EFFECTS OF REVERBERATION TIME AND SOUND SOURCE COMPOSITION ON SENSE OF PLACE

CASE STUDY IN PRIVATE OFFICES

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ABSTRACT

EFFECTS OF REVERBERATION TIME AND SOUND SOURCE COMPOSITION ON SENSE OF PLACE CASE STUDY IN PRIVATE OFFICES

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This study investigates the influence of physical room acoustics parameters on sense of place: place attachment, place identity, and place dependence. The experiments were conducted in the private lecturer offices located in the Faculty of Architecture, Çankaya University. The sense of place of 15 participants was tested in the original offices of each participant and eight additional acoustic auralization, in which reverberation times and sound source compositions were altered. The statistical analysis of the results revealed that there is a direct influence of reverberation time and sound source composition on the sense of place. It was observed that longer reverberation times partially enhanced the sense of place. Additionally, the sound source composition influenced the relation towards the place, and certain sound signals diminished the sense of place in the private offices. Furthermore, this study used a psychophysical scaling method (Absolute Magnitude Estimation scale [AME]) which indicated its validity and importance in investigating the effect of physical stimuli on sense of place. The AME revealed participants' sense of place by directing the influence towards the constructs' indicators rather than investigating their general relation towards the place. It was concluded that reverberation time and sound source compositions could enhance and/or diminish users' sense of place; hence, RT and sound source compositions can affect users' interpretation of and behavior towards a given place.

Keywords: Room acoustics, Reverberation time, Sound source composition, Sense of place, Place construct, Place attachment, Place identity, Place dependence, Acoustic indicators, Place indicators

ÖZ

YANSIŞIM SÜRESİNİN VE SES KAYNAĞI KOMPOZİSYONUNUN YER DUYGUSU ÜZERİNDEKİ ETKİLERİ: ÖZEL OFİS ÖRNEĞİ

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Bu çalışmada, oda akustiği parametrelerinin yer duygusu yapıları (yer kimliği, aidiyet ve yere bağımlılık) üzerindeki ilişkisi incelenmektedir. Deneysel çalışmalar, Çankaya Üniversitesi Mimarlık Fakültesinde bulunan kişiye özel öğretim üyesi odalarında gerçekleştirilmiştir. Çalışma kapsamında toplam 15 ofis kullanıcısının yer duygusu, hem fiziksel ofis ortamlarında, hem de toplam 8 işitselleştirilmiş sanal ses ortamında ölçülmüştür. Akustik işitselleştirmelerde yansışım süreleri ve ses kaynağı kompozisyonları değişkenlik göstermektedir. Toplanan verilerin istatistiksel analizleri sonucunda yansışım süresinin ve ses kaynağı kompozisyonunun yer duygusu üzerinde doğrudan etkisi bulunduğu gözlemlenmiştir. Yüksek çınlama süreleri yer duygusunu kuvvetlendirmektedir. Bunun yanı sıra, belirli ses kaynaklarının kişiye özel ofislerde yer duygusunu zayıflattığı görülmüştür. Bu çalışmada ayrıca ikincil bir veri toplama yöntemi olarak, Mutlak Büyüklük Tahmin Ölçeği (Absolute Magnitude Estimation scale [AME]) kullanılmıştır. AME psikofiziksel bir ölçüm tekniğidir. Sonuçlar bu ölçeğin fiziksel parametrelerin yer duygusu üzerindeki etkisinin ölçümünde verimli bir araç olarak kullanılabileceğini göstermektedir. AME tekniği, katılımcıların yerle genel ilişkilerini araştırmak yerine, etkiyi yer duygusu yapılarının duyusal göstergelerine yönlendirerek katılımcıların mutlak yer duygusunu ortaya çıkarmaktadır. Sonuç olarak, yansışım süresi ve ses kaynağı kompozisyonunun, mekan kullanıcılarının yer duygusunu, algısal yorumlarını ve mekandaki davranışlarını olumlu ve/veya olumsuz yönde etkilediği gözlemlenmiştir.

Anahtar kelimeler: Oda akustiği, Yansışım süresi, Ses kaynağı kompozisyonu, Yer duygusu, Yer duygusu yapıları, Aidiyet, Yer kimliği, Yere bağımlılık, Akustik indikatörler, Yer indikatörleri.

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LIST OF ABBREVIATIONS

RT	Reverberation Time
SoP	Sense of Place
PA	Place Attachment
PI	Place Identity
PD	Place Dependence
AME	Absolute Magnitude Estimation
SNR	Signal to Noise Ratio
STI	Sound Transmission Index
SPL	Sound Pressure Level
PA_E	Place Attachment indicator Emotions
PA_O	Place Attachment indicator Orientation
PI_M	Place Identity indicator Meaning
PI_C	Place Identity indicator Character
PD_E	Place Dependence indicator Expectation
PD_A	Place Dependence indicator Advantage
AR	Augmented Reality
VR	Virtual Reality

CHAPTER 1

INTRODUCTION

We perceive and experience our daily environments in a holistic and multisensory way. We simultaneously receive sensual stimuli from the environment, and the integration of the stimuli results in correcting, enhancing, and assessing each other for a holistic perception of the environment (Bregman, 1994). For its part, the environment is an integration of physical settings, social dynamics, and socio-cultural factors (Park & Evans, 2016). Accordingly, places are formed by the physical space, users inhibiting the space, and their activities in the space (Gokce, 2009). Thus, a variation in these elements will lead to a different perception of the environment and affect users' behavior to some degree (Yi & Kang, 2019).

As a part of the physical setting, the aural environment is crucial for forming places. Therefore, room acoustics is decisive to achieve sense of place. Room acoustics is determined by space's geometrical shape and materials. Despite the eventual result of room acoustic parameters of a specific space, users' spatial experience determines whether these physical parameters are suitable or not for their designed purpose. When a space is experienced through time, users perceive it as a place with meaning and significance. Hence, sense of place emerges and creates a relation between users and the place. This relation is denoted by several dimensions, such as place attachment, place identity, and place dependence. Each dimension emerges when the physical and social settings achieve and suffice certain attributes.

Sense of place is not limited to an effect from a specific physical or cultural factor. Rather, sense of place is a holistic experience that users form with places. Nevertheless, investigating how the aural setting plays a role in forming sense of place is important. The fact that both sound and forming sense of place require a temporal domain for being experienced indicates an interwoven relation between these two phenomena. This is emphasized by the fact that sound influences the spatial awareness (Tuan, 2001), emplaces users within the space by providing the feeling of how exposed or safe they are (Stocker, 2013), and illuminates the acoustic space to make it aurally perceptible (Blesse & Salter, 2007). Space's objective elements modify aural perception through reflection, refraction, diffusion, and diffraction, as well as sound intensity. Furthermore, it affects sound characteristics produced by users. For instance, high ambient noise and decreased reverberation time outdoors give a tendency towards raising voices and acting demonstratively in public places. Contrarily, sound in enclosures is affected by echo and reverberation. These two indicators lead to different reactions from the users towards the space. They give an illusion of permanence to sounds and an impression of acoustic authority (Schafer, 1977). Thus, sound sources in an aural environment play a significant role in emplacing users within a setting, physically and socially. Users produce their sounds to shape, modify, and affect their experience of the space and their surroundings (Stocker, 2013).

Space and place are arguably interchanging terms. However, it is agreed that space is the objective construct, waiting for experience and temporal investment to become a place (Gokce, 2009; Norberg-Schulz, 1976; Vanclay, Higgins, & Blackshaw, 2008). Yet, there is a limited number of studies that investigated objective room acoustics parameters and their influence on sense of place. Knowing that there is a problem of finding a balance between objective parameters in environmental analysis and its subjective interpretation (Truax, 1984), it becomes important to involve the holistic experience of environments in understanding the subjective interpretation of the physical sound.

1.1 Aim of the study

The aim of this study is to investigate the influence of physical room acoustics parameters (i.e. reverberation time and sound source composition) on users' sense of place.

In the last decades, the interest in soundscape theory is highly increased due to the awareness of human-centered studies. The soundscape theory tries to explain the influence of sound in forming places by users who consciously experience the temporal acoustic environment. In general, the soundscape theory can be considered as the auditory sense of place. However, being a human-centered research discipline on sound perception (A. L. Brown, 2014), the studies that implement the concept of sense of place into the soundscape research are very limited. We hypothesize that the results of this study will eventually support the ongoing research on the soundscapes and create a balanced interdisciplinary connection between room acoustics, soundscapes, and sense of place studies.

1.1.1 Research questions

The study attempts to answer the following research questions:

RQ_1: Can reverberation time influence place attachment, identity, and dependence?

RQ_2: Can background noise in a sound source composition influence place attachment, identity, and dependence?

RQ_3: Can sound signals in a sound source composition influence place attachment, identity, and dependence?

RQ_4: Can Absolute Magnitude Estimation scale (AME) be used as a prediction tool for place indicators?

RQ_5: Can reverberation time influence place indicators?

RQ_6: Can background noise in a sound source composition influence place indicators?

RQ_7: Can sound signals in a sound source composition influence place indicators?

1.1.2 Hypotheses

The study hypothesizes the following:

H_1: Reverberation time influences place attachment, identity, and dependence.

H_2: Background noise in a sound source composition influences place attachment, identity, and dependence.

H_3: Sound signals in a sound source composition influence place attachment, identity, and dependence.

H_4: AME can be used as a prediction tool for place indicators.

H_5: Reverberation time influences place indicators.

H_6: Background noise in a sound source composition influences place indicators.
H_7: Sound signals in a sound source composition influence place indicators.

1.2 Outline of the thesis

Chapter 2 of the thesis presents the literature review. First, it explains the components of the auditory environment from physical, psychoacoustical, multisensory, and soundscape perspectives. Then, the concept of sense of place is thoroughly introduced. This is followed by giving essential information on room acoustics in private offices being the case study of the thesis. Lastly, a conclusion of the provided information is introduced.

Chapter 3 presents the methodology of the study. It explains the setting of the experiment and the phases of conducting it.

Chapter 4 presents the results and findings of the study. It explains the effects of the sound source composition in terms of background noise, signals, and spectrogram analysis obtained from the experiment on evaluating place constructs. This is followed by presenting the effects of reverberation time obtained from the experiment on place constructs.

Chapter 5 explains the Absolute Magnitude Estimation method, the justification of using it in this study, and the results obtained from using it in evaluating place indicators. Furthermore, it shows the results of a comparison between the results obtained in original environments and simulated ones, emphasizing the importance of using AME.

Chapter 6 discusses the findings of the study and the relevant literature. It denotes the effects of room acoustics physical parameters on the sense of place and explains the findings further from psychoacoustics, multisensory, and soundscape perspectives. Furthermore, it presents the limitation of the study and suggestions for future research.

Chapter 7 presents the conclusion of the study and the main findings.

The questionnaire used in the study is presented in the Appendix.

CHAPTER 2

LITERATURE REVIEW

This section of the thesis critically reviews previous scientific literature regarding the auditory environment, sense of place, and place constructs.

2.1 Auditory environment

We react to the physical environments differently due to the relations and interactions between the various elements within an environment. Accordingly, our senses are stimulated by such elements. The visual sense responds to visual stimuli; the auditory sense to sound; the haptic sense to different textures or temperatures; the olfactory to smells; and the gustatory to taste stimuli. Furthermore, these senses can modify, correct, or affect each other in perceiving the environment (Bregman, 1994). Thus, a multisensory perception towards these elements/stimuli occurs.

In this chapter, being the core of this study, the auditory environment is mainly investigated. The auditory environments consist of sounds, which carry semiotic information. It is a pressure wave that transfers auditory events, as well as space's acoustic properties to its users. It is the result of dynamic action, periodic vibrations, sudden impacts, or oscillatory resonance (Blesse & Salter, 2007). Sounds act according to the acoustic properties of the space it travels within. Thus, it has several behaviors within a space, such as reflection, absorption, diffraction, and diffusion. In the following sections, physical characteristics of sound, its behavior in enclosures, its subjective counterparts in psychoacoustics, multisensory perception, and the soundscape theory are introduced.

2.1.1 Physical characteristics of sound

Sound is a wave phenomenon; a vibration in a fluid or solid medium (Egan, 2007; Vorlander, 2008). As a wave phenomenon, sound has several physical characteristics related to each other and affects the overall auditory perception and evaluation. The following subsections explain the fundamentals of these parameters.

Frequency

A sound wave is produced when a physical medium is disturbed. This medium can be in the form of solid, liquid, or gas. Sound in a medium creates a series of compressions and rarefactions caused by the particles vibrated by the sound source. The number of times per second the air particle takes to return to its neutral position is called the frequency. Frequency is the rate of repetition of a periodic event. It is measured in cycles per second—a unit known as hertz (Hz) (Figure 2.1). The greater the number of cycles, the higher the frequency is. Humans can hear frequencies between 20 Hz and 20,000 Hz (Ballou, 2008; Egan, 2007).

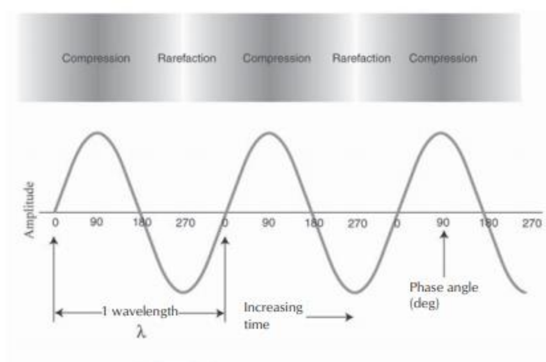

Figure 2.1. Frequency as a result of compressions and rarefactions (Ballou, 2008)

A single-frequency sound is called pure tone (Long, 2006). Despite their importance and extensive use in auditory research, pure tones are rare in the physical environment (Goldstein, 2010). The everyday sounds in the environments consist of many frequencies and are known as complex tones (Goldstein, 2010; Long, 2006). Despite either forms of frequency, high and low frequencies, and accordingly their behavior, depend on the wavelength.

Wavelength

As sound passes through a medium, the distance between adjacent regions of rarefaction and compression is called wavelength (Long, 2006). It is also the distance a sound travels during one cycle of vibration (Egan, 2007).

