Applied Acoustics 131 (2018) 28–37

Contents lists available at ScienceDirect

Applied Acoustics

journal homepage: www.elsevier.com/locate/apacoust

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

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ARTICLE INFO

Keywords:
Indoor soundscape
Open plan office
Grounded theory

ABSTRACT

This paper 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. Aim of this study was to conduct a grounded theory survey which captures individuals' subjective response to the soundscape and creating a conceptual framework in the end. In order to achieve this goal, acoustical environment and sound sources were identified. In-situ measurements of sound levels (*LAeq*) and simulations, prepared by Odeon Room Acoustics Software 13.10 Combined, were used to explore the acoustical environment of the office spaces. Grounded Theory was used as the main research method to create a conceptual soundscape framework, and to reveal employees perception of the soundscape of their work environment. As part of grounded theory, semi-structured interviews were conducted with forty-nine employees from both types of offices. The results showed how the task at hand were affected by the sound environment and employees' characteristics. Sound that were not expected or out of context and those that interfere with the concentration demanding tasks caused a negative interpretation of the soundscape. Due to this, employees' adopted coping methods such as, accepting and habituating, intervening to the sound source, or putting on headphones to isolate themselves from the soundscape. It was discovered during the interviews that employees were concerned with silence as much as they were concerned with the noise. 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.

1. Introduction

Open-plan offices are one of the most popular workspace layouts as they provide increased net usable area, higher occupant density, ease of reconfiguration and most importantly improved communication and interaction between employees, [1,2]. However there is no empirical evidence showing that open plan layout will increase task performance. In fact they are associated with lack of visual and acoustic privacy, and uncontrolled sounds levels, which can cause significant decrease in task performance and workplace satisfaction [1–4]. These factors may also cause disturbance in various activities employees are performing, which can make them change their work strategy or behave differently by adopting coping methods [1]. An appropriate acoustical design of an open office should involve a sufficient control of speech. In order to achieve this, several factors need to be considered, such as; absorbers on ceilings, walls, and furniture, high screens and storage units, distance between workstations, enclosure of workstations, and the use of artificial masking sound [4,5]. An extensive literature exists regarding the physical environment of open offices. Among all the parameters that affect an indoor physical environment, the acoustical environment and uncontrolled sound levels are the most frequent source of dissatisfaction [1–4,6]. Dissatisfaction with the sound environment can have a negative effect on a variety of factors such as health, wellbeing, job satisfaction, productivity, etc.

A number of studies have focused on the associations between these factors and lack of speech privacy. Researchers identified that prolonged noise exposure and lack of speech privacy caused a major decrease in the workplace satisfaction [2,6,7]. Satisfaction with the work environment and overall job satisfaction are some of the most important aspects of an office environment. Regarding this, Frontczak and his colleagues carried out a very extensive study and revealed that highest level of satisfaction is observed for ease of communication and amount of light [7].

Another challenge of the open offices is the fact that they can contain variety of different sound sources. Numerous studies have focused on investigating the types of sounds and their effects on employees. Studies have shown that both intelligible and unintelligible sounds are major sources of annoyance. [8]. Brocolini et. al., found that

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http://dx.doi.org/10.1016/j.apacoust.2017.09.018
Received 12 January 2017; Received in revised form 18 September 2017; Accepted 19 September 2017
Available online 18 October 2017
0003-682X/

intelligible speech causes significant decreases on task performance for serial memory tasks and also observed that masking sound does not have any effect on performance. [9]. Pierrette et. al. also found a decrease in task performance caused by intelligible conversations, followed by unintelligible conversations and phone ringtones [8]. Aside from this, an interesting finding regarding open office task performance has been discovered by Seddigh and colleagues [10]. Their results indicate that a decrease in performance in concentration demanding tasks is observed for employees working in cell type offices when compared to those working in small and medium sized office spaces [10]. The authors discuss that due to the high amount of irrelevant stimuli found in open offices, occupants might have a stronger incentive to develop methods of coping with them [10]. Zhang and colleagues also focused on the impact of noise in open office environments [4]. A large portion of employees (ranging from 30% to 50%) thoughts that various sound sources inside and outside the office environment were either disturbing or very disturbing.

Based on the literature, the sound environment of an open office space has a crucial influence on occupants' wellbeing, performance, health and satisfaction. However, various recent studies suggest that when it comes to perception of the sound environments, the objective measurements may not be enough [11,12]. Understanding the perception of the sound environment requires a different approach, which is concerned with individuals' subjective response to their sonic environment, and various elements within that environment. In order to achieve this goal, this paper will report the findings of a qualitative indoor soundscape research.

1.1. The soundscape concept

Soundscape approach was introduced by Schafer, a composer and a scholar, who was concerned with the radical changes in the auditory environment of modern society [13]. According to Schafer, the only time modern society pays significant attention to this matter was either when it is too loud or when there is a technological innovation [14]. Most common methods employed by the authorities regarding the changing auditory environment were to determine the maximum sound levels (SPL) through guidelines and legislations. Yet these methods fails to reflect the subjective human perception of the auditory environment which is crucial to explore and evaluate [15].

