ Electrical ▪ Outside ▪ Music ▪ High Sound Levels ▪ Low Sound Levels 	<ul style="list-style-type: none"> ▪ Promoting Motivation ▪ Promoting Concentration ▪ Promoting Privacy ▪ Promoting Relaxation ▪ Workplace Satisfaction 	<ul style="list-style-type: none"> ▪ Indifference 	<ul style="list-style-type: none"> ▪ Loss of Concentration ▪ Decreased Motivation ▪ Annoyance ▪ Disturbance ▪ Irritability ▪ Nervousness ▪ Self-Restriction

Second office is used by the engineering company. This company fully occupies a four story building. There are 135 m² open office area at the ground floor and the first floor. Similar to the other research setting, this one also has private office rooms adjacent to the open office area. The open office area is divided into two spaces; a large area for fifteen employees and a smaller subspace for six employees. The materials used for these spaces are; epoxy for floor finish and paint on plaster for walls and ceiling. There are not any acoustical ceiling treatments present in this office spaces and the ceiling high is very low all around the building (h=2.20m). Acrylic screens are used between workstations.

Relevant permissions are taken from the owners of the companies and project leaders for conducting interviews with the employees. A total of 49 interviews are held with 21 male and 26 female volunteering employees' from both offices, throughout the business hours. Interviews are held in meeting rooms and lasted two days for each office. Interview durations varied from 7 to 20 minutes. With the permission of the interviewee, each interview is recorded and later transcribed by the researchers.

3 DISCUSSION

Expectation and Preference: Expectations are formed by individuals past experiences. In Çengelhan Museum, almost half of the participants were unfamiliar with the museum and unaware of the theme of the museum. When the participants' were told that they will be visiting a museum, majority of them thought that it will be a modern building, like a contemporary art museum based on their former experiences with museums. Majority of the individuals preferred the quiet environment in the museum as they expected that it would be hard to concentrate on the exhibit if

the environment is loud. Similarly some of them preferred the museum to be a modern environment beforehand. Once they experienced the historic build environment and its relation with the exhibit, they were satisfied regardless of their preference.

In the religious historical space, as Hacı Bayram Mosque and its surrounding area has centuries of history, individuals expect something more than they would expect from a regular mosque. A group of participants who visited the mosque for the first time stated that they were disappointed with the overall atmosphere of the mosque. Further inquiry revealed that part of it was caused by the soundscape. When they were inside the mosque, the composition of visual and aural environment evoked a mystique, tranquil and spiritual atmosphere. However, upon exiting the mosque, the mystique atmosphere is transformed into a mix of street merchants, shops and traffic. Participant prefers religious spaces to be quite and if it actually is a quite environment it can be interpreted as a tranquil place.

In the high school environment, students were asked to define their preferences for their learning environment. Students mostly preferred to hear music as a wanted sound in their learning environment. However, students defined their preferences in terms of the context of lesson. For example, students generally prefer to work with music if task requires less effort or the lesson is based on applied method. Therefore, computer laboratory students preferred music more compared to classroom students in their learning environments.

In open-office environment, vast majority of the employees preferred to have a background music while they are working (n=35). However, using music as source of background sound is an issue. Central music broadcast is already available at one of the offices but even though employees preferred to hear music in theory, they do not prefer to do so in practice. They do not use the central broadcast system unless they leave their workstations for lunch. Some of the new employees are not even aware that there is a music broadcast sound preference depends on three aspects; mood, task and personal preference. If the existing auditory environment is negatively affecting employees' task performance, it leads to a negative interpretation of the soundscape as it disturbs concentration, decreases motivation, etc. A common event stated by majority of employees is, while performing a routine visual task such as modelling a building façade, they can listen a song based on their personal preference. However, if they are performing a semantic task or a task involving high amount of problem solving, they prefer to listen a music with as little lyrics as possible or not to hear anything at all. These findings indicate that music is not only a sound preference but also, and more likely, *a coping method*. It is employees' method of creating their own auditory environment when the present one is no longer satisfactory.