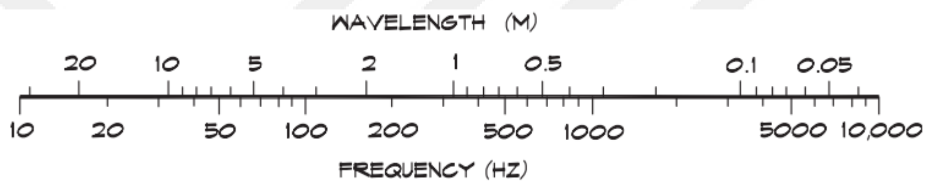

Figure 2.2. Wavelength versus Frequency in air at 20° (Harris, 1992; cited in: Long, 2006)

The higher the frequency of a sound, the shorter the wavelength is. The general relation between frequency and wavelength is:

$$\lambda = c/f \tag{2.1}$$

Where λ = wavelength (m)

c = velocity of wave propagation (m /s), and

f = frequency (Hz) (Long, 2006).

That being said, the audible range of frequencies for humans is between 20 Hz to 20 kHz has a wavelength range of 17 meters to 17 millimeters respectively in the air (Figure 2.2) (Ballou, 2008). Thus, wavelengths lead some frequencies to interact with specific dimensions and structures. Thin materials interact with short wavelength and high-frequency sounds, while thicker materials interact with longer wavelength and lower frequency sounds (Stocker, 2013).

Velocity of sound

Velocity is the speed of sound waves move through a medium. It depends on the nature of the wave and the medium in which the sound energy passes through (Egan, 2007). In air, at room temperature and atmospheric pressure, the velocity of sound is approximately 343 m/s (Ballou, 2008).

Intensity

Sound intensity measures the energy propagating through a given area at a given time. Thus, the lowest intensity a human may experience is about 10^{-12}w/m^2, which is the threshold of hearing. Similarly, the threshold of pain, which resembles a sound of a jet taking off, has an intensity of 1 w/m^2 (Long, 2006).

A sound source's intensity can be obtained by the formula:

$$I = {p^2}/{\rho c} \tag{2.2}$$

Where I = maximum acoustic intensity (W / m2)

p = root-mean-square acoustic pressure (Pa)

ρ = bulk density (kg / m3), and

c = velocity of sound (m / s) (Long, 2006).

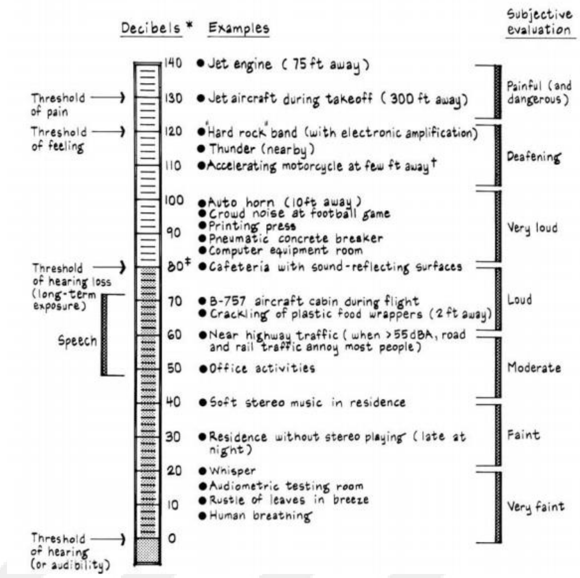

Figure 2.3. Sound pressure levels in dB of different activities and their subjective evaluation (Egan, 2007)

Due to this extensive range of intensities, an adoption of the decibel notation is practiced—known as level. Sound levels are the acoustical pressures or powers measured in decibel (Ballou, 2008). It is a fraction, expressed as ten times the logarithmic of the ratio of two numbers (Egan, 2007; Long, 2006). Decibel represents “The level difference caused by changing a quantity will depend upon the initial value of the quantity and the percentage that it is changed” (p:26; Ballou, 2008). Thus, the decibel (dB) is very useful as it allows changes in parameters of sound energy to be related to level changes heard by humans (Figure 2.3.) (Ballou, 2008).

<u>Sound pressure level (SPL)</u>

The most used sound intensity level scale is the sound pressure level. It is defined as:

$$L_p = 10\ log\, {p^2}/{p_{ref}^2} \tag{2.3}$$

Where p = root-mean-square sound pressure (Pa)

p_{ref}= reference pressure, 2×10^{-5}Pa (Long, 2006).

It is considered an equivalent to sound intensity in most architectural acoustics situations. The sound pressure level is mainly affected by the environment where sound events occur (Egan, 2007). It correlates well with the perception of loudness.

Sound power level

The other sound intensity level scale is the sound power level. Regardless of the space within which the sound source is placed, the sound power level expresses the amount of energy radiated by the sound source (Egan, 2007). Its reference power is 10^{-12}watts (Long, 2006).

By using the formula

$$L_p = L_w - 10\log S + K \tag{2.4}$$

Where L_w = sound power level (dB re 10^{-2} W)

L_p = sound pressure level (dB re 2 * 10^{-5} Pa)

S = measurement area (m^2)

K = 10 log ($\rho_0 c_0/400$) + 20 log (r_0)

= 0.1

r_0 = 1 m (Long, 2006)

it is possible to measure the sound power level of a sound source by measuring the average sound pressure level over of a known area that bounds that surface.

2.1.2 Room acoustics

Assuming an absence of obstacles, the characteristics of the outdoor sound field are considered relatively simple. That means the sound wave spreads freely and attenuates with distance. This is not the case with the indoor emitted sound. The indoor sound field is more complicated because of the multiple reflections from the walls, ceiling, and floor. Thus, the characteristics of the indoor sound field can be described as follows: (1) the sound intensity at receiving point is not attenuated equally as that in the free field, even if the distance between source and receiver is large. (2) Indoor emitted sound creates reverberation due to the reflected sound arriving after the source has stopped. Furthermore, echoes, flutter echoes, etc. may occur indoors depending on an enclosure's shape and surface furnishing. (Maekawa, Rindek, & Lord, 1997). The main acoustic elements that control sound fields in enclosures are sound absorbers, reflective surfaces, and diffusers. A sound absorber is used for the reduction of sound levels and control of reverberation. Reflectors and diffusers are used for preserving and distributing sound energy (Cucharero, Hänninen, & Lokki, 2019). This subsection explains the concepts behind how sound responds and reacts in enclosures.

Absorption

A sound wave's energy in an incident is reflected, transmitted, and absorbed when it interacts with a material (Long, 2006). Absorption turns the sound energy into another form, usually heat. It is measured in sabin, named after W.C. Sabine (1868-1919) (Figure 2.4.) (Ballou, 2008).

Theoretically, 1.0 sabin equates to one square meter of complete absorption (Ballou, 2008). Thus, the absorption coefficient can vary from 0 (no sound absorption) to 1.0 (perfect complete absorption) (Egan, 2007). Yet, absorber performance changes with frequencies. Low frequencies are more difficult to be absorbed than higher frequencies. Thus, various isolation and attenuation methods are applied in order to treat the absorption of low frequencies in a space (Stocker, 2013). The absorption application is mainly made by three classifications of absorbers: porous, discrete, and resonant (Ballou, 2008).

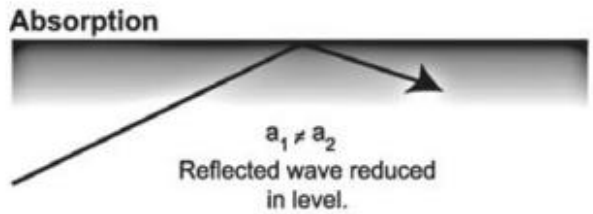

Figure 2.4. Illustration of sound wave absorption (Ballou, 2008)

The amount of surface absorption in a space is decided depending on the intended function of the room. High absorption is usually subjectively rated as warm and less lively due to the resulting low reverberation times (Ballou, 2008). If too much absorption is used, the space will feel dead and unresponsive—like anechoic chamber's acoustics characteristics. On the contrary, low absorption will make the space feels uncomfortably live, similar to a reverberation chamber (Ballou, 2008). Furthermore, because there is a difficulty in absorbing low frequencies and ease with higher frequencies, sound absorbers create auditory cues that give users a notion about the distance of the various sound sources in the space (Stocker, 2013). It provides information about spatial relations in the space, and influences users' perception of the spaces friendliness or hostility (Ballou, 2008; Truax, 1984).

Reflection

When a sound wave encounters a surface, a kind of interaction takes place that depends mainly on the incident's wavelength. If the surface is much larger than the wavelength, the reflection occurs. However, if the surface is smaller than the wavelength, the wave diffracts around the obstacle and continues its propagation (Ballou, 2008). Thus, sound reflection is the return of a sound wave from a surface when faces a change in acoustic impedance. The reflection angle equals the incidence angle in the ideal cases (Figure 2.5.) (Ballou, 2008; Egan, 2007). Furthermore, the more the absorption of the surface, the less the level of reflection will be—the contrary is also true. Additionally, if the surface is random, the wave will be scattered depending on the size relation between the wave and the aid of the surface (Ballou, 2008).

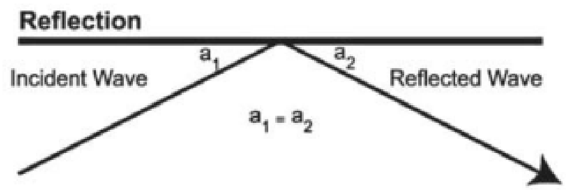

Figure 2.5. Illustration of sound wave reflection (Ballou, 2008)

Similar to sound absorption, the application of reflection in a space depends on the desired performance of that space. In spaces such as concert halls, reflection is a beneficial form of acoustic treatment (Ballou, 2008). This statement does not limit reflection application to concert halls, since reflection is the treatment to achieve spaces that feel live, reverberant, and responsive.

Reverberation time

Reverberation time is defined as the time required for a sound to decay 60 dB after the sound source is stopped (Egan, 2007). It is originated with Wallace Clement Sabine's correction of the unintelligible speech problem in the Fogg Art Museum lecture hall at Harvard College (Long, 2006). It was found that the sound in the hall would persist for 5 seconds due to multiple reflections from the hard plaster finished surfaces. The unintelligibility was due to the fact that the English-speaking person can complete about 15 syllables within that time; thus, most of the words were impossible to be understood (Egan, 2007). Recognizing the problem due to the size of the room and its occupants, Sabine used various amounts of absorbent materials and placed them in different locations in the hall to test the time took the sound to decay. When the absorbent materials (3-inch thick seat cushions) were placed around the room, the sound decay was quicker. When 550 cushions were arranged in the hall in the platform, seats, aisles, and the rear wall, the reverberation time decreased to about 1 second (Egan, 2007; Long, 2006). The formula he discovered, and known as Sabine reverberation time is:

$$T_{60} = 0.161\ {}^{V}/_{A} \tag{2.5}$$

Where T_{60} = Reverberation time (sec.)

V = Volume of the room (m^3)

A = total area of absorption in the room (sabins)

= $S_1 \propto_1 + \ S_2 \propto_2 + \cdots + \ S_n \propto_n$ (Long, 2006).

Reverberation time is the most fundamental concept in geometrical acoustics for evaluating the sound field in a room (Maekawa et al., 1997). Thus, reverberation time within a space can determine the acoustical success or failure of a room (Long, 2006). The ideal reverberation time for a specific space depends on the nature of that space's activity (Berg & Stork, 2005). Generally, the more the speech content is desired in the space, the lower the ideal reverberation time (Figure 2.6.) (Long, 2006). However, Sabine's formula is applicable to live rooms with low absorption and long reverberations. Applying this formula to absorptive rooms results too large values for this kind of spaces (Maekawa et al., 1997). To correct this defect, C. F. Eyring (1931) derived a new formula:

$$T = \frac{55.3\ .\mathrm{V}}{-\mathrm{c}\ .\mathrm{S}\ .\mathrm{In}\ (1-\overline{\alpha})} \tag{2.6}$$

Where V = Volume of the room

S = total surface area

$\bar{\alpha}$ = mean absorption coefficient (Maekawa et al., 1997)

This formula shows that in the extreme case of an anechoic chamber ($\bar{\alpha} = 1$), the reverberation time is equal to 0 (Maekawa et al., 1997). However, both formulas were rejected by Schroeder and Gerlach (1974) for not considering room shape and absorbers location (cited in: Cucharero et al., 2019). These factors were found influential on reverberation time: shorter reverberation times were obtained when absorbers were located on the smallest walls. However, absorbers location showed no significant influence on reverberation time in rooms with nearly equal dimensions.