In 2014, ISO 12913-1 published the first part of the soundscape standard which provided its clear definition and a conceptual framework [16]. According to this, the term "soundscape" is defined as "the acoustic environment perceived or experienced and/or understood by a person or people, in context" [16]. With this regard, the recent consensus on the soundscape approach suggests that soundscape exists through human perception. The framework described by the ISO 12913-1 explains the process of perceiving or experiencing the soundscape through seven general concepts and their relationships (Fig. 1). These concepts are; context, sound sources, acoustic environment, auditory sensation, interpretation of the auditory sensation, responses and outcomes [16]. The framework acknowledged the context as a key element. Sound sources compose the soundscape which is modified by the acoustics environment (absorption, reflection, etc.). Context can influence the soundscape through, auditory sensation, interpretation of the auditory sensation and the response to the acoustic environment [16]. It can be said that the soundscape approach is concerned with individuals' or society's understanding and perception of the acoustic environment and the meaning associated with it, rather than the sound energy. [11,14,15,17,18].

Regardless of its recent popularity, soundscape still lacks a well-accepted evaluation method and much of the case studies are limited to urban spaces. Over the decade, researchers proposed various methods to explore and evaluate soundscapes. Some of the researchers used the soundwalk method to investigate the urban soundscapes [12,19–21], while various others used binaural recordings and psychoacoustic measurements [18,22,23]. More subjective evaluations of soundscape consists of analysing questionnaires, interviews, semantic differential scales [6,12,19,21,24–26]. Indoor soundscape on the other hand, not only lack a well-accepted evaluation method but also greatly lack case studies.

Every space has its own unique sound environment; soundscapes, the underlying sound sources and the acoustical requirement differences [27–30] This requirements would vary and more complex in indoor spaces, since auditory perception will differ due to the interfering factors such as building geometries, finishing materials, activities and reverberation [17,31]. Indoor spaces have much more complex acoustical environments than outdoor spaces and any kind of indoor space (metro stations, high schools, restaurants, opera-concert halls, hospitals, etc.) should be involved in soundscape studies [32–34]. For these reasons, the classification of sound sources should be elaborated with different case studies that consider all types of acoustic environments and in addition to the outdoor soundscape studies, indoor soundscape also needs to be investigated. Using a qualitative approach can provide individuals' subjective response to the indoor soundscape clearly.

1.2. Grounded theory method

Grounded Theory (GT) is a less frequently used but a more user-centred method that can systematically analyse individual's subjective perception of the soundscape. Its inventors, Barney Glaser and Anselm Strauss, described GT as" The discovery of theory from data" [35]. This approach is favoured by numerous researchers to analyse the qualitative data traceably, systematically, and due to its ability of providing an in-depth information about the phenomenon [12,17,32]. GT's multidisciplinary and systematic approach generates an inductive theory about the field of study. Using the GT in a soundscape research will provide an insight on individual's subjective perception of the auditory environment. The method achieves this through face to face interviews, constant comparative method, theoretical sampling, systematic coding,

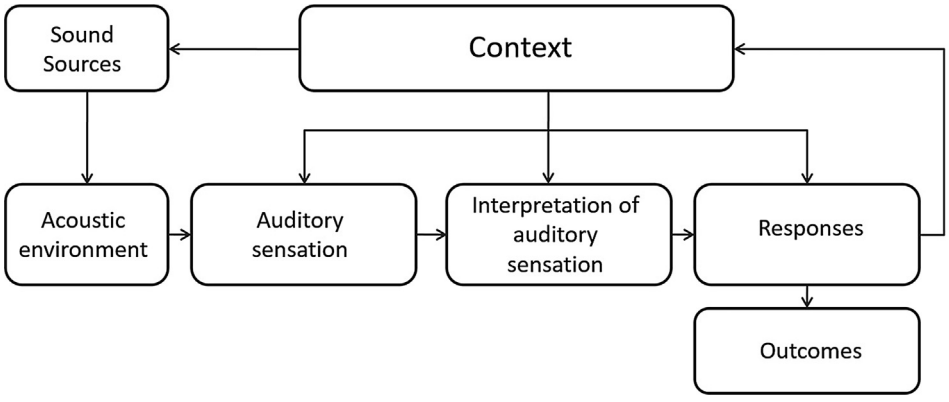

Fig. 1. Soundscape Framework created by ISO12913-1 [16].

conceptualizing, variation and integration [17,32,36–38]. Interviews and observations are main tools of collecting the data. Individual's experiences regarding the auditory and the physical environment serves as a key element, therefore each interviewee is considered as an "ear-witness" [17,32]. In a method that focuses heavily on user experience, what matters is not the number of interviewees but rather the depth and informative character of the interviews, which is called the theoretical sampling. Interviews can continue until the data is saturated. Once the data collection is completed, it is analysed through series of coding procedures.

In contrast with majority of other methods, data collection and analysis are interrelated in GT [37,39]. The two crucial points of data processing are the "Constant Comparison" and the "Theoretical Saturation". Constant comparison allows the researcher to develop an inductive theory by coding, categorizing, connecting the data [40]. As soon as the data are gathered from the interviews, they are compared with the previously gathered key phrases/labels of that same interview [41]. Afterwards, researcher relies on constant comparison for connecting the bits and pieces [40,41].