Sound Environment and Build Environment: In Çengelhan Museum, Build Environment divides into two subcategories, *Physical Aspects of the Environment* and the *Perceptual Aspects of the Environment*. Physical aspects consists of items such as material, layout, content of the exhibitions, and space definition (large-small, open-enclosed, historic- modern). On the other hand, perceptual aspects of the space are comprised of statements that describe the space regardless of the sound environment, such as cozy, orderly/complicated, crowded, and boring/ordinary. *Sound Environment* includes the subcategories of sound sources, background sound, and participants' descriptions regarding sound environment (high-low sound levels, controlled-uncontrolled sound environment).

In Hacı Bayram mosque, besides its religious function, mosque is also a social place. Various different kind of people come together either in or around the mosque. Some of the social function of the mosque is tied to its religious function. Our observations point out that those who came to the mosque for religious functions (prayer, visiting the mausoleum, etc.) often prefer to stick around the mosque for a time. People do not hesitate to sit near complete strangers and engage in group conversation.

In the high school, the answers of students in classroom and computer laboratory are found different. Classroom students are said most frequently heard sound source is speech (n=13) whilst computer laboratory students said computer fan sound (n=12). Actually, this result is expected due to their different environmental conditions. To explain sound environment in detail, roadway traffic, laughter and birds singing can be given as examples of outstanding dominant sound sources in classrooms and keyboard sound, ventilation sound, speech in computer laboratory. Generally, students do not prefer to hear high sound levels because they interpret the high-level sound as a noise even if they like to hear in their learning environment. In addition, even if the acoustical measurements values are higher than recommended ones, some students are happy with their learning environment, and it shows that sound levels are not enough to explain the perception of the students.

In the open-office, employees were asked what they expect to hear, what they would prefer to hear and what they actually hear in their office space. Most commonly heard sounds were *human generated sounds*, followed by *mechanical and electrotechnical sounds*, *outdoor sounds* and *music*. Among human generated sounds, speech and its derivatives such as group conversation and phone conversation make up for the majority of sound sources. With this regard, employees reported that conversation sounds coming from the meeting rooms and the management floor to be the most dominant sound (n=7) regardless of their proximity to the locations. It is also revealed that employees expect to hear speech in their work environment. From this point on, discussion will occasionally include direct quotations from employees', to show their perception explicitly.

Context: In Çengelhan Museum, throughout the research it was seen that even the most frustrating sound environments can become non-irritating, if not satisfactory if it is consistent with the context. Indoor environment of a museum can be comprised of different sections with various different themes. Physical and auditory elements within the environment create a context.

Classroom and computer laboratory environment does not give very different responses towards the acoustic environment. The answers of students were analyzed as positive responses, negative responses and neutral responses. Sound sources resulted in positive responses such as promoting the relaxation, interaction, comfort, attention, concentration, motivation and mood or negative responses such as distraction, disturbance, annoyance, loss of concentration, loss of productivity.

Context determines how the soundscape will be interpreted, in terms of positive, neutral or negative. In open-plan office environment, keyboard sound is a fine example in terms of showing how a sound source can be interpreted. It is perceived positively by a substantial amount of employees, (n=33) while no one stated that sound of a printer or sound of a computer fan is positive. Employees expressed that the sound of keyboard and mouse means that they are working at that moment, there are other people around, and they are not working alone, or not working overtime. An employee even described it as a motivator. Employees

stated that the sound of keyboard can be interpreted as an indicator of company's business. The individual is not alone in the office, company is in a good shape because there are tasks people are attending to. This, in a way, motivates the employees, encourages them to work, by making them think "*People around you are working, you should do the same*" as it was expressed by an employee. This particular sound source is perceived as positive, or neutral by the employees most of the time. However, as the context of sound is altered by emotions, the perception can become negative.

Interpretation of Soundscape: In Çengelhan Museum, even though having a background sound is appreciated by majority of the participants. Almost all expressed dissatisfaction with the type of music that is broadcasted. Participants' common choice of background sound is found to be classical music, as they think that it will not interfere with their concentration but merely create a soft background sound. Not having any background sound at all is not preferred, as the participants' were aware that it is impossible to rid the space of uncontrolled sound, especially human generated, and these sounds would will cause more distractions with the absence of a background sound that can mask at least to a certain degree.