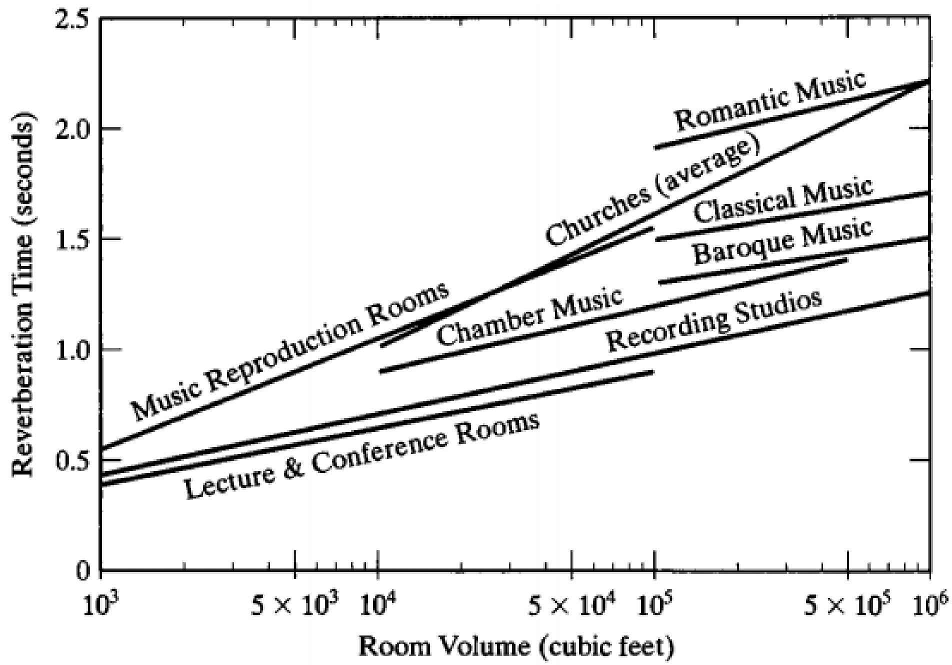

Figure 2.6. Ideal average reverberation time versus room volume for several room types (Berg & Stork, 2005)

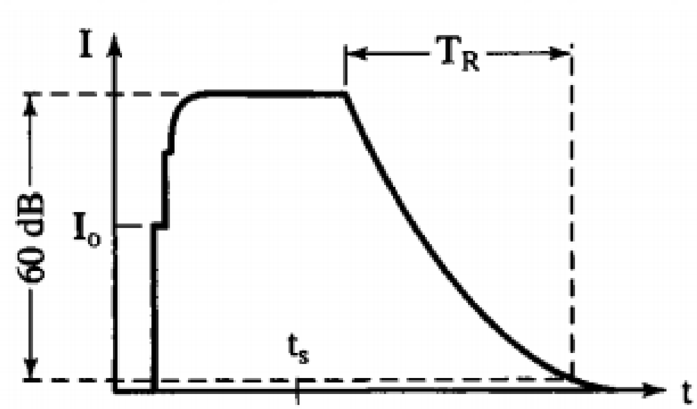

Figure 2.7. Intensity versus time for a steady-state room. t_s denotes the time when the source stops; T_R is the reverberation time (Berg & Stork, 2005)

Along with the physical properties of sound, reverberation time creates an interactive experience with the space's occupants through several acoustical properties, such as liveness, intimacy, fullness, clarity, warmth, brilliance, texture, blend, and ensemble (Berg & Stork, 2005; Blesse & Salter, 2007). For instance, reverberation time is used in music production to create sense of space and to give different feelings of individual voices or played instruments (Serences & Wixted, 2018). As sound sources are altered in different environments, reverberation may cause a challenge for sound recognition. Too much reverberation drastically reduces the intelligibility of speech, as is the case in some large auditoriums. In most spaces where moderate reverberation occurs, minimal effects to recognize speech and sounds are witnessed (Serences & Wixted, 2018). However, on two opposing extents, excessive reverberation degrades the speech intelligibility and makes the space aurally unpleasant. To the other extent, poor reverberation makes the space sounds dead, unresponsive, and uninviting (Blesse & Salter, 2007).

Signal to noise ratio (SNR)

Signal-to-noise ratio (SNR) is the signal level minus the noise level in dB (Long, 2006). In other words, it is the amount of a sound signal in dB being above or below the acceptable background noise (Egan, 2007). It is commonly used in acoustics as it shows to what degree the noise of a space inhibits the intelligibility (Long, 2006).

The presence of background noise in environments leads to using the SNR in designing enclosures (Goldstein, 2010). Since speech has a limited dynamic range and frequency range in the auditory area (Figure 2.8.), special treatments in enclosures for intelligibility are required (Ballou, 2008). Thus, SNR is the key to speech intelligibility (Long, 2006). A minimum SNR is essential for the brain to separate the desired signal from the competing noise in the space (Truax, 1984). Controlling the sound source, increasing the path attenuation, and raising the masking sound level are the means to influence SNR in enclosures (Long, 2006).

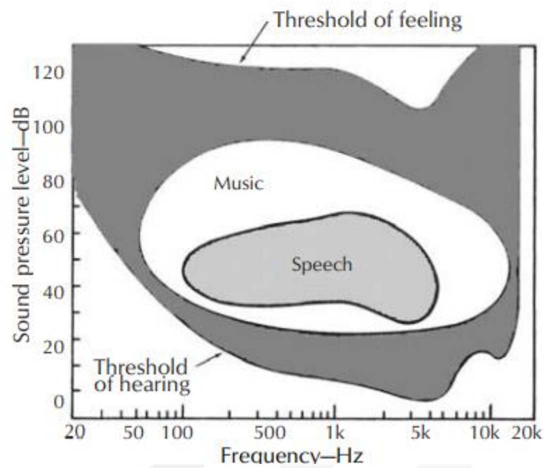

Figure 2.8. The range of speech within the auditory system (Ballou, 2008)

Background noise and masking

The sound that interferes with the desired sound signals is known as background noise (Long, 2006). It can be generated from any source such as HVAC systems, people, exterior noise, or electronically generated masking noise (Long, 2006).

Users in enclosures with low background noise levels may have complaints about speech intrusion (Egan, 2007). Thus, adding masking sound is essential to achieve the desired level of privacy in the space (Long, 2006). Masking is introduced purposefully to increase speech privacy (Long, 2006). It should be an unobtrusive, uniformly distributed sound, with an intensity between 43 to 49 dB. Thus, it raises the noise level and increases privacy without being noticed by users (Egan, 2007; Long, 2006). Accordingly, the masking system must produce random noise that does not change as the user moves from one location to another within the space (Ballou, 2008).

Diffusion

It is stated earlier that if a sound wave faces a random surface, it will be scattered (Ballou, 2008). This kind of reflection is known as diffusion. Thus, the diffuser redirects the sound wave energy in all directions and over a wide range of frequencies (Figure 2.9.). This diffusion occurs when the hard-surfaced material is comparable to the wavelengths of the sound (Ballou, 2008; Egan, 2007).

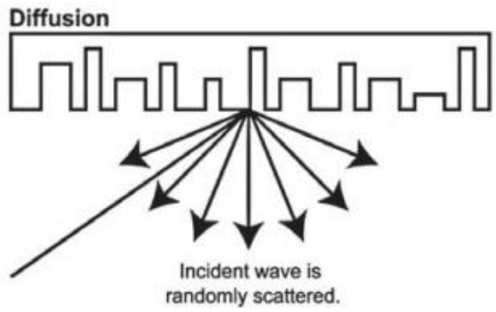

Figure 2.9. Illustration of sound wave diffusion (Ballou, 2008)

Diffusers reflect sound waves temporally and spatially (Azad, Meyer, Siebein, & Lokki, 2019). The performance of a diffuser can be expressed as the sum of diffusion and of scattering provided by a surface. The more reflected the sound in a non-specular manner, the higher the scattering (Ballou, 2008). This acoustic treatment plays a crucial role in the enclosure's acoustic quality (Azad et al., 2019). It is essential for musical performance spaces. When it is properly achieved, listeners will have the sense of sound coming from all directions equally (Egan, 2007). Thus, the listening experience is enhanced with diffusion as users can feel welcomed by the space's sound and embraced within it (Ballou, 2008; Blesse & Salter, 2007; Egan, 2007).

Diffraction

Sound diffraction occurs when the sound bends within the same medium around an object or through an opening (Figure 2.10.); sounds can be heard around corners or behind barriers that cut off the direct view of the sound source (Ballou, 2008; Berg & Stork, 2005; Egan, 2007). It occurs at objects with free edges, at corners, and at boundaries between materials with different impedances (Vorlander, 2008). Thus, it influences the sound transmission through incompletely sealed doors or windows, and in the orchestra sound from an orchestra pit in an opera house, causing musical tone distortion (Egan, 2007; Vorlander, 2008).

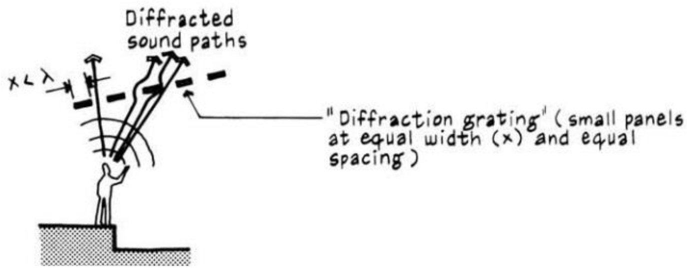

Figure 2.10. Illustration of sound wave diffraction (Egan, 2007)

It is understood that enclosures, depending mainly on their functions, prefer specific acoustic treatments to achieve their desired acoustical experience. Surfaces' materials, areas, and locations can drastically influence the performance. Thus, users experience within the space is influenced, and may affect the perceived performance by other non-sonic elements and treatments of the space.

2.1.3 Psychoacoustics

The importance of clarifying psychoacoustics lies in linking the physical properties of sound to its subjective counterparts. This association clarifies how users interpret different sound sources in the environment due to frequency, intensity, amplitude, and other sound properties. Accordingly, sound source's location, attributes, and occurrences set to action are identified. Users unconsciously employ these factors in emplacing themselves in a given environment. Hence, their relation to the environment and judging its suitability and usability are determined.

Psychoacoustics denotes the processing of sound waves by the auditory system to extract usable information for the brain (Truax, 1984). It allows subjective reactions to acoustics to be scalable. Thus comes the distinctions between the objective acoustic parameters—such as intensity, frequency, and waveform—and their subjective counterparts—loudness, pitch, and timbre respectively (Truax, 1984).

The following sections briefly explain three psychoacoustic parameters those are essential in clarifying sound source's identification in the environment.

Loudness

Loudness is the human perception of the magnitude of a sound: the sensation of its intensity (Fastl & Zwicker, 2007; Long, 2006). It is related to sound's amplitude or sound pressure (Goldstein, 2010). Its unit is sone. The loudness level of a sound, which is best known for loudness levels of pure tones frequencies, is the sound pressure level of 1 kHz tone in a plane wave and frontal incident that is as loud as the sound. Its unit is phon (Fastl & Zwicker, 2007).

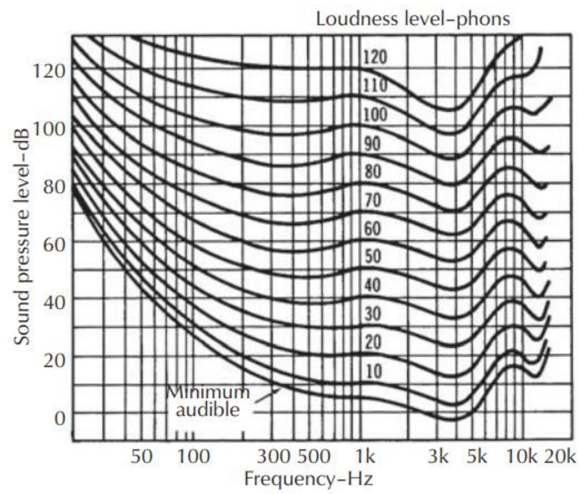

Figure 2.11. Equal loudness contours for pure tones in the frontal sound field for humans of average hearing acuity. The loudness levels in phones correspond to the sound pressure levels at 1kHz (Ballou, 2008)

In real environments, loudness is suggested to influence the estimation of the intensity of a sound source. Furthermore, loudness is influenced by the apparent distance of a sound source. Sounds that appear more distant sound louder than those appear closer but have the same overall intensity. Moreover, as visual cues influence the perceived loudness, the cues provided by the amount of reverberation are essential. As the sound source gets farther in distance, the sound from the source to the listener gets weaker. This is related to the direct-to-reverberant ratio in the environment. At the critical distance, where the direct and reverberant levels are equal, moving the sound source beyond the critical distance will not increase the sense of distance (Ballou, 2008; Serences & Wixted, 2018).

Thus, loudness seems to function like size or brightness perception in vision: the perception is not merely based on retinal size or light intensity (Adelson, 2000; cited in: Serences and Wixted 2018). However, there will always be some differences from listener to listener. Furthermore, the same listener perceives loudness differently in various environments depending on psychological and physiological states (Long, 2006).

Pitch

Pitch is defined as the perception of a sound being high or low, faint or strong (Fastl & Zwicker, 2007). Besides describing the perception of sound frequency, pitch is also defined as the perception of periodicity. Thus, it can help perceiving sound sources' properties, such as size (Serences & Wixted, 2018). As sound's pitch increases and decreases, humans can capture the identity of a melody, or the intention of a speaker (Serences & Wixted, 2018).

Pitch is mainly related to the sound's frequency: low pitches are associated with low fundamental frequencies, and high pitches are associated with high frequencies (Goldstein, 2010). However, pitch can vary with intensity and waveform. If a 300 Hz-below tone is sounded first at 60 dB and then at 80 dB, the louder sound will have a lower pitch. At mid-frequencies (500-3000 Hz), pitch is relatively independent of intensity. When frequencies are above 4000 Hz, pitch increases with increasing levels (Long, 2006).

Timbre

Timbre distinguishes two sounds identical in position, pitch, loudness, intensity, and subjective duration (McAdams & Drake, 2002). It depends mainly on the spectrum of the stimulus, waveform, sound pressure, frequency location of the spectrum, and temporal characteristics (Ballou, 2008). Thus, in many cases, timbre seems to be the chief influencer for sound source and event recognition (McAdams & Drake, 2002).

Psychoacoustics parameters explain the effects of sound sources on experiencing a space. Sound sources' physical properties majorly influence perceived loudness, pitch, timbre, and sound source localization. The variance in sound intensity, frequency distribution, and amplitude of sound sources in the environment create different perception and interpretation of the space/place due to the perceived loudness, pitch, timbre, and other psychoacoustical parameters. As it is explained in the previous sections, estimating sound source's location, recognizing its properties, and recognizing occurrences are modified by loudness, pitch, and timbre perception, respectively. Thus, occurrences in the environment are rendered perceived and clear by users. Accordingly, space experience and forming places are influenced.

2.1.4. Auditory sense and perception

When an elastic medium is vibrated and its pressure is changed, sound stimulus occurs, and the ear plays its role in decoding these changes through its auditory system (Goldstein, 2010). Humans use these stimuli to infer many important occurrences around them, such as sound sources that cannot be distinguished by vision, or someone's intonation and emotional condition while stating something. Thus, by listening, comprehending the aspects of surroundings becomes possible (Serences & Wixted, 2018). Listening provides the ability to understand the state of the surroundings based on the behavior of sound-producing objects, regardless of being in the field of vision (McAdams & Drake, 2002).

Physically, sound is the pressure changes in the air or other medium. Perceptually, it is the experience humans have when they hear (Goldstein, 2010). In either way, the ears are to receive and analyze the sound phenomenon. The ears are rarely presented to isolated sounds. The sound signals reaching the ears are usually a mixture of different sources and various natures. However, humans hear sounds as if they arrive independently, without distortion or interference to their ears. Thus, the brain must derive a representation of the mere sound of interest (Haverkamp, 2013; McAdams & Drake, 2002; Serences & Wixted, 2018).