Theoretical sampling is the process of systematically selecting a new participant who will provide data samples which are more likely to contribute to development of the theory [37]. Theoretical sampling goes hand in hand with constant comparison [37,39,40]. During comparison, the units should be chosen in a way that enables new questions or answering the questions at hand efficiently and effectively, which will allow the comparison process to progress [40]. There are two steps of theoretical sampling: selecting participants with minimal differences and then selecting those with maximum differences. Minimizing the differences allows researcher to quickly develop categories and their properties. Maximizing, on the other hand, ensures that the categories are fully developed and the data is saturated [37,42].

Over the past decade, GT methods were used in a couple of soundscape investigations. Schulte-Fortkamp and Fiebig are among the first to use GT as means of a sociological approach to gather both physical and perceptual data from the individuals, whom were also considered as experts of their own auditory environment [17]. The researchers aimed to demonstrate the advantages of soundscape approach for environmental noise research. They generated a framework of six categories; acoustical setting, disposition, source identification, internal negotiation process, psychological reactions and action/strategies. Qualitative analysis of the GT method revealed the evaluation of the soundscapes depends on the social and cultural structures in which the individual is imbedded. A major impact of the socio-cultural background on individuals' subjective sensations is observed. Mackrill, Cain and Jennings, also used qualitative methods to conceptualize the lived soundscape experience of a hospital ward [43]. Researchers expressed that the soundscapes constitute of a diverse mix of sound sources which held both positive and negative aspects. The perception of this sound environment is not tied to specific sounds but also on physical, temporal and social context they are heard. Individuals can cope with soundscapes by accepting and/or habituating to aspects of it. Liu and Kang expressed that individuals place value on sounds not based on the sound itself or its physical properties but based on the positive and negative behaviours associated with the sounds [44]. People require fresh soundscape experiences as time goes by, therefore there should not be a fixed style when it comes to designing soundscapes; they should rather contain refined emotional attribute evaluations [44]. Cankaya and Yilmazer used GT to compare the indoor soundscapes of two different type of classrooms [38]. Their results indicate that the sound source that do not belong in that space are perceived negatively and students develop methods to cope with it.

Aim of the study is to conduct a GT research to capture individuals' subjective responses to the indoor soundscape of their work environment. There have been a few examples of indoor soundscape researches in recent years. However, this approach should be more involved with the indoor spaces to provide a clearer idea about the indoor soundscapes. Considering the fact that a significant amount of people spent vast amount of time in open offices, investigating the auditory environment of these spaces, based on the data gathered from the "ear-witnesses" can provide valuable information about indoor soundscapes.

2. Method

2.1. Office settings

The offices were chosen taking the slight differences between the work tasks they are performing into account. One of the chosen offices was used by an architecture company and the other one was 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 [27].

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 m^2 space at the ground floor. About one third of this area has a very low plaster suspended ceiling (h = 2.40 m) 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 = 5.79 m) 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 m^2 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.

Second office is used by the engineering company. This company fully occupies a four story building. There are 135 m^2 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 = 2.20 m). Acrylic screens are used between workstations.

Bruel & Kjaer Sound Level Meter type 2230 is used to measure the *LAeq*, while the offices were occupied. Three dimensional models of the offices were prepared by SketchUp 14 software and imported to the Odeon Room Acoustics Software 13.10 Combined to simulate approximate STI values (Table 1). These parameters were used to acquire basic knowledge about the acoustical conditions of the office spaces. Grid maps and Cumulative distribution graphs were prepared by Odeon Room Acoustics software. According these, the STI ratings are ranging from 0.36 to 0.64 for the architecture office and having the median

Table 1
Number of participants, total area dedicated to the open Office spaces, mean LAeq (dB(A), and median STI values.

	Number of Participants	*Office Area*	*LAeq dB (A)*	*STI*	
				Range	*Median*
Engineering Office	25	270	55,3	0.36 – 0.64	0.52
Architectural Office	24	215	59,4	0.52 – 0.67	0.59

rating of 0.52 (Table 1). For the engineering office, STI ratings are ranging from 0.52 to 0.67, with median rating of 0.59 (Table 1).

2.2. Participants

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 (Table 1). Interviews are held in meeting rooms and lasted two days for each office. Interview durations varied from 7 to 20 min. With the permission of the interviewee, each interview is recorded and later transcribed by the researchers.

2.3. Data analysis

GT procedure started with collecting the data through semi-structured interviews, observations and field notes. The semi-structured interview only consisted of 7 core questions at the beginning. These questions were adapted from *"Positive Soundscape Project",* of Davies and colleagues [45], and adjusted for indoor spaces. Questions are meant to be very generic, and aimed to direct the interview towards employees' habits, observations, important issues and reoccurring events. Through the course of the interviews new questions were added to the interviews, as significant issues, links and patterns are identified.

Coding procedure is the integral part of constant comparison and consists of three parts. Open Coding, breaks down the interview data into key phrases and eliminates the irrelevant ones. During the analysis, the interview transcriptions were searched for reoccurring issues, events, significant factors and habits (Table 2). A key phrase was assigned to each of these. As part the second part, the axial coding, key phrases were conceptualized. Based on their relations and similarities they were grouped together, creating the core categories and their subcategories (Table 3). Afterwards, the relationships between categories were explored through diagrams and/or schematics (Fig. 2). Diagrams were used to visualize the relationship patterns between core categories which helps explaining the theory.