In Hacı Bayram Veli mosque, the spatial elements and activities which individuals use to define the identity of the space constitutes the Place Identity category. Most common descriptors individuals used to describe the space are, mystique, spiritual, tranquil, peaceful, and impressive. Place Identity is a direct response to interpretation of the soundscape. Many respondents said that music and prayer broadcast contributes to the mystique and spiritual atmosphere of the space.

Outcomes: In Çengelhan museum, for this specific environment, interaction with the displayed object is perhaps one of the most important factors to promote an appreciable museum experience. To some extent sound is used as a design element to create the feeling of being present in that environment. Building historic characteristic greatly helped participants to imagine themselves being in the actual environment. This atmosphere is further enhanced with introduction of different sounds depending on the contents of the exhibitions. The combination of the historic aspect, function and the sound of the building created a unique atmosphere. As a participant stated, mixture of the historic stone walls and the wooden floors, with the exhibitions that display the life of the past generations, created a unique sensation that feels like the building is speaking with them. Every participant appreciated the usage of sound based on the theme of the section. . Participants especially enjoyed the sections where they can control the sound with buttons but could not use this to its full extent as the sound within that room was too low and the sound outside the room was too high. Participants expressed that when the space becomes so crowded and full of irrelevant speech it caused a loss of concentration, disturbance and made them want to get away from that part of the exhibition as an outcome.

Last category of the framework is the outcomes individual gives after being subject to the spatial and auditory characteristics of the mosque. During coding, most obvious outcome of the soundscape perception is found to be preferring to go the mosque or not. Based on the spatial function, individuals' have a general idea about this, which predetermines their sound preference and expectation from the soundscape.

Outcomes are also seen as a part of conceptual framework as a long-term consequences of soundscape perception. It may be analyzed in two sections as physical outcomes or long-term

outcomes. In high school environment, results showed that perceived sound resulted in physical outcomes such as headache, fatigue and long-term outcomes such as lesson failure.

In open-plan office, results showed that employees used headphones for two main reasons; to isolate themselves from their workplace and when they want to listen to music. It has been also found that employees tend to react more positively towards semantic sound sources, such as music and speech, when they are performing visual based tasks. On contrary, employees performing semantic tasks stated a negative attitude towards nearly all kinds of sound sources and preferred absence of sound. Methods developed to cope with the negative interpretation of soundscape can be considered as the “*outcomes*” core category of ISO 12913-1 standard.

5 CONCLUSION

This research investigated the individuals’ subjective perception of the soundscape of four different indoor spaces and the associations between the soundscape, function and different aspects of the building. Findings indicate that individuals’ desire the sound environment to be designed just like the physical environment. Under right conditions sound can be used to create a living environment with a unique atmosphere that would enhance the users’ experience to maximum degree.

Overall, individuals place a great importance on the spatial function of the space which determines their soundscape expectation and sound preference. Another respondent said that he finds nothing special about the soundscape because he expects and prefers it to have some degree of variation but as this is not the case he feels nothing special about the soundscape. When going to a particular space, participants have a clear idea about what that space is and why they are going to that place. They know what to expect from it and have a predetermined preference. Once they start to hear the soundscape they subconsciously compares it with the soundscape they expect and prefer. This influences the way they interpret the soundscape.

Context is an intervening condition. *Context* shapes, facilitates and/or constrains the interpretation of the sound environment. *Context* is divided into two items as consistency and inconsistency.

Central phenomenon of this research is the Interpretation of the Soundscape. It consists of subcategories of positive interpretation, neutral, and negative interpretation. These subcategories are also a response to the interpretation of the soundscape. When the interpretation is positive, it can lead to appreciable, interesting or intriguing environment. On the other hand, when it is negative it leads to irritating, unenjoyable environment. Context of the sound is the major factor that influences the interpretation of the sound. As previously given examples demonstrated soundscape can be interpreted positively if it matches with individuals’ expectation and context. Soundscape can also be interpreted positively even if does not match individuals’ expectation, as expectations are not necessarily positive.

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