For the brain to know this sound of interest, the sound will take a journey through three parts of the human's auditory system: (1) the ears, (2) the auditory nerves, and (3) the brain. The ear consists of the outer ear, middle ear, and inner ear. The outer ear (i.e. the pinna) is the visible part of the system. It primarily aids for sound localization and spatial-filtering of unwanted sounds. A received sound is channeled down the auditory canal, which ends with the tympanic membrane that transmits incoming vibrations to the middle ear. The middle ear is an air-filled chamber. Its main components are the three ossicles: the malleus, incus, and stapes—the body's smallest bones. The most crucial function of the middle ear is matching the impedances of outer and inner ears, as the sound travels from one medium (air-filled) to another (liquid-filled). It is separated from the liquid-filled inner ear through the oval window. The inner ear provides the ability of balance and orientation in space; and analysis of frequency and intensity of sounds—the vestibular system and auditory system respectively (Ballou, 2008; Hulusic et al., 2011). Afterwards, sound waves will be converted to neurological signs and processed by the brain. Thus an interconnection will occur between the external world and the inner consciousness (Figure 2.12.) (Blesse & Salter, 2007).

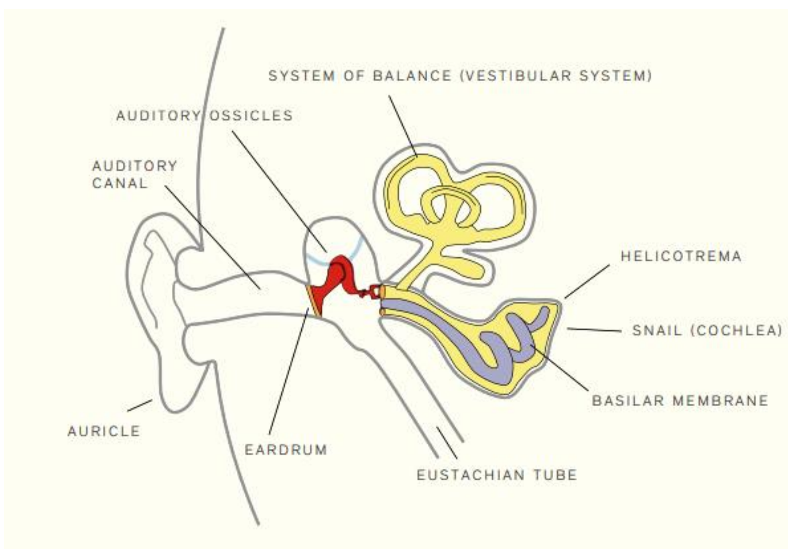

Figure 2.12. The structure of the ear and the balance system (Haverkamp, 2013)

Sound, which is defined as the vibration that excites hearing sensation, plays an integral part in perceiving environments and forming users' reactions. More or less, sound is a survival tool for humans. By sounds, perceiving space's size, shape, and density is different and more placement-offering than vision. By different generated frequencies and, accordingly, comprehending different occurrences in the surroundings, users can estimate the level of safety offered in that space and their position of dominance (McAdams & Drake, 2002; Stocker, 2013).

Such estimation requires a period of time—time is central to sound (Blesse & Salter, 2007). Inhibiting time and being in the temporal continuum of place is essential through the process of listening and hearing (Vanclay et al., 2008). Even though there is no sensory organ for coding time, humans' perceptual system is capable of indicating the duration of events relatively. Thus, speech and music perception occur by organizing events over long periods (McAdams & Drake, 2002).

The complex structure of ears is efficient in interpreting the equally complex and different occurrences in an environment indicated by sounds. Objects' shapes, materials, sound sources; spaces' volume, state of occupancy; and temporal patterns are perceived differently when they are out of sight range due to sound's various parameters and its omni-directionality. Its close relation with time gives it further importance for building a better comprehension of space's opportunities in fulfilling its made-for function. Thus, auditory sense and perception can be considered as a mediator interpreting an environment's function and spirit to its users.

Sound sources

The aural environment is rendered perceivable by sound sources in the space. By listening to sound sources, users can effectively understand the occurrences in the space they are experiencing, regardless of if these sources are within or outside their vision field (Pashler & Yantis, 2002). The perception of an aural environment is as a scene of auditory images. Each image in this context corresponds to a sound source (Bregman, 1994). Thus, depended on context and function of the space, sound sources are influential factors in affecting users' subjective evaluation of acoustic comfort and the overall environment (Kang, Meng, & Jin, 2012).

Each context has its set of sound sources. Sometimes these sources are judged suitable, and sometimes not. Their influence is not limited to auditory perception: sound sources can affect both auditory and visual perception of places (Kang et al., 2012). For instance, the urban context has various sound sources, such as natural sounds and technological sounds. Despite the coexistence of these two sources, it was found that users prefer natural sounds more (Kang et al., 2012; Lindborg, 2016). A study found that sound sources of human activities in residential areas are factors of increasing the eventfulness of the aural environment (Kang et al., 2012). On the other hand, traffic noise reduced the pleasantness of the soundscape and even affected the perceived visual quality of the place (Kang et al., 2012). Similarly, as speech is essential in a restaurant space, it is judged more as a noise source and an obstacle for social interaction (Lindborg, 2016). Furthermore, it was revealed in a study that users engage with and respond to real-world valid sound sources more effectively than with artificial synthesized sound sources (Wilkie & Stockman, 2020).

Identifying sound sources occurs by comparing sound properties those aided with the enclosure's acoustics. Sound sources relative size, form, properties of materials, and action set them into vibration are perceivable due to acoustics properties (Pashler & Yantis, 2002). Therefore, sound perception tells about the sound itself and the existence of an event or incident within the space experienced (Nudds, 2007). For instant, surface reflection creates reverberation and direct-to-reverberant energy ratio—they are considered as acoustic cues for depth perception and distance determination of a stationary sound source (Wilkie & Stockman, 2020). Amplitude increase and frequency change are associated with approaching sound sources (Wilkie & Stockman, 2020). The change in spectral cues also affects motion perception of objects. When the spectral contrast decreases, users tend to perceive the sound source approaches. On the contrary, increasing spectral contrast leads users to perceive the sound source retreating (Wilkie & Stockman, 2020). This happens along with estimating other nonauditory properties—visual, tactile, verbal, and context-related properties (Giordano, Rocchesso, & McAdams, 2010).

Pitch parameter is essential in sound source identification as well. Due to periodicity, pitch gives more auditory information about the source's size and conveys meaning or emotion for communicative purposes. Furthermore, users can track a sound source of interest by its pitch (Serences & Wixted, 2018). Another parameter, such as timbre, is responsible for facilitating sound source and event recognition (Pashler & Yantis, 2002). Furthermore, loudness gives additional influence that serves to estimate the sound source's intensity and distance. The intensity of a sound source at the ear is determined along with its intensity and distance as intensity attenuates with distance from a sound source (Serences & Wixted, 2018). Thus, sound source perception seems more linked to peripheral processing than being a perception ability (Serences & Wixted, 2018).

The auditory system is an alerting system that signals occurrences outside the visual field, creating further visual and other sensory exploration (Giordano et al., 2010). Within the experienced environment, sound sources create the auditory scene and influence the holistic judgment of the environment. The environment's elements—such as space's size, shape, and materials—alter the sound reaching the ears from the source. Once it leaves its source, sound faces multiple reflections from surfaces before reaching its destination: the ears. This journey affects the auditory cues reaching the ears—hence, identifying and localizing the environment's sound sources.

2.1.5. Multisensory perception

As places are formed by physical settings, social dynamics, and socio-cultural factors (Park & Evans, 2016), various factors of different natures influence forming places. The place accordingly is a complex combination of sensory stimuli. This complexity is met equally by the human sensory system. The perception the user will form towards the place depends on how the stimuli are represented in the space and which stimuli dominate the space. Furthermore, altering a stimulus will change the entire perception of the space, forming the place, and user's relation with the place. Sound stimulus created and aided by the physical setting in enclosures influences users' perception of the place. This influence exceeds the auditory perception and affects other modalities as well.

Each sense receives information about the environment differently due to a particular stimulus. The combined information in the human brain is to determine the perception of this environment (Driver & Spence, 2000). Thus, senses enhance and correct each other, remove the ambiguous input in a sense, or even alter the entire perception, generating perceptual qualities those no individual sense can generate by itself (Alais, Newell, & Mamassian, 2010; Bregman, 1994; Haverkamp, 2013).

Perception is the result of a complicated process in the human brain. It is a dynamic and a continually changing process. As humans interact with an environment, they receive stimuli from it. These stimuli are to be processed and transmitted through brain nerves. After that, perception occurs; followed by recognition and action taken toward these stimuli, mainly facilitated through experience and memory (Goldstein, 2010)(figure 2.13.). Once the multisensory inputs are encoded, they are ready to interpret the environment accurately (Alais et al., 2010).

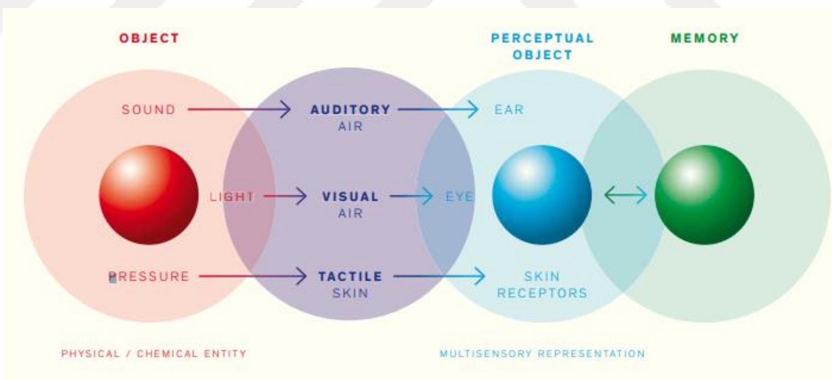

Figure 2.13. The construction of multisensory perceptual object (Haverkamp, 2013)

Multisensory perception is essential for humans to explore the world around them. The judgment of environmental characters is depended on the interaction of the main five senses of humans, adding to them the sense of orientation, gravity, balance, stability, motion, duration, continuity, scale, and illumination (Goldstein, 2010). This interaction provides complementary information about the environment. However, if the stimuli are ambiguous in one sense or another, the multisensory interaction may shift the attention from this ambiguity, providing a complete perception. Sometimes, it may change the perception entirely (Alais et al., 2010). Thus, what enters the conscious in a multisensory way influences the attention span and judgment's quality of the context at social, emotional, and cognitive levels (Haverkamp, 2013; Spence, 2020).

The necessity to experience a place in a multisensory way has to be carried out in design and planning process to enhance the perception of places (Sepe, 2013). In architecture, Pallasmaa denotes the importance of spaces as lived spaces rather than physical ones. As there is a continuous interaction between users and their movement in the spaces, users always perceive spaces in a multisensory way. However, today's architecture ignores the body and senses, and causes an imbalance in users' sensory system. This results a sense of alienation and detachment from experienced environments, and an isolation of the architecture in the mere realm of vision (2005).

As multisensory is defined as the integration and interaction among two or more different sensory inputs, cross-modal is defined in a bit broader way (Serences & Wixted, 2018). Cross-modal describes the biased perception a stimulus presents in a modality in perceiving or responding to a stimulus presented in another modality. Multisensory integration occurs when stimuli in different senses are presented simultaneously. This integration falls off as the temporal separation between the component unisensory stimuli increases. Contrarily, cross-modal interactions occur both when the component stimuli are presented simultaneously, and when pairs of unisensory stimuli are presented sequentially. Thus, it is possible to argue that multisensory integration creates a subset of all cross-modal effects (Serences & Wixted, 2018).

Multisensory perception is definite regarding perceiving any occurrence, and accordingly taking action towards it. As Tuan suggests that users' senses and mentality are reflected in their spaces (2001); accordingly, spaces should provide proper and sufficient communication to every and each sense of the users. Such spaces can evoke the users' thinking, productivity, and curiosity to both explore and develop the environment. Human interaction with the environment is done by receiving and analyzing stimuli those transmitted to the brain by the senses.

2.1.6 Soundscape

Soundscape is described as the middle ground between science, society, and arts (Schafer, 1977). It is essential in understanding the concept of sense of place from a sound perspective since it involves context, semantics, users' expectations, familiarity, and other dimensions with the place. It is centered on human perception and preference of the environment and considered as the perceptual construct of the acoustic environment (A. L. Brown, 2014). Thus, it includes place attachment, sense of harmony, wellbeing, and place appreciation (A. L. Brown, 2014; A. Lex Brown, Gjestland, & Dubois, 2016). Accordingly, soundscape clarifies and suggests the auditory sense of place.

According to the International Organization for Standardization ISO, a soundscape is a perceptual construct, related but not distinguished from the acoustic environment (ISO 12913-1:2014; cited in: Maculewicz, Erkut, and Serafin 2016). It is the subjective listener-centered model of the acoustic environment: it emphasizes the perceived construct of the acoustic environment of a place (A. L. Brown, 2014). Soundscape deals with sound from physical, psychological, acoustical, architectural, and social perspectives (Schafer, 1977). Thus, it studies how people consciously perceive their acoustic environment (Kang, 2007). The term is an analogy to landscape. As a visual environment is defined by its background properties and significant foreground elements, the soundscape is defined by background noise and individual acoustic sources in the environment (Figure 2.14) (Haverkamp, 2013).