The major limitation of this method comes from the fact that the researcher is part of the process. Whole data collection is held by the researcher through interviews, observations and interview memos. Researcher is also the sole actor during the coding procedure which makes him/her part of the process, therefore the researcher is not value neutral. In order to minimize this effect, researcher should be as objective as possible. Researcher's lack of experience, style, and the depth of the questions/answers can also limit the generalizability of the theory [12,36,41,46].

3. Results

Total of 1142 key phrases are created from the two different types of offices, during the first phase of coding. Data gathered from transcriptions are broken down into pieces by key phrasing each significant event. For example, comments about the sound of keyboard and mouse, are labelled as "*Sound Source (Mechanical)*", and while the comments regarding headphones are simply labelled as *"Headphones"*. Afterwards these key phrases are compared for their differences and similarities, and put together in accordance with their relations. At the end of this phase, key phrases generated during the *Open Coding phase*, created core categories and subcategories. The labels of "*Sound Source (Mechanical)*", for keyboard and mouse sound, were arranged together with other mechanical sounds (eg: printer and copier) and created the subcategory of "*Mechanical and Electronic Sound Sources"* which is under the Core Category of *"Sound Sources"*. These core categories and their subcategories can be seen in Table 3. On the other hand, headphones are regarded as a method of isolating one's self from the environment, thus creating the subcategory of *"Isolation",* which is under the core category of *"Coping Methods"* (Table 3). In last phase, the *Selective Coding*, main category is identified, and the relations between the core categories and the main category are examined. During this process irrelevant key phrases are eliminated. Based on the patterns between the core categories, a conceptual model that explores the interpretation of the perceived sound environment is created (Fig. 3).

How these sound sources are interpreted is decided based on a series of factors. One of these factors is the physical attributes of the space. Layout of the office space, receiver's location within this space, his/her proximity to specific sound sources (printers, meeting rooms, etc.) is the first determinant on the level of exposure to uncontrolled sound levels and interpreting the soundscape. This factor is followed by a more complex determinant, the *context* of the sound. Findings suggest that, factors contributing to the context of sound are the key elements towards the interpretation of soundscape. These factors consist of environmental factors, activity, and work type. The elements of context create a positive, negative, or neutral interpretation of the soundscape. While positive interpretation of soundscape can promote concentration, motivation and satisfaction, negative response can lead employees' to come up with coping methods.

Employee's sound preference depends on two factors, how the task at hand will be affected by that sound and employees' characteristics, together, these are significant predictors of how soundscape will be interpreted. Employee characteristics consists of, experience, health, mood and employees' behavioural tendency. For example an employee suffering from a health condition, such as migraine, will likely have a negative mood and would not tolerate irrelevant noises.

During the interviews, no differences between the offices are seen in terms of the sound sources, the factors contributing to the context of sound or the way employees interpret the soundscape of their work

Table 2
Examples from the coding process. Memos are broken down into key phrases and grouped back together through conceptualizing and creating the core categories.

Memo	I mean normally, people work better in quite environments, but sometimes it feels so silent."	You can only hear the keyboards and it makes you feel like "Look people around you are working, you should work too".	When there are a group of people chit chatting, it makes you lose all your concentration and makes you want to join them
Key Phrases	Expectation Task Performance Low Sound Levels Sound Environment	Sound Source (Mechanical) Motivation	Sound Source (Speech) Losing Concentration Disturbance
Conceptualizing1	Task performance affected by sound environment.	Keyboard sounds are promoting motivation.	Group conversations disturbs the concentration
Conceptualizing2	Silent environment affecting task performance	Increased motivation as a response to the sound environment	Negative interpretation
Categories	Task performance, low sound levels,	Promoting Motivation Interpretation of Soundscape Sound Sources	Loss of Concentration Interpretation of Soundscape Sound Sources

Table 3
Core categories and subcategories created by the end of the coding.

Coping methods	Task type	Physical attributes of space	Task performance	Sound preference	Activity
• Adaptation • Isolation • Intervention	• Routine Task • Concentration • required task	• Heating • Lighting • Office Layout • Proximity	• Positive • Negative • Neutral	• Task • Dependent • Mood Dependent • Personal Preference	• Length of Exposure • Activity
Employee characteristics	Environmental factors	Sound sources & Sound Levels	Interpretation of Soundscape		
			Positive	Neutral	Negative
• Behavioural Tendency • Mood • Health • Experience	• Crowdedness • Tension • Relaxation • Workload • Privacy	• Human • Mechanical Electronical • Outside • Music • High Sound Levels • Low Sound Levels	• Promoting Motivation • Promoting Concentration • Promoting Privacy • Promoting Relaxation • Workplace Satisfaction	• Indifference	• Loss of Concentration • Decreased Motivation • Annoyance • Disturbance • Irritability • Nervousness • Self-Restriction

environment. At the beginning of the research, it was predicted that the type of task performed in each office can be a distinction. However, interviews showed that this distinction is based on whether the tasks require concentration or not. The interpretation of soundscape is affected negatively if the task does indeed require concentration and the auditory environment interferes with this. This issue is not exclusive to any of the offices and valid for both visual and computational tasks. The data from offices are handled together as the similarities became more obvious during the analysis. Therefore, categories generated through conceptualizing and categorizing the data will discussed throughout this section.

3.1. Acoustic environment and sound sources

Regardless of an indoor or an outdoor environment, sound sources and the acoustic environment form the basis of perception of soundscape. Questions designed to identify the sound sources within the office environment constitute the first part of the semi-structured interviews. Based on employees' subjective responses, four major types of sound sources are identified (Table 4). While identifying the sound sources, employees' frequency of mention are taken into consideration.

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 electronical sounds, outdoor sounds* and *music* (Table 4). 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' (*E*), to show their perception explicitly.*

> **E:** I don't know what the ideal is but I think I expect to hear human dialogue, which is the ideal sound for me, not a printer sound.

According to the interviews the second most frequent sound sources are mechanical sounds such as computer fans and printers. As it was expected, proximity to the main circulation routes and the sound sources had an impact. Employees seated near the printers have reported that they expected to hear the sound of the printers, while those seated away from the printer room barely mentioned it.

> ***E:*** *As* the printer is right around the corner its sound is associated with office in my mind. When I don't hear the noise of printer I'm thinking if it's broken or something.

3.2. Context and interpretation of soundscape

It is found that the *Context* of the auditory environment has a major influence on the way soundscape is perceived. ISO 12913-1 defines

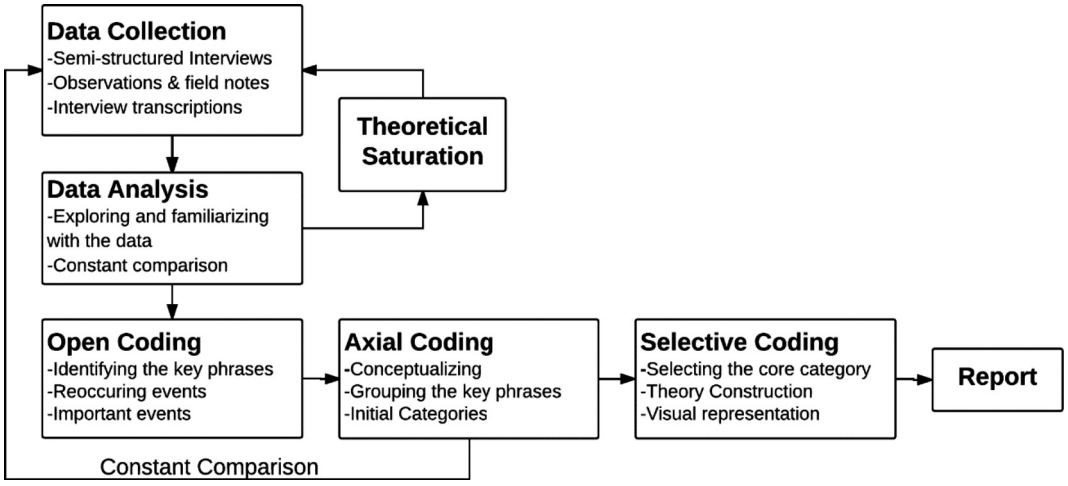

Fig. 2. Collection and analysis of the grounded theory data [32].

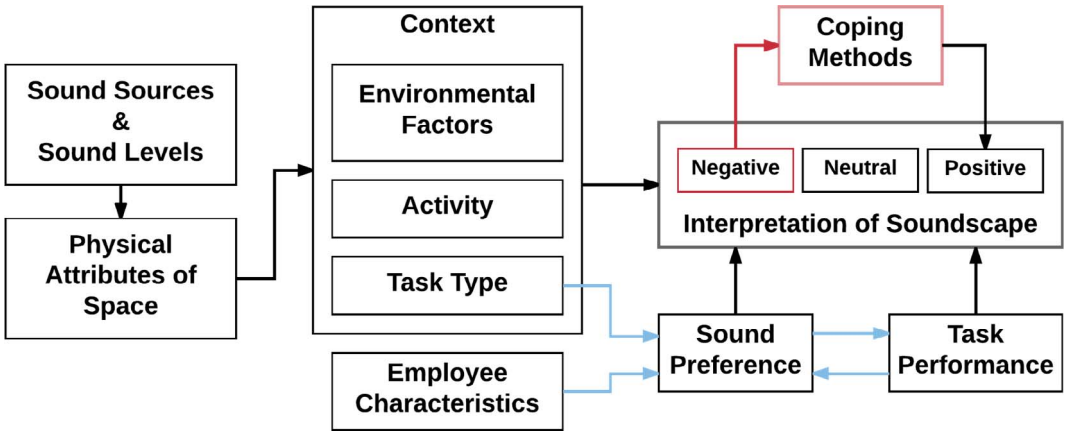

Fig. 3. The conceptual framework which shows the interpretation of the indoor soundscape [47]

context as "the interrelationships between person and activity and place, in space and time" [16,48–50]. Based on the subjective responses of the employees, Task *Type*, *Environmental Factors* and *Activity* are the factors that forms the *Context* of the sound. Context determines how the soundscape will be interpreted, in terms of positive, neutral or negative. 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 (*E*) even described it as a motivator.

E: Well as for the positive ones, keyboard sound doesn't affect me negatively. It shows that there is work. Sometimes when I slow down it even motivates me.

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.