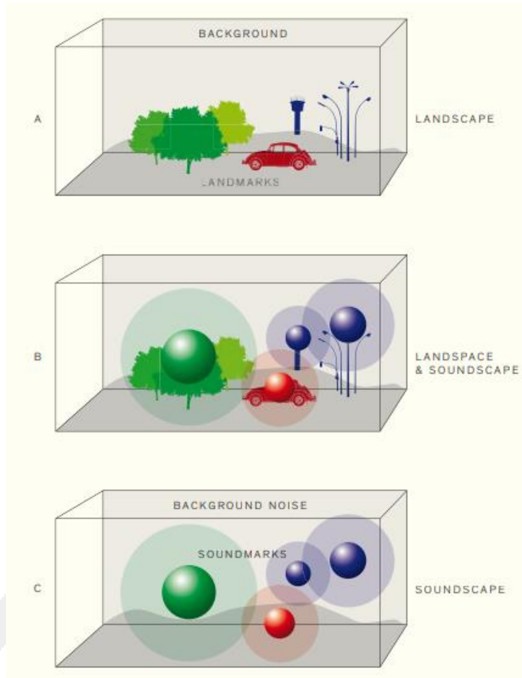

Figure 2.14. The derivation of the soundscape from the analogy to the landscape (Haverkamp, 2013)

According to Schafer, sounds can be classified in several ways: according to the physical characteristics or the perception of these characteristics—acoustics and psychoacoustics respectively; according to the function and meaning of sound—semiotics and semantics; or according to the emotional or affective qualities—i.e. aesthetics (1977). Accordingly, the function of sound, and hence perceiving it, depends on the social and environmental context (Truax, 1984). Physically similar sounds that appear identical in perception are distinguished in meaning and aesthetic effects due to the context (Schafer, 1977). The user within a soundscape is a engaged in a dynamic information-exchange system, not in a passive type of energy reception (Truax, 1984). Thus, soundscape may include place attachment, a sense of harmony, restoration of well-being, or appreciation of nature through its sounds (A. L. Brown, 2014).

Soundscape seeks to preserve, encourage and appreciate the sounds within the acoustic environment rather than eliminate noise sources (Schafer, 1977). Thus, understanding sound as a mediator between the user and the environment becomes more comprehended. This comes from understanding how sound functions in addition to how it behaves

(Truax, 1984). Soundscape judgment is determined by context, information in the sound, and individual attitudes and expectations (A. L. Brown, 2014). Accordingly, soundscape tries to understand how sound weaves users with their environments through sound's contextual characteristics and functions. Thus, it evaluates the attachment sound creates between users and places.

In enclosures, sounds are mainly affected by the acoustic properties of the space and the type of functions taking place. Different functions produce different acoustic cues, and functions related to a specific activity reflects the sound environment in the space (Dökmeci & Kang, 2011). Thus, space's function, usage, and physical properties are as important for evaluating the objectivly and subjectivly experienced sound, as well as the overall environment (Dokmeci Yorukoglu & Kang, 2016).

Both physical room acoustics and soundscape studies are concerned with studying the acoustic environment and human response to it. They complement each other (A. L. Brown, 2014). Soundscape is a holistic approach. It assesses the acoustic environment by depending on the contribution of different disciplines (Kang et al., 2016). Thus, soundscape is beyond the sound level or audibility of sounds (Kang et al., 2016). However, most acoustic research treats acoustics as discomfort, annoyance, and communication difficulties. Soundscape is concerned with how sound enhances, facilitates, and creates human satisfaction and wellbeing in the place (A. L. Brown, 2014). Despite the human experience in both approaches, room acoustics relays on physical measurements and sets limit criteria for human exposure to sound accordingly. Soundscape approach does not determine this limitation by physical measurements and judges the sound environment quality by context, information in sound, and users' expectations. It suggests a less dominant role for physical parameters (A. L. Brown, 2014).

The acoustic environment creates both direct and indirect outcomes. Direct outcomes are those experienced by users in the acoustic environment and consciously assist the outcome directly to the perceived soundscape. Indirect outcomes are provided by the acoustic environment and enable the users to have specific responses towards the overall environment without consciously understanding why the environment is suitable for a certain activity. In this case, users seek to achieve positive outcomes in places facilitated by the acoustic environment, in addition to other dimensions of the place. The conscious attention to the acoustic environment then is not necessary (A. L. Brown, 2014; A. Lex Brown et al., 2016). Both outcomes are called for to be considered in soundscape assessment (A. L. Brown, 2014). This implies that users evaluate the soundscape of a place consciously. Nevertheless, the acoustics of the space facilitates this conscious attendance and contributes to the indirect outcomes of users towards the place. Hence, physical parameters of sound in spaces and their potential effects upon users' behaviors and judgment of the environment should be investigated equally.

2.2 Sense of place

Place and sense of place are discussed, investigated, and presented in various fields of study, resulting in a wide range of understanding and usage of this term. It refers to the relation users have with their environment—it does not refer to the place itself (Vanclay et al., 2008). Additionally, it denotes the relation formed from users' experience with a place and the development of their activities according to the given environment (Parker & Doak, 2014). Steele defines the term by referring to the subjective perception of the environment and users' reactions toward the place (1981; cited in (Altman & M. Low, 1992). It is formed by spiritual qualities and fortified by architecture and human activities, leading by these two constructs a meaning of presence in place (Gokce, 2009). Sense of place gives a sense of wellbeing, an emotional experience, and reaction to the place, which lures users to return to time and again (Larkham, 2003).

Sense of place can be employed to evaluate the quality of an environment, since the relation between place and its users is transactional: the place acquires changes from the user who obtains the sense of place (Najafi, Kamal, & Mohd, 2011). Moreover, this evaluation is almost perfectly accurate since sense of place is a holistic process involves each sense of the users to obtain it. Edward Relph (1976) confirms the combination of "… sight, hearing, smell, movement, touch, imagination, purpose, and anticipation" to reach a sense of place. "It is both an individual and an inter-subjective attribute, closely connected to community, as well as to personal memory and self" (cited in: Vanclay et al., 2008; p. 7). Arefi mentions the statement "structure of feeling" when referring to the ties and attachments users have to their places (1999). To some extent, users create the place itself when their holistic experience responds and integrates with the place's physical and social features (Cross, 2015; Larkham, 2003).

Due to its direct effect on human experience, sense of place affects behaviors and reactions of users. When a place is sensed, it is more likely to evoke pride, feeling of ownership, identity, commitment, positive aspiration, and a sense of responsibility toward the physical and cultural structure of the place (Convery, Corsane, & Davis, 2012). However, sense of place may cause feelings of un-involvement, homelessness, unreality, and disbelonging to place (Relph, 1976).

In the following subsections the argument between space and place is clarified. Additionally, sense of place from the point of philosophy and social and environmental sciences' views are explained.

2.2.1 Place and space

Despite the various studies about places and sense of place, *place* and *space* are being used or understood interchangeably. Tuan (1977), Relph (1976), and Norberg-Schulz (2000) agree that space is the objective geometric extent, while place is the subjective human construct (cited in (Gokce, 2009). Space for Norberg-Schulz denotes the three-dimensional organization of the elements which make up a place. The place is a qualitative, holistic phenomenon. Hence, it cannot be described according to one or some of its properties least it would lose its concrete nature (1976). Tuan admits the inseparable relation of space and place by stating their denoting common experiences, where place represents security, and space represents freedom; "… we are attached to one and long for the other" (2001; P. 3). Tuan simply defines a space as a "room" that is getting its geometric personality from places and objects, and provides the ability of movement (2001). Relph states the importance of clarifying the relationship between place and space. This importance is to avoid the separation of place from its conceptual and experiential context (1976). Casey argues that there is no separation between a given place and its concrete region in which it is found—its space. Space is simply a pre-given medium with cultural and historical properties that it is to result a place once experienced (1996).

Place is the concrete term for any given environment. Its essence is the character of this environment, which is determined by material, substance, shape, texture, and color. The result is an atmosphere with a reference to a specific locale. Although space is a three-dimensional geometry and a perceptual field, neither of these constructs to satisfy its purpose without the everyday experience (Norberg-Schulz, 1976). Norberg-Schulz argues that scientific and analytic concepts should not be the main method to describe places. The scientific analysis would derive the place from the everyday life-world, which is the main concern for users, planners, and architects. Human actions and behaviors do not take place in a uniform space, but in a space distinguished by qualitative differences (1976). Accordingly, Vanclay, Higgins, and Blackshaw defines place as a space poured with meaning. It is considered a place once suffices a geographical location, material form, and investment with meaning and value (2008). Hence, a space is any one of these three not integrating with the other. That is agreeable with Tuan's argument that any particular geographic locale becomes a place once it is attached to meaning (cited in: Boerebach, 2012). This meaning does not come from a particular object or specific occupation, it can be an environmental conflict (Parsaee, 2015), a shared story, or a personal experience. This is apparent in Casey's statement that a place is more an event than a physical entity. It is the processed result of human experience with space and time together. Casey continues arguing the fact that a place cannot be one kind of things: it can be psychological, physical, cultural, historical, and social, but it holds all these kinds together (1996).

Thus, the existence of space is essential for users to experience a place. It is as necessary as senses are essential for users to experience the space, and thus having a sense of place. According to Relph, appearance is the most prominent attribute of place. Place has a physical and visual form what makes it mainly perceived visually (1976). However, Norberg-Schulz's definition of character, which denotes the general atmosphere of any given place, can be of any nature other than visual. This character may be a function of time, changes within different time occurrences (1976). In addition to visual characters, this character can be the odor of the place, its unique sound, how the texture is felt or seen, or a haptically pleasant light. No matter how it would be, these characters create the atmosphere, which is significantly based on the participation of different senses (Haverkamp, 2013). This holistic experience of places is inescapable since the quality of human senses is always reflected in their spaces (Tuan, 2001).

As a result, it is agreeable that places have meaning due to users' experiences and interactions with them. They are not merely the 'where' of something. Place is a location that includes everything occupied within it (Relph, 1976). While Relph suggests that the place's context is a space (1976), Casey emphasizes the necessity of place to give a personality and specification to its context-provider space. Once this space is placeless, it will turn into a mere abstract space (1996). It is possible to suggest that architecture creates the space, whereas experiencing this given space creates a place. The characteristics of place can simply be enhanced by manipulating the physical characteristics of the space. In this way, the new organization of space will attempt to change users' perception of the setting (Vanclay et al., 2008). The place is created of human behaviors, concepts, intentions, expectations, psychological, social, physiological, and physical characteristics. On the other hand, space is created by different elements and defined by these elements' characteristics, conditions, and relationships (Parsaee, 2015).

As place and space are hardly separated, users and their environment are, as well. There can be no emerging of a place without a designed space for a specific function. Similarly, there would be no space without an eventual meaning and occurrences to take place within it. What attaches users to the environment is identified by every element constructs this environment. This is unquestionable due to the multisensory and holistic experience users have to interpret their surroundings. Due to the temporal quality of both phenomena, sound plays an important role in creating the sense of place and defining the value of a place by perceiving and comprehending the different occurrences and events within a particular space/place. Accordingly, the aural environment within a designed space is as equally pleasant and satisfying to the users as the visual environment can be.

2.2.2 Sense of place in philosophy

Philosophical opinion about sense of place is essential, since philosophy is the field of study that questions the existence and origin of different phenomena. Sense of place is investigated in philosophy since the time of Aristotle and Archytas during the fifth and fourth century BC (Gokce, 2009).

There is an argument in philosophy about whether place or space exists first to prepare the experience for the other. Archytas and Aristotle proclaimed that place is prior to space. This claim was carried on later by Kant who suggested that to begin with something means to initiate by it. This means in order to sense the place, one must be in the place first—place is not created by a space with meaning (cited in: Casey, 1996). Casey continues this explanation by stating that knowledge of the place is not a subsequent to perception other than an ingredient in perception itself (1996). However, Heidegger wonders whether places are first to occur; and whether the result of 'making-room' takes its character from places. Heidegger adds, "…if this proven right, then we would have to search for the special character… in the grounding locality, and we would have to meditate on locality as the interplay of places" (cited in: Crowther, 2007; P. 157).

However, there is a contradiction between Descartes and Locke defining place and sense of place. Descartes argued that one cannot clearly distinguish physical identity from the personal one—place and self are integrated. Fifty years later, Locke stated that place is a constitutive of one's sense of self. He claimed that place belongs to the physical world—the space, and self belongs to the consciousness; these two are never to meet (Locke [1690]1975; cited in: Casey, 2001). Nevertheless, Kant was the first western thinker to point out the importance of the body in achieving emplacement. He emphasized the holistic necessity to sense the place (Casey, 1996). Thus, the concept of place has changed from an integrated physical-personal entity to a separation between them. This alteration in theories did not stop there, since Heidegger proposed further important consideration to understand sense of place correctly.

Heidegger insisted on the importance of the active and practical human involvement as well. "Space is not in the subject, nor is the world in space. Space is rather 'in' the world in so far as space has been disclosed by being-in-the-world which is constitutive for Dasein (the being-here). Space is not to be found in the subject, nor does the subject observe the world 'as if' that world was in space; but the subject, if well understood ontologically, is spatial" (Heidegger, 1962 P.146; cited in: Wollan, 2003; p. 57). Hereby, Norberg-Schulz emphasizes the importance of the everyday life-world property to accurately explain the concept of place and sense of place. He suggests integrating the scientific and the analytic concepts with phenomenology to avoid abstracting the essential meaning of place (Norberg-Schulz, 1976). Suggesting phenomenology is for being a disciplinary field of philosophy. It studies the appearance of things, things as they appear in user's experience, or how user experiences things. Thus, it studies the conscious experience from a subjective point of view (Smith, 2003). Henceforth, several phenomenological theories treat place and sense of place holistically (Casey, 1996). Some phenomenological views suggest that place, as a spatial construct, is made possible through our bodily interaction with space. In that way, the sense of place occurs (Gokce, 2009). Additionally, it is suggested that users are in the place and of it; users' bodies reflect the kinds of places inhabited. Accordingly, Casey comments that the user is never without perception; hence, there is always an emplacement experience within one's self (1996).

Tenacity and subjection help places to be embedded within one's self. Thus, places become part of the enduring character, and become the driver to perform and move on. Tenacity is obtained when a place is experienced for a period of time, and when an intense experience with the place is marked. The place is present within self after departure. The sense of this place is ready to be revived once a proper sensation or motive occurs. On the other hand, subjection ranges from obedience to place, to appreciation of place, and then to change the place (Rawlinson, 1981; cited in: Casey, 2001). This suggests that every spatial setting provides an emplacement experience for users.

Place and self are inseparable, just as the French philosopher, Gabriel Marcel states, "An individual is not distinct from his place; he is that place" (Cited in: Relph, 1976); p. 43). As a result, it does not matter if place or space occurs before the other: both are the ultimate result of the other. The holistic experience of humans of a spatial setting, and the actions and involvement occurs toward it are to determine the place and sensing it. This holistic experience makes the self and the place an integrated entity—each one completes the other. Accordingly, Casey (2001) comments "…places will not merge with, much less turn into, space" (p.685). Thus, the sense of place is not to be weakened; instead, it would turn uniform and casual to human. Otherwise, this weakened sensed place eventually and simply will turn to space.