Based on the responses of 5 employees' there can be an underlying theme beneath this type of perception, such as the mood and emotions that is associated with the act. These employees expressed that they are in fact annoyed by the sound of keyboard, but not because it disturbs them. The context of the sound provides information to the listener about his/her co-worker. In a way, context of the sound acts as mediator between the individual and his/her surroundings. For example:

E: The colleague working next to me uses the keyboard very roughly. Sometimes he types like he is bashing the keyboard which disturbs me a lot.
E: When someone is typing an angry email or trying to rush a job, they type really hard which breaks all my concentration.

It can be seen from these examples that when sound is heard by the listener, they search for pieces of information within it. Environmental factors, such as the tension within the environment or workload, coupled with employee characteristics can lead to a negative interpretation of that particular sound as it makes the listener lose his concentration or affect his mood.

3.3. Task performance and sound preference

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.

E: I would prefer music but I don't know if it would work. I think it's really hard to implement **because it's very hard for people to find a common ground.**
E: Playing music is very important, if it's not something that I like, it's better to play any music at all.

Responses indicate that the main reason why people do not want music broadcast is because it is very hard to find a music genre that everybody would appreciate, it's even impossible. Employees state that genre of the music is very important; if it is something they don't like,

Table 4
Sound sources perceived by employees and frequencies of mention.

Sound Sources							
Human Generated Sounds	203	Mechanical & Electronical Sounds	111	Outdoor Sounds	36	Music	74
Speech	107	Keyboard and Mouse	28	Animal	19		
Group Conversation	30	Printer/Plotter	29	Nature	8		
Phone Conversation	23	Computer Fan	16	Traffic	4		
Rattling Noise	7	Telephone Ring	23	General	5		
Footsteps	17	Ventilation	4				
General (Laughing, coughing, etc.)	19	General	11				

music is interpreted as a major negative sound source. Based on these findings it can be said that, in theory employees' would like to hear music, but in practice, due to their sound preference, it is quite the contrary.

Based on the observations and employee statements, 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.

3.4. Coping methods

Throughout the research three major coping methods had been identified, which are; adaptation, isolation and physical or verbal intervention. Further investigation of sound preferences revealed that when employees said they preferred music, what they actually meant was that they preferred to hear their own music and utilize it as a method to minimize distractions. 46 out of 49 employees said that they are using headphones while they work. These responses can be interpreted as, using headphones is much more than just listening to music. Employees are using headphones to isolate themselves, to cope with speech interference, to cope with high sound levels and even with low sound levels. They are used as a tool to isolate themselves from the existing auditory environment and create their own. In some extreme situations where headphones are not enough, it has been stated that employees leave their workstation to avoid the sound levels.

E: Sometimes it gets so noisy that I feel like just to go and get a tea just to avoid exposure to sound for a while.
E: Sometimes this place gets very noisy, but we deal with it using headphones. Sometimes I keep them on even without music.
E: When it gets really silent it bothers, it feels like there is a distance between us and everything I do is creates a noise. It bothers me so much that I put on headphones.

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.

Issues with the speech privacy are expected as both research settings have at least fair amount of STI ratings. Findings of the research also support this, as employees expressed concern about the silent periods due to lack of background noise, which indicates problems with privacy. During the interviews it has been mentioned several times that employees tend to reduce their voices in order to avoid disturbing others most of the times and rarely due to speech privacy concerns. This restriction, when performed all day long, leads to a negative perception of the work space. Those who were working there for a shorter period of time are more concerned with speech privacy but in time they habituate and become far less concerned about it.

E: At the beginning I was bit concerned. But after sometime I got used to it and started talking without being concerned about what a third person would think.

Even though, they are not as concerned with speech privacy as it was anticipated, they still expressed a need of background sound. As it was stated previously, too low sound levels cause concern and anxiety on employees due to privacy issues. This also indicates that objective measurements alone do not reflect individuals' perception of the soundscape. Optimizing the sound levels to predetermined parameters does not necessarily create a positive interpretation of the soundscape. One employee from Company E explained this situation as:

E: When it is silent it feels like people are not bonding with each other, it feels like there is a conflict. If people don't communicate with each other it means there is no teamwork.

4. Discussion

Grounded theory analysis identified interpretation of the soundscape as the main category of this research. The physical attributes of the space influence interpretation of the soundscape to a certain degree. However, similar to many other soundscape studies, this research also identified the context of the sound as the primary element that influences the interpretation of the soundscape. Context is comprised of different elements such as activity, task type and environmental factors. Individuals' sound preference and soundscapes effects on the task performance also have an influence on the interpretation. Based on all these factors, the individual interprets the soundscape as positive, neutral or negative. A positive interpretation of the soundscape can cause an increase in motivation or concentration etc. A negative interpretation, on the other hand, can result in a decrease in concentration and cause the individual to develop certain coping methods as response such as habituating or isolating themselves from the sound environment. In time, a response like habituation can lead to a re-evaluation of the soundscape which may be interpreted as positive this time.

4.1. Comparison with the ISO 12913-1 and other existing grounded theory research

The comparison of the framework suggested by this paper with the ISO 12913-1 revealed both similarities and differences. Sound sources, acoustic environment and context are common core categories for both research. In the ISO 12913-1, context of the sound influences *Auditory Sensation*, *Interpretation of Auditory Sensation* and *Responses.* This paper suggest similar patterns for the context of the sound. However, rather than affecting a chain of three different core categories, context directly effects the interpretation of the soundscape which is sort of an umbrella category that covers interpretation, sensation and response to the soundscape. Based on the context of the sound individuals' interpret the soundscape as positive, negative or neutral. As a response to a negatively interpreted soundscape, individual can move to a more satisfying location or put on headphones to cope with the dissatisfying sound environment.

An example of negative interpretation of soundscape can be as follows. Environmental factors such as tension, workload, alongside with mood and proximity to sound signal locations, form the context of soundscape, which will be interpreted negatively. With this regard, employees become unsatisfied with the soundscape of their work environment due to decreased motivation, fatigue, annoyance, etc. It has been found that employees develop certain coping methods to handle with this negative implications. Responses indicate that by doing so, the employee's perception can be affected positively. Usage of headphones is by far the most common coping method. The question is whether it is the perception the office soundscape, or the one he created for him/

herself through the headphones, is improving? The former one seems highly unlikely.

Major difference with the ISO 12913-1 are the core categories of *Employee Characteristics, Sound Preference* and *Task Performance*. Explanation of this can be due to the fact that ISO standard covers a board area of soundscape, offers general explanations for both indoor and outdoor spaces. This research, however, specializes in open-plan offices, thus includes features that are exclusive to them. It is identified that the task performance is greatly affected by *Employee Characteristics* and *Sound Preference*. It should be considered that the Health and mood are subcategories of *Employee Characteristics* (Table 3) and they are also affecting individuals' *Sound Preference*. This once again shows the importance of a design and promotes positive health and mood.

Soundscape research conducted by Mackrill et. al. also has similar principles with both this paper and ISO 12913-1 [16,43]. One of the significant findings of their research was the coping methods. As a response to the interpretation of the soundscape individuals could accept and habituate to the soundscape, which is also supported by this paper. Schulte-Fortkamp and Fiebig's results also demonstrated a similar response field which they referred to as "A*ctions, Strategies*". The headings under this field are a direct influence of individuals' evaluation of the soundscape, which is on par with the findings of this research, with Mackrill et al. and with Çankaya and Yilmazer [17,38,43].

According to Schulte-Fortkamp and Fiebig, the interpretation of the soundscape is influenced by the socio-cultural and psychological background [17]. In an open-plan office environment, sound sources such as keyboard, printer or even the telephone conversation of co-workers are not regarded as the major sources of disruption because they belong in the office environment. Employees expect to hear those sounds up to a certain degree. Discomfort with these sound sources occur when something out of the ordinary happens, such as sound peaks. For the rest of the time, these sounds blend in with the background noise.

4.2. Discussion on the developed framework and the existing open-plan office literature

Some of the main factors causing issues in open plan offices were exposure to uncontrolled sound levels, lack of speech privacy and decrease in task performance. It was discovered during the interviews that employees were concerned with silence as much as they were concerned with the noise. Seddigh et. al. [10] suggested that when compared to cell type offices, those working in open plan offices can cope with the noise levels due to exposures ofhigh level irrelevant stimuli and have better concentration. This paper also indicated that sounds that are expected to be heard in an office and those originated from human activities, such as speech and footsteps, do not have as much negative effect on the employee as it was anticipated. Sounds that are artificial or foreign to an office space should be suppressed.

Therefore, creating a satisfactory open office soundscape lies upon controlling the sound levels and sound sources. Both a very loud and a very quite office environment can cause a negative effect on factors such as task performance, satisfaction and wellbeing [1]. A balance between the two is required. One way to achieve this is to consider employees' expectations from an open office soundscape and filter the out of context sounds rather then decreasing it all together. It was stated by Truax [14] and later supported by Davies et al. [45], that soundscape competence is a tacit knowledge and based on previous experiences. Expectation can affect employees' perception and behaviour greatly. There are examples that sounds, such as keyboard, can promote motivation while private phone calls of co-workers and notification sounds of the cell phones are disturbing and undesired. The literature also suggest that sound coming from outside are also very disturbing (ex: car alarm, traffic) [4]. This is especially disturbing when the sound levels of the outdoor sound sources exceed the background noise of the open office space. For companies that are located in busy districts, creating a background noise that is capable of masking the outdoor sounds can be useful. But, in order to properly implant a method like this the level of the background noise and individuals' reactions to the outdoor sound sources should be investigated in detail.

While accepting and habituating to the soundscape can be a rather positive aspect, not all coping methods should be desired as much. The usage of headphones for isolation can improve concentration but also has a negative effect on the communication. One of the strongest points of open-plan offices are their ability to improve communication and it was indicated that satisfaction increases as communication with co-workers increase [7]. Headphones greatly damage the communication. It was observed that supervisors are not happy with this as well. Due to their personal preferences, employees will always want to listen music of their liking. However, it should be ensured that they used headphones because they want to, not because they need it to avoid the office soundscape. If the choice is to use headphones to cope with the soundscape, noise cancelling headphones can be looked into in further studies as it will not affect the communication as much. If found succesful, an equipment like this can even be incorporated to the office furniture.