2.2.3 Sense of place in environmental and social studies

Sensing the place is a multisensory process, requires a full interaction of the users with their given environment. Physiology itself cannot give sufficient definition and explanation to this phenomenon, neither can psychology, sociology, geography, or architecture individually. Each one of these fields of study has given definitions and approaches to achieve the sense of place. Theoretical and methodological considerations of place include the construction of place, place's meaning and developing overtime, and people's attachment to places (Convery et al., 2012). Sense of place involves effects and emotions, knowledge and beliefs, and behaviors and actions in reference to place (Nielsen-Pincus, Hall, Force, & Wulfhorst, 2010; cited in: Boerebach, 2012).

Both Relph, a phenomenologically oriented geographer, and Tuan, a geographer, emphasize how users inhabit places through their bodies, feelings, and emotions. They emphasize the idea that experiencing a place is not through consciousness (Convery et al., 2012). In addition, Hall (1966) stated the role of culture, relationship, activity, and emotion in creating the perceived world. However, the reviewed literature explains that what makes sense of place can be cognitive and perceptual factors and/or physical characteristics and physical setting. Yet, it is agreed that response to the environment may be aesthetic, emotional, or multisensory (Cross, 2015). The personal experience of the place is made up of the perceived ambience of a location, safety and security, background noise, odor, lightings, and view-creating elements (Vanclay et al., 2008). However, and despite what the environment should be experienced with, it is essential that the built environment is to achieve a pleasant living and working arrangements to evoke positive feelings and a sense of contribution and belonging within the users (Haverkamp, 2013). It is more likely for a user to be lost without the sense of place, since it is essential for sense of identity and community (Vanclay et al., 2008).

Being essential for human identity and feeling safe and secured, place and sense of place get a proper and comprehensive structure by Norberg-Schulz. First, he determines the basic features of any human-made place: concentration and enclosure. Hence, it has boundaries that gather functions to the setting. These boundaries are not to limit the place; instead, they are to initiate further possibilities of experiencing it. They make the spatial structure visible, and provide the means of orientation. Accordingly, the functions of the place will denote the character of this place and its general atmosphere. Once this is achieved, places are to be designated by nouns, indicating their becoming "…real things that exist". "Places are hence designated by nouns. Space is denoted by preposition. Character is denoted by adjective… the very structure of everyday language confirms our analysis of place" (Norberg-Schulz, 1976; p. 16). Additionally, this structure awaits the user's experience and involvement to add the meaning and the 'sense' to the place (Shamai & Ilatov, 2005). Accordingly, Relph (1976) suggests three components of place: physical settings, activities, and meanings. This created relationship with place does not have to be positive. Sometimes a strong affection may occur (topophilia), and sometimes it can be an aversion toward a place (topophobia) (Relph, 1985; cited in Manzo, 2005).

Places may need utility, accessibility, perceived safety, and aesthetic appeal to be sensed (Convery et al., 2012). These requirements are applicable through architecture. Architecture is as complex as the human structure itself. It is what Pallasmaa states, "…our primary instrument in relating us with space and time, and giving theses dimensions a human measure" (2005; p. 17). Its purpose is to uncover the potentials of any given environment; to make a site becomes a place (Norberg-Schulz, 1976). Additionally, it enables the settlement of users within a place and its continuum of culture and time (Pallasmaa, 2005). Tuan suggests that architecture is a tool of comprehending reality when formal regulations and instructions are missing (2001). Architecture's task can be 'the creation of place' or the development of a meaningful places' system that give form and structure to the user's experience of the world (Gauldie, 1969; Norberg-Schulz, 1969; cited in Relph, 1976). The architect is the 'composer' of the physical setting, which is employed to receive its occupants' qualities, thus would reflect these qualities in its character (Gokce, 2009). An architectural language which addresses the features of "enclosure and exposure, verticality and horizontally, mass, volume, interior spaciousness, and light" to its users is the main influencer on senses and feelings of the occupants (Tuan, 2001; p. 116). When it achieves a good environmental image, architecture succeeds providing the user a sense of emotional security. Otherwise, it can cause emotional insecurity and fear (Norberg-Schulz, 1976).

Setting the user as the main dimension to measure direction, location, and distance, Tuan (2001) argues that the multisensory fact enables sensing places, and that senses reinforce each other to provide a complicated "emotion-charged" world for users. Additionally, the physical environment influences the sense of spaciousness and crowding. Even though it is more a matter of sense of space, users feel spaciousness and crowding by conflicting activities, being-observed feeling, and satisfaction of the environment. "The world feels spacious and friendly when it accommodates our desires, and cramped when it frustrates them" (Tuan, 2001; p. 65). This statement is closely related to Hall's (1966), "One can measure by tape the needed space and distance for a person to reach something, but we must apply a different set of standards those judge the individual's feeling of being cramped" (p.52). Hall, thus, is reminding about the continuous presence of the human factor in creating different environments and the importance of measuring the 'area' and the 'sense' of this environment to satisfy the user's needs. Experiencing the given environment is not only about how the users perceive it, but also what can be screened out (1966). This perception depends mainly on the user's intentions, expectations, and personal preference (Boerebach, 2012). However, the architecture today does not seem to take this factor as a priority in creating places anymore. The main character of nowadays environments is distinguished by monotony. Environments are isolated in the mere realm of vision due to losing their connection with the language and body of the users. Furthermore, they lack providing enclosure and density, resulting in a difficulty with orientation and loss of place (Norberg-Schulz, 1976; Pallasmaa, 2005). Hall comments upon this issue by stating the importance of the capability of proper orientation. "Such knowledge ultimately linked to survival and sanity. To be disoriented is to be psychotic. The difference between acting with reflex speed and having to stop and think in an emergency may mean the difference between life and death" (1966; p.105).

Places are considered satisfying if they allow control, creativity, opportunities for privacy, security, and serenity (Altman & M. Low, 1992). Hence, psychologist Canter (1988) calls for more attention regarding the physical settings' influence on psychological and behavioral processes and the importance of considering places from the users' perspective. He believes that the term "place" is technical, and Relph's notion of it is "romantic" (cited in Gustafson, 2001). Places are to create a sense of ownership, "be permissive about how they are used… and have variety and organic dynamism" (Convery et al., 2012; p. 122). The sense of self is widely related to the sense of place: the users' modalities and perceptions may be inhibited or encouraged to develop by the environment (Hall, 1966). This supports the claim that once a co-existence and enhancement occurs between environment, people, and their actions, a successful place will emerge (Gokce, 2009).

When explaining place and sense of place, geography is defined as "…to satisfy man's curiosity concerning the differences of the world from place to place that geography developed as a subject of popular interest" (cited in Relph, 1976; p. 5). The main aim of geography is investigating the place where someone is. The concepts of location, region, or landforms are subsequent (Relph, 1976). Geography is a mirror that reflects and reveals human nature and seeking order and meaning in human's experience with the world. Relph states that "to be human is to live in a world that is filled with significant places: to be human is to have and to know your place" (Relph, 1976; p. 1). Thus, according to Relph, sense of place is linked mainly to the sense of being human. Moreover, Agnew (1987) states two levels for the place: location and locale, where location refers to fixed coordinates on earth, and locale to the material settings such as the built or natural environment where social relations are conducted. Accordingly, the concept of sense of place is the interaction between emotional and subjective attachments to places (cited in Convery et al., 2012).

Sense of place would not be achieved without the complexity of the sensory system. Each sense (visual, auditory, smell, taste, tactile) and other perception systems, such as the vestibular, sense of vibration, sense of temperature and pain, and memory system has its unique part in this process. Humans perceive objects, backgrounds, places, scenes, landmarks, borders, geometries, shapes, and distances during their interaction with the environment. It is discussed that encoding information and making a mental representation of place occur in different parts of the brain. This process is accompanied by spatial attention and emotional stimulus (Lengen & Kistemann, 2012). In other words, a space is being analyzed, a character is distinguished, and a sense of place will emerge. Accordingly, acoustic cues, similar to other cues in the environment, can provide acoustic information about the nature of objects involved, the way they interact, and the changes in the geometric structures (McAdams & Drake, 2002). Thus, acoustic cues determine the overall experience and meaning of users within a space and influence their formed sense of place.

Despite different theories and opinions, sense of place is an integration of the environmental context with user's feelings and understanding of this given environment (Altman & M. Low, 1992). The place is a combination of physical and cultural elements. They are interpreted differently between groups or users, depending on their understanding, connection, and relationship with the place (Convery et al., 2012). Places are dynamic and are always in change (Vanclay et al., 2008). Despite its positive or negative change, a place to fit one purpose, in other words, static, is soon to be useless, and more likely to turn to an abstract space (Norberg-Schulz, 1976). Thus, the geographical size and boundaries are not to set a place and sense of place but rather the perceptions and personal experiences and values are to set it (Nanzer, 2004).

Giving the fact that humans are never without perception at any given second, and places are to create a positive or negative attitude towards them when experienced and perceived, sense of place is an absolute phenomenon. The integration of each element in the environment to create this sense is essential to determine users' ability of being emplaced in the environment. Thus, sound plays a significant role in this determination. Especially that sound has the capability of providing information about how exposed or safe the users are, the perception of size and volume of the space, and comprehending occurrences taking place within the environment (McAdams & Drake, 2002; Stocker, 2013). It is not an option to consider when a new environment is to be designed. Otherwise, the environments will evoke a sense of placelessness, alienation, and disconnectedness.

2.2.4 Place constructs

Place constructs are used to measure and understand the sense of place. However, most social-psychological research uses place attachment to measure sense of place. This is probably for its significance in explaining how people perceive places based on social and environmental changes (Quinn, Bousquet, & Guerbois, 2019). Thus, place attachment is discussed to have several sub-dimensions: place dependence, identity, and affect (Alonso-Vazquez, Packer, Fairley, & Hughes, 2019). The number of dimensions is not agreed upon, and new dimensions are continually emerging. Accordingly, several concepts are introduced as sub-dimensions of place attachment, such as place identity, place dependence, place meaning, place appropriation, place memory, place expectation, place satisfaction, and social bonding—to name only a few.

These sub-dimensions, alongside place attachment, are explained in this section. Furthermore, an emphasis is given to place attachment, place identity, and place dependence constructs. The constructs give an efficient understanding and empirical measurements of users' relationship with their experienced environments.

Place attachment

Place attachment is the emotional bond between users and their places (Boerebach, 2012). Its processes reflect the behavioral, emotional, and cognitive experiences users have in their socio-physical environments. Thus, place attachments are holistic, multifaceted, and include several levels of environmental scales (Altman & M. Low, 1992).

Place attachment has been the concept for research fields such as environmental psychology and social impact assessment. It is even believed that place attachment is the environmental psychologist's term for geographer's term of sense of place (Vanclay et al., 2008). However, place attachment is subsumed by several ideas such as topophilia, place identity, insideness, environmental embeddedness, community sentiment, and identity (Altman & M. Low, 1992).

Place attachment—or also might be known as place connectedness, connection to place, and place bounding—is the closest place construct to the concept of sense of place as a whole. It refers to the positive and/or negative feelings users have about their environment (Vanclay et al., 2008), and the messages and meaning those can be perceived according to the users' role, expectations, and motivations in a place (Najafi et al., 2011). The word 'attachment' refers to the effect of the place and the users, whereas the word 'place' is concerned with the environmental setting to which users are attached, affected, and affecting. Thus, this concept is essential for understanding and discovering the different ways of how users build meaningful relations with their places. Hence, place attachment is integral to self-definition and identity. The definition explains how attachments provide anchors in life, directing users for the proper attitude towards their environment (Altman & M. Low, 1992).

Place attachment exceeds the emotional bond and cognitive experience with environment. It includes cultural beliefs and practices those linking people to place through time (Cross, 2015). Therefore, time is essential for a place attachment. As Casey explains, space and time—or event, in other words—are place-provided coordinators. These coordinators enable users to apprehend spatial relations or temporal occurrences in the place. The spatial qualities and relations occur at a specific time (1996). Riley (1992) agrees with this suggestion by stating that attachment is the result of long-term emersion in a place and accepting this place's values (cited in Nanzer, 2004). On the other hand, Gustafson (2001; p.13) defines attachment as a phenomenon of continuity, and emphasizes the involvement of time dimension "…where places become connected to the life path of the individual through origin, length of residence, important events or life stages, or frequent visits" (cited in Nanzer, 2004). It is clear from this definition that every environment should provide special characters those are suitable for the to-be-taken action in there. Norberg-Schulz states that the satisfaction of place comes when users' different actions take place in a suitable environment (1976). This compatibility is essential to enable users to control the environment. Thus, they enhance their 'fit' with the environment (Altman & M. Low, 1992). The total result of this long-term emersion with place, controlling it, and feeling 'fit' within it creates a strong place attachment. Strong place attachment leads to comfort, satisfaction, a desire and an eagerness to maintain closeness, and care (Boerebach, 2012).

Hereby, place commitment emerges. It refers to the extent users are willing to contribute to their environment. Furthermore, users will have high levels of belongingness, rootedness, or community connectedness. All these terms explain the strong ties users attached to their local place and the feeling of belonging to the environment (Vanclay et al., 2008). Relph suggests that attachment creates roots for the place's users and a familiarity with the place. This familiarity is not just about knowing the place's details, but includes a sense of care and concern for that place (Relph, 1976). Place commitment—or rootedness, as Tuan (1980) calls it—is an unselfconscious state of comfort and wellbeing in a place. It is a state when a person does not feel the flow of time or the world beyond his/her immediate surroundings (cited in Arefi, 1999). Relph adds that there is a necessity for roots in order to have order, liberty, responsibility, equality, and security in place. "…and indeed to have roots in a place is perhaps a necessary precondition for the other needs of the soul" (p. 38). Furthermore, there is not only an interaction between place and user, but also a tension. Commitment to place involves accepting the restrictions the place imposes and the 'misery' it may offer due to its tasks, hardship, meanness, and preoccupation with necessities (Relph, 1976).

Being a construct of place, the place attachment can be mainly influenced by the physical features of the environment. It is well known now that the lived body integrates with its immediate environment (Casey, 1996). The lived body has a transactional relation with the place: the user takes something, positive or negative, from the place, and reacts accordingly towards it (Cross, 2015). Similarly, the place takes its qualities from its occupants, and reflecting them through different occurring events (Casey, 1996). Tuan states that users tend to organize space due to their biological needs and social relations (2001). Due to this intense relation between user and place, Norberg-Schulz set the term ‘dwelling’ to indicate the total user-place relationship. Accordingly, the dwelling’s features to satisfy the user’s need to sense the place and have a proper place attachment were suggested.

Norberg-Schulz emphasizes the importance of creating places where users experience themselves as an integral part of the environment. Otherwise, missing this experience and feeling can lead to human alienation and environmental disruption. Thus, Norberg-Schulz suggests creating an environment with spatial structure to facilitate orientation and having concrete objects of identification (Norberg-Schulz, 1976). Likewise, by explaining human perceptual system, Haverkamp is noting the importance that ‘dwelling’ must provide clear selection and hierarchical organization of objects and characters (2013). If this is not taken into consideration, poor imageability will occur, leading to emotional insecurity and fear (Norberg-Schulz, 1976). Yet, the modernity and internationalization of the architecture nowadays produce ‘placelessness’: lacking the sense of place and inauthentic attachment to place. The users may experience existential outsideness. This is a self-conscious and reflective uninvolvement, alienation from people, alienation from places, a sense of unreality of the world, and of not belonging (Relph, 1976). This displacement and alienation expresses itself in person’s perspective and feelings about the community (Altman & M. Low, 1992), resulting in a possible negative attitude toward the environment and its community. Accordingly, the new environments do not provide density and enclosure, leading to scattered units, unclear spatial setting, loss of place, and a difficulty of orientation (Norberg-Schulz, 1976). However, orientation is essential for a true feeling of sanity and survival in environments. Hall states that to be disoriented is to be psychotic (1966). Furthermore, there is a crucial interaction between body, place, and motion. Place encouragement of motion is a part of its power to attach people to it (Casey, 1996). However, Norberg-Schulz states that the surroundings may offer protection, in some other places may menace, and in others may offer the feeling at the center of a well-defined world (1976). There is no rule for a perfect place-creating process. What is desirable is flexibility within design and function that creates variety of spaces and involvement possibilities as the occasion and mood demand (Hall, 1966).

Places may offer warmth and sense of belonging, just as they can offer tension and alienation (Manzo, 2005). As a result, place attachment reflects stability, familiarity, and security. It creates a sense of self connected with the environment (Altman & M. Low, 1992). However, it is argued that "if place forms the circumference of our experience, we are attached to it for better or for worse. Therefore, there is a shadow side…composed of frustrating or frightening places" (Chawla, 1992; p.66; cited in Manzo, 2005). From this statement, it is concluded that place attachment, such is sense of place, is to occur in any given environment. However, the human perceptual system's ability can manipulate this sense. There is no perfect environment where positive place attachment is definitely to take place. Especially that sense of place and place attachment are essentially subjective phenomena. Some of the requirements of place attachment's constructs existence can achieve the attachment. For example, if there is compatibility between the expectations of a user for a specific task and the given environment for this task, the attachment may be achieved. Hence, the commitment and responsibility towards this place will grow and accordingly the environment will develop.

Place identity

Place identity is about the place that provides its individuality and uniqueness from other places, and being recognized as a separate entity to its users (Lynch, 1960; cited in Relph, 1976). It is distinguished from place attachment by focusing on self-identity and linking it to purpose and meaning—it is not about wellbeing and security. Thus, place identity is cognition, beliefs, perceptions, and thoughts of users' reflection in a spatial setting (Boerebach, 2012). It is simply to become friends with the given environment (Norberg-Schulz, 1976).

Therefore, place identity is a component of self-identity. It contains memory, ideas, feelings, attitudes, preferences, and conceptions, which relate to the physical settings of a desired experience of every user (Proshansky, Fabian, & Kaminoff, 1983; cited in Altman & Low, 1992). "These processes enable individuals to distinguish between themselves, others and the physical environment, and thus develop a self-concept" (Lalli, 1992; p. 287; cited in Nanzer, 2004) Accordingly, a strong place identity gives meaning to life, increases life confidence, and enhances the sense of belonging to the group in the same place (Nielsen-Pincus et al, 2010; cited in Boerebach, 2012). Hence, it develops once users locate themselves within the environmental context throughout daily routines or exceptional circumstances (Pretty, Chipuer, & Bramston, 2003).

Due to the strong link between self-identity place identity, identification is argued to be the basis of the user's sense of belonging (Norberg-Schulz, 1976). Once enhanced by art and architecture, self-identity allows users to engage with their environment, and to be closer to achieve their dreams, desires, and aims (Pallasmaa, 2005). Norberg-Schulz states that users experience a space and be exposed to certain environmental characters once they dwell. Thus, orientation and identification are involved in this process. The user "has to know where he is, and has to identify himself with the environment; he has to know how he is a certain place" (1976; p. 19). Similarly, the user must be able to answer 'who am I?' by answering 'where am I?' (Cuba & Hummon, 1993; cited in Pretty, Chipuer, & Bramston, 2003). To Norberg-Schulz, this fact is already noticed clearly in the daily usage of language. "When a person wants to tell who he is, it is in fact usual to say: I am a New Yorker. This means something much more concrete than to say: I am an architect" (1976; p. 21). Hereby, human identity presupposes the place identity, and it generally depends on experiencing a characteristic environment (Norberg-Schulz, 1976). That is agreeable with Relph's argument that the physical setting, the activities, and the meanings of place are the three fundamental elements for place identity (1976). However, modern environments are lacking characteristics. The attention is concentrated on the function of orientation, and identification is left for chance. Thus, 'dwelling' has been alienated (Norberg-Schulz, 1976).

As a result, it can be concluded that people, identities, environments, and places are mutually constructed. Places are linked to users' sources of meaning and experience (Convery, Corsane, & Davis, 2012). In this way, places can provide self-development opportunities, and influence users' self-esteem, self-efficacy, and distinctiveness (Manzo, 2005). Hence, the user's identity will be reflected in the place and vice versa; each entity will speak for the other. The judgment of a place's character is more of a judgment of the user in that very place. That is due to the place's ability providing its users the proper connection and opportunities to develop themselves and develop the place. However, the place may fail to evoke the true identity of its users. This may lead to carelessness and rejection towards the place, and feeling of the place's insignificancy from the user.

Place dependence

Place dependence is the perceived advantage of a spatial setting over other settings when it achieves the aims, needs, and expectations of a user (Boerebach, 2012). Thus, users become strongly associated with and dependent on this particular place (Nanzer, 2004). From this definition, it is apparent that place dependence is the sum of two components: the quality of the place in term of satisfying goals, expectations, and needs of users and hence their behaviors; and how it is compared to other alternative places (Pretty, Chipuer, & Bramston, 2003). Hence, place dependence occurs when users perceive that setting as the proper provider for their needs and that it cannot be substituted by another setting (Nanzer, 2004; Tsaur, Liang, & Weng, 2014).

Place dependence, known as functional attachment, is more of a behavioral component of the sense of place. It is perceived by the functional characteristics of the space (Boerebach, 2012; Convery et al., 2012). It is considered the component that orients goals and behaviors of users' sense of place (Pretty et al., 2003). Thus, the interaction between the physical setting and users' behaviors create a relationship between place and people (Boerebach, 2012). Accordingly, familiarity and place awareness of users towards a specific place occur (Vanclay, Higgins, & Blackshaw, 2008).

Being a place construct, place dependence is more likely to be an advanced stage of sense of place for users. When a place is experienced for enough time, users perceive its functionality and suitability for supporting the actions and activities they need to do in that place. The desired responsibility to be taken towards a place from its users can probably be observed when there is a place dependence relationship.

Place meaning

Place meaning is the functional, motivational, and evaluative information and impressions linked to a place that shape users' readiness to observe changes in their environments (Quinn et al., 2019; Stokols & Shumaker, 1981). It answers what elements construct the environment rather than how users are attached to it. Thus, there is an interaction between the physical properties of a place and the emotional and social ties associated with it (Sebastien, 2020). Accordingly, the stronger the attachment to a place, the stronger the meaning attached to the place, and thus the stronger the willingness of users to accept and adapt the changes those may occur in their places.

Place appropriation

Place appropriation explains users' attachment to the physical environment that leads to the sense of place ownership, active use of the place, and place meaning. It is one of the methods by which users change the space to place (Rioux, Scrima, & Werner, 2017). Fieldman and Stall (1994) define this construct as, "… a term that has been used in environment and behavior research to describe individuals' and groups' creation, choice, possession, modification, enhancement of, care for, or simply intentional use of space to make it one's own… [it] is conceptualized as an interactive process through which individuals purposefully transform the physical environment into a meaningful place while in turn transforming themselves." (p.172; cited in (Rioux et al., 2017). Thus, there is some overlapping between place appropriation, identity, and dependence. The three constructs deal with the physical setting of the environment rather than an emotional attachment to it. They reflect users' identity and their sense of responsibility and desire to change and develop the place. However, place appropriation can result from a longer experience with place than of place identity and dependence. The claiming of ownership and taking control of the place likely requires a longer emersion within a place.

Place memory

Place memory denotes the strength of memories and special experiences users associated with a place. Thus, the place becomes unique and of a special meaning and value (Chen, Dwyer, & Firth, 2014). This construct has the importance of making the place more than a stimulus-response phenomenon. Furthermore, memorized places are more meaningful, powerful, and important than concretely-experienced places (Convery et al., 2012).

Place expectation

Place expectation is defined as the expectations of future experiences to occur in a place (Chen et al., 2014). The physical details of the place are more likely to influence these expectations. Thus, this construct is linked to the characteristics of the place (Milligan, 1998; cited in Chen et al., 2014). This construct, as well, requires a long experience and identification with the place in order to form such expectations.

Place satisfaction

Place satisfaction is defined as a multidimensional judgment of the perceived quality of a setting and the spatial setting as an object, based on a set of beliefs that may influence reactions towards the place (Sebastien, 2020; Stedman, 2002). Thus, it depends on the cognitive experience with the place, and sums a set of beliefs, evaluations, and judgments about the place, including place expectations (Milligan, 1998; Chen et al., 2014; Insch & Florek, 2008; cited in (Sebastien, 2020). Place satisfaction seems a stage between the development of place attachment towards place identity through experiencing the place for a sufficient time: more or less satisfaction with a place that emerges from the cognitive experience and the satisfied beliefs and desires can result a self-identity and reflection in the spatial setting.

Social bonding

Social bonding refers to the social relationships users have with each other, users have with the community, and users have with the culture (Altman & M. Low, 1992). It consists of two levels: (1) the strength connection users have with the people and places, and (2) users sense of belonging to places (Chen et al., 2014). Thus, a solid connection to the place emerges due to the shared history, interest, or concerns (Song & Soopramanien, 2019). As strong social bonding creates strong emotional ties to place (Chen et al., 2014), it can be argued that social bonding is the social-cultural place attachment construct to form the sense of place.

2.2.5 Spirit of place or genius loci

Genius loci is a Latin expression indicates the dwelling god in ancient Rome (Vecco, 2019). The concept of genius loci may date back before the Roman time. This belief is due to the ancient civilizations' rituals with choosing a new establishment site, which is treated as a decision of high importance since the dawn of civilization (Samalavicius, 2015). However, the original Roman meaning refers to the sacredness of a place devoted to an idol (Loukaki, 1997). Thus, the genius loci were concerned with the space where god was situated. It could be a space among statues, icons, amulets, and ancient burners. In addition, it could be in a larger space-range beyond the dwelling, such as bordering temples, churches, and pagodas (Vecco, 2019).

According to Norberg-Schulz, genius loci is a concept believes that every being has its own guardian spirit. This spirit gives life, character, and essence to people and places. Furthermore, it refers to what the 'being' is or what it wants to be (1976). In addition, it denotes the integration of characteristics that give some locations special personality and identity (Cross, 2015). Thus, genius loci seems a more appropriate term to identify the qualities, uniqueness, and specialties of a certain place (Vanclay et al., 2008). It is used to emphasize people's experience, using, and understanding of places, leading to understanding place attachment, place identity, and place dependence (Convery et al., 2012). Due to these definitions, genius loci, or spirit of place, is defined as "…the tangible (buildings, sites, landscapes, routes, objects) and the intangible elements (memories, narratives, written documents, rituals, festivals, traditional knowledge, values, textures, colors, odors, etc.), that is to say the physical and the spiritual elements that give meaning, value, emotion and mystery to place" (Campolo, 2014; p. 468).

It can be concluded that genius loci represents the sense people have of a place (Larkham, 2003). It has been recognized for ages as "the concrete reality man has to face and come to terms with in his daily life" (Norberg-Schulz, 1980, p.5; cited in Variation & Nordostafrikas, 1980). The genius loci makes each place unique by combining cultural attributes, different forms, and meanings to the environment (Vecco, 2019). Hereby, it is made up of topography, geography, cosmology, built environment, social activities, psychology, history, and emotional engagement with the place (Convery et al., 2012; Relph, 1976). This integration of elements to construct the place and its spirit makes the place a qualitative, total phenomenon. Thus, the human-made genius loci should be applied according to space and character—in terms of organization and articulation. Any reduction of these properties will make the place loses its concrete nature out of sight. Hereby, architecture's duty is to concretize genius loci in making it visible (Norberg-Schulz, 1976). Hence, the spirit of the place does not depend merely on physical structures— objects and items within the human-made place may encourage the user attempting for an attachment to and connection with the place (Christou, Farmaki, Saveriades, & Spanou, 2019).

Being an integral part of existence, the place can influence every action taken by a user within it (Casey, 1996; Norberg-Schulz, 1976). It cannot be ignored or freed from, despite the modern life and technology, which create a new kind of dependence and identity. The result of this technology created a chaos that urged the human being to search for the place's entity and importance once again (Norberg-Schulz, 1976). This need for places may be because that places are as alive, dynamic, and full of meaning to people as people are to places. Accordingly, Ian Narin (1965) states, "sense of place is not a fine art extra, it is something we cannot afford to do without" (p.6; cited in Relph, 1976).