Our findings indicate that, other than some employees' behavioural tendencies, majority of the participants are uncomfortable with low sound levels nearly as much as they are with high sound levels. A possible explanation can be based on the STI ratings. As seen on Table 1, STI is usually fair or good which causes issues regarding speech privacy and a decrease in task performance. Issues regarding speech privacy are hardly ever stated by the employees on their own. However, when it is asked directly, their responses reveal that during the silent periods, employees, as specially the new ones, are hesitant to talk as they think rest of the office will listen in. The model introduced by Hongisto (2005) also suggest that highly intelligible speech (STI > 0.60) causes a lack of speech privacy and a decrease in task performance up to 7%. This model predicts that a significant change in the distracting power of speech is taking place between the STI ranges of 0.20–0.60. In order to provide sufficient amount of speech privacy and to reduce the distractions caused by the sound environment, designers sound aim for lower STI ratings.

Employees' main privacy concerns are mostly limited to their private phone conversations. They tend to make these private conversations in a separate location. In one of the settings, it is observed by the researchers and frequently expressed by the interviewees that employees go outside to answer their phones. In the other research setting however, there is a special room dedicated to this activity. The important point here is, in the former office, employees came up with the method of making their private phone calls outside. But in this particular office it is a rule to make every single private phone call at the telephone room. During the interviews, twelve out of twenty four employees from this office expressed discomfort about this situation. The employees from the first office did not express any need for a telephone room. It should also be noted that when one of the companies dictate a special place for phone conversations, it is received more negatively than the actual problem of speech privacy. An employee stated that "*Sometimes you want to answer the phone without changing location. For example, my mother calls, it could be an emergency, but the telephone hangs up before I get to the phone room*". The question is, what the employees' would do if STI and RT ratings are adjusted to provide the right amount of speech privacy. Results imply that people like to have the freedom of answering their phones in their workstations regardless of if they would do it or not.

A difference between indoor and outdoor soundscape occurs when the individuals choose to move to a quitter place. In an urban context, such as a park, you have the option to choose where you want to stay, thus, you can pick the soundscape. Even if you get dissatisfied, it is always possible to relocate. In an open-plan office, it is not always likely to relocate to a more satisfying location in terms of soundscape while working. This makes relocation an unlikely coping method for open-

plan offices. However, for other indoor environments, such as dining spaces, it might be a possibility.

Arranging the layout of the open office space according to the sound elements can possibly improve the soundscape quality of the office environment. While placing the sound sources, their contributions to the context of the sound environment should be considered. For example, the employees expected to hear the sound of printers as they are an integral part of every office environment. However, this does not mean that employees seated around the printer are comfortable with it, but disturbance related to this sound source is expressed only by those seated directly around it. As the proximity increases, the sound spreading from it blends into the background noise which causes employees to adopt and habituate to the soundscape. Observations and interviews showed that this proximity can sometimes be as close as just one workstation.

During the interviews, employees expressed that a great disturbance is caused by the meeting rooms and the restrooms. In accordance with the design guidelines and the previous research [52,53], we are also suggesting creating buffer zones. Job content should be analysed before determining the type and layout of the office [54]. Along with this, dedicating quite zones will provide flexibility and reduce the effects of irrelevant sounds. Similarly, sound sources should be identified at the very beginning of the design process and distributed to zones. Over the decades, modern open office design has come far since its initial popularity in the mid twentieth century with respect to employees' changing needs. Major corporations are putting emphasis on providing well-being and social activities to create a corporate culture that promotes creativity, communication and performance to attract the best minds to join them. Similar to other research [51,52], a buffer zones we are also suggesting implementing a social zone to reduce the amount of irrelevant speech. Employees can use this space for their non-work related conversations and activities which will reduce the build-up sound energy caused by irrelevant stimuli in the office area of the space.

5. Conclusion

This paper aims to contribute to the qualitative evaluation of indoor soundscapes. Within the context of this research, grounded theory method is used to capture employees' subjective response to the soundscape of their work environment. Objective parameters are also measured to identify the acoustical conditions of the office settings. Semi-structured interviews are conducted with 49 employees, as part of GT. Their responses are used to create a conceptual framework that shows the perceived sound environment of an office space.

One of the contributions of using a grounded theory approach is, subjective responses of the employees' showed that objective measurements alone are not sufficient enough to reflect their perception of the soundscape. As a result of the research, the sound sources, which compose the perceived auditory environment of the open plan office, context of the sound, behavioural tendencies, sound preference and task type are identified as the factors that affect the interpretation of the soundscape. One of the significant findings of this research is the coping methods that can be employed due to negative interpretation of the soundscape. One of the most common method to cope with the soundscape was headphones to provide isolation from the sound environment. It has also been identified sounds that do not belong in or that were not expected to be heard in an open office space caused the soundscape to be negatively interpreted. Based on the findings, this some design solutions were offered regarding the layout of the open office, using masking sounds.

Main concern of this research is to contribute to the soundscape theory, by rising questions, offering design suggestions to provide a foundation upon which the future indoor soundscape studies can build. Sounds that are expected to be found in an office cause less issues in overall, while those do not belong in the office are undesired. There are various indoor spaces that still lack case studies such as airports, shopping malls, libraries, train stations, historic buildings, etc. As there are factors that are exclusive to open plan offices, each of these spaces has exclusive factors depending on their size and function. Each of these can present unique elements and requirements for their soundscapes. In order to close this gap, further studies should focus on various types of indoor soundscapes.

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