It has been discussed earlier that sense of place is not to be weakened; instead, it would turn familiar and casual. The reason is that the spirit of the place is not to change or to get lost (Norberg-Schulz, 1976; Relph, 1976). Knowing that they have a spirit, places are to be experienced and explored stage by stage, and to evolve and create new meanings and possibilities by time just as any other spirited being. Thus, it is essential to consider the place's needs and demands while designing a new establishment to achieve a proper attachment between the user and the place where each *being's* spirit is evoked accordingly.

2.2.6 Measuring sense of place

Being a subjective phenomenon that has deep roots in phenomenology, sense of place is almost immeasurable. It is an abstract, intangible, complex phenomenon that it cannot be observed or lend itself to psychometric measurements easily (Boerebach, 2012; Manzo, 2005; Shamai & Ilatov, 2005). Even some authors would declare that "it is quite useless to try measuring it" (Lewis, 1979; p.40; cited in Shamai & Ilatov, 2005). However, measuring the sense of place is not less important than the phenomenon itself. It defines the relation people have with their surroundings and used environments. Most of the times, sense of place seems to be linked more to sense of home at the large and small scale. Having a way to measuring it, sense of place can be understood in different places other than *home*.

Several sense of place definitions are introduced to conduct a proper scale for measuring it. For instance, Jorgensen and Stedman (2006) describe sense of place as a multidimensional construct built up from beliefs, emotions, and behavioral commitments. Kaltenbom (1998) states that sense of place is a complex affective bond of variable intensity, and it can be ranked along a continuum from weak to strong. Hay (1998) defines it through social surveys and ethnography, adding the importance of time and duration of stay to sense a place (cited in Convery et al., 2012).

All of the definitions must admit the positive and negative sense of place. one one side, there is belonging to place and identity within it; and on the other side, there is alienation, homelessness, and not-belonging to place (Relph, 1976). Thus, sensing the place can be measured by conducting questionnaires using the Likert-type response scales (Boerebach, 2012). Accordingly, Piveteau (1969) distinguishes between three levels of sensing a place (no, yes-low, and yes-high). Shamai and Kellerman (1985) use a four-level scale: (0) not having a sense of place, (1) knowledge of the place, (2) belonging to a place, (3) attachment to a place. Shamai developed this scale to become of seven levels: (0) not having any sense of place, (1) knowledge of being located in a place, (2) belonging to a place, (3) attachment to a place, (4) identifying with the goals of the place, (5) involvement in a place, (6) sacrifice for a place (Shamai & Ilatov, 2005).

Shamai and Ilatov emphasized the importance of both negative and positive experiences in a place. Accordingly, the *positivistic* scales for measuring sense of place are constructed by four attributes:

1- Polarity, in which the ‘poles’ are the highest positive score of sense of place and the lowest negative score. However, bi-polar studies apply negative and positive attitudes towards the sense of place. The unipolar studies include the positive attitudes alone. Whereas semi-polar studies range from not having sense of place to the positive pole (Shamai & Ilatov, 2005)

2- Directness, in which the direct questions’ technique assumes that the place exists in the respondent’s mind. Whereas indirect questions’ technique is complicated and open to different interpretations (Shami & Ilatov, 2005).

3- Components, which can be a multi-component scale that is based on several questions. These questions eventually compose one scale. In addition, it can be a uni-component scale of one question. It avoids the question of selecting the attributes that compose the sense of place (Shamai & Ilatov, 2005).

4- Dimension, in which questions are clustered into a scale, which sometimes can be divided into sub-scales. A uni-dimensional scale uses reliability measures, factors analyses, and correlations to construct a single scale. On the other hand, the multidimensional scale is based on sub scales of different but related attributes of sense of place (Shamai & Ilatov, 2005).

Accordingly, several studies use surveys and questionnaires to measure the sense of place using one or several previously mentioned attributes. For example, in a study to measure the intensity of attachment of Michigan’s residents toward their city, the sense of place is measured through a scale of several questions, each indicates a specific construct of the place (as shown in Table 2.1).

Table 2.1. Attachment and sense of place of Michigan's residents (Nanzer, 2004)

Place construct	Description
Place attachment	1. I am happy living in Michigan 2. I would like to live in Michigan for a long time 3. As far as I am concerned there are better places than Michigan 4. I like living close to the Great lake
Place identity	1. I feel connected to the Great Lakes and Michigan 2. Living in Michigan has helped make me what I am 3. Michigan and the Great Lakes mean very little to me. 4. The Great lakes are important to me
Place dependence	1. Michigan provides many opportunities to engage in my favorite activities 2. Michigan is a good place for doing the things I enjoy most 3.For water-related activities no other place can compare to the Great Lakes state 4. I believe some other state would provide more opportunities to do the things I like to do

Additionally, Nielsen-Pincus et al. (2010) uses the same place constructs to assess differences in the relation between the place and the new, long-term, and absentee residents. A 7-point Likert-type scale was used, ranging from ‘very strongly agree’ to ‘very strongly disagree’ (as shown in Table 2.2).

Table 2.2. Nielsen-Pincues’ questionnaire to measure the sense of place (cited in Boerebach, 2012)

Place construct	Question “How important to you is this country and its landscape?”
Place attachment	1. It is my favorite place to be 2. I feel happiest when I am here 3. I really miss it when I am away
Place identity	1. I do not identify with this landscape very well 2. Everything in this landscape is a reflection of me 3. This landscape says very little of who I am 4. I feel I can really be myself when I am here
Place dependence	1. As far as I am concerned there are better places to be 2. It is the best place for me to do the things I enjoy 3. I would enjoy the outdoor activities I do here just as well in another place

Despite the apparent attempts to measure the sense of place and its positive and negative attributes, a number of authors criticize this approach and refuse the necessity for measuring the sense of place. For example, Graham et al (2009) argues that people should be allowed to define place themselves, which is a more accurate definition to understand the actual engagement with places. It is believed that this subjective definition should replace the pre-determined sense of place through scales and indicators (cited in Convery, Corsane & Davis, 2012). However, both types of ‘measurements’ are necessary to understand the sense of place completely. The subjective, spontaneous definition of sense of place is essential to apply logical, scientific, and philosophical application in creating a proper sense of place through design—they are to complete each other.

2.2.7 Sense of place by sound

Sense of place is agreed to be a multisensory phenomenon. Each sense of the human being enhances, corrects, and assists the other for a better perception of a given environment. This enhancement and correction are of a great utility, since each sense is good at different functions and operates in different ways (Bregman, 1994). Thus, new perceptual qualities will emerge where no sense individually would generate by itself (Haverkamp, 2013). The main duty of perception is to take the sensory input and derive a good representation of reality from it (Bregman, 1994). However, this is the duty of architecture to address all the senses and fuse people’s image of self through experiencing the world (Pallasmaa, 2005).

According to Pallasmaa, the multisensory approach is not applied to the modern architecture. On the contrary, there is an evident dominance of the eye and a suppression of other senses. As a result, detachment, isolation, and exteriority occur when environments are experienced (1994). However, sense of place seems to owe visual and auditory senses and other modalities (Gokce, 2009). Bregman states that sound serves to supplement vision by giving information about the nature of events and defining the ‘energetic’ situation (1994). Vision is to collect information from the surroundings, while sound is to achieve the experience of where the user is within these surroundings (Stocker, 2013). Thus, the interaction between sound and vision perception gives the users of an environment a sense of involvement and comfort— such as, for example, the visibility of sound sources modifies the perception of environmental sounds (Haverkamp, 2013; Kang, 2007).

Visual and aural spaces are different. Visual information is less ambiguous and more focused compared to auditory (Hall, 1966). Bregman states that the auditory world would be like the visual one if all objects were highly transparent, if they start by their light, and reflect the light of the nearby objects. This would be a complicated world for eyes to deal with (1994). Pallasmaa gives further differences between vision and sound, stating that sight isolates, whereas sound incorporates; sight and vision are directional, whereas sound is omni-directional; sight implies exteriority, but sound creates an experience of interiority. “I regard an object, but sound approaches me; the eye reaches, but the ear receives. Buildings do not react to our gaze, but they do return our sounds back to our ears” (2005; p. 49). As for perceiving size and volume, vision decodes size as length, width, and height. It observes distance by the way objects obscure each other or change their relative size. However, hearing decodes size as a volume because sound fills air as a fluid. Hence, volumes are heard, unlike the seen-size. The volume of large spaces is perceived by its long reverberation time, while the volume of small spaces is sensed due to the sharp frequency resonance. Additionally, the volume or the area remains primary to hearing, and boundaries are secondary. For vision, the opposite is true. Moreover, hearing acoustic objects and surfaces enhance vision, and when vision is disabled, hearing does replace it. That is why the integration of both senses creates reinforcement for each other to properly experience the size, volume, and linear extent. Thus, visualizing objects and spatial geometry of an environment is developed: “we can see with our ears” (Blesse & Salter, 2007; p.2).

The auditory system can build an image of the world through its sensitivity to sound (Bregman, 1994). Generally speaking, vision allows a detailed scanning of the environment, whereas hearing provides a more comprehensive image of the entire environment in all directions at the same time (Truax, 1984). This is because sound is not limited or narrowed to a frontal cone as vision is. Vision can receive what is in front of the eyes, while hearing can sense and receive sounds from all directions at once (Gokce, 2009). Stocker gives a similar statement by claiming that hearing is a survival tool, being a perception that allows a sense of place and space hidden from the eyes, out of reach from touch, and downwind from the sense of smell and taste. In other words, hearing is the perception where size, shape, density, and sense of placement occur within (2013). It can be possible that acoustic space gives more possibilities to users to sense a place than vision does. Especially that listening requires a sharing of temporal space; acoustic space is where time and space fused as they are articulated by sound. This is a common experience defined by the sense of place (Vanclay et al., 2008).

According to Tuan, sound can enhance the sense of place due to its ability to enlarge the spatial awareness by including areas behind the head. Sound dramatizes spatial experience; if a space is soundless, it will be sensed as calm and lifeless no matter how visually alive it is. Furthermore, sound provides a sense of distance by projecting voices within a space. Simply, sounds enrich the human feeling of space and place (2001). Users must make an active gesture to be heard, and the acoustic reply is necessary for orientation and sense of relation to the context and its users (Truax, 1984). Thus, sound and hearing structures and articulates the experience of the space and understanding it (Pallasmaa, 2005). This is agreeable with the fact that each acoustic space is different from another. Physically similar sounds are to be understood and sensed according to their contexts and several aesthetic effects, hence they would keep distinguished (Schafer, 1977; Vanclay et al., 2008). Sound is not only perceived through ears, but also through bodies (Stocker, 2013). Additionally, sound affects users differently and causes accordingly different behaviors and reactions (Schafer, 1977). Hence, sense of emplacement is better explained through sound. This statement suggests that auditory perception is not voluntary: users are unconsciously affected by the sound from surroundings; thus, mediating placement is achieved consciously or unconsciously (Stocker, 2013).

The complex acoustic events in everyday environments provide acoustic information about the nature of objects involved, how they interacting, and changes in geometric structures (McAdams & Drake, 2002). Thus, aural architecture can influence users' moods and emotions within a place. This influence can result from how the space modifies sounds: amplifying background noise to an uncomfortable level, creating enveloping reverberation, distorting aural localization cues, or blending a sequence of musical notes (Blesse & Salter, 2007). The reason is that every space is made up of absorbent or redirecting materials. For some spaces, reflections are problems to be removed, and in others, they are purposely created to enhance the experience (Ballou, 2008).

Every space “has its characteristic sound of intimacy or monumentality, invitation or rejection, hospitality or hostility. A space is understood and appreciated through its echo as much as through its visual shape, but the acoustic percept usually remains as an unconscious background experience” (Pallasmaa, 2005; p.50). This statement affirms the aesthetic perception of an environment is affected by sound. As visual objects can make a space aesthetically pleasing to the eyes, there are aural objects that can make the space aesthetically pleasing to the ears as well. These objects give a space a unique identity. Otherwise, each similar space in size and shape would sound the same and would be aurally indistinguishable (Blesse & Salter, 2007).

Obviously, every sound carries special qualities, meanings, and information that are not possible with seen mediums. These qualities are shaped by the acoustic space of the occurrence and the background soundscape (Vanclay et al., 2008). Due to these qualities, sound bonds people to the environment and its community, creating auditory signatures imprinted into the user’s psyche. Since being imprinted and forth, these auditory signatures are to become sounds taken for granted, confirm a daily experience, and likely to be motivating. Thus, any new sound within this context will be easily distinguished. As a result, a sense of familiarity and belonging to this environment will be constructed (Stocker, 2013).

Sounds of an environment are to emplace users within the space, to provide a feeling of how exposed or safe they might be, and to establish a position of dominance or deference in the spatial setting (Stocker, 2013). In other words, sound illuminates the acoustic space to make it aurally perceptible (Blesse & Salter, 2007). A look at the effects of an anechoic chamber on users can explain the importance of sound ‘illumination’. The combination of sound absorption and isolation in this chamber reduces the background sound to a non-masking level of the listener’s beating heart and flowing blood. Thus, organs’ sounds become a part of the acoustic space of the listener. In addition, the absence of reflective surfaces makes the sounds experienced as strange, remote, and lifeless. Listeners feel uneasy and anxious due to the disorienting sensation of the chamber’s acoustics. Hence, a sense of spacelessness occurs. This example shows that the absence of nearby surfaces to reflect sounds can create a sense of fear in some users who are not likely to experience an open space. In an open field, the absence of enclosure is heard (Blesse & Salter, 2007). On the other extreme is the reverberation chamber. Too little absorption makes the room feels uncomfortably live. The chamber sounds and feels hard and cold. These two examples represent the most acoustically hostile spaces (Ballou, 2008).

The satisfaction of an environment and its acoustic space are interrelated. Hall mentions an example of a conference room where the inadequacy of its chairman was complained. Studying this issue revealed that the acoustic of this space was the main reason behind this claim: the room was next to a busy street whose noise was intensified by reverberation from the rugless floor and hard-surfaced walls. When the auditory interference was reduced, complaints about chairman ceased (1966). This finding is similar to a study conducted by Southworth (1969) which found that areas with pleasant sounds were recognized as more informative, unique, and interactive compared to the unpleasant ones. Furthermore, despite the attention to visual cues which reduced the perception of sound, the presence of sound enhanced the sense of involvement in the environment (cited in Gokce, 2009). Similarly, a study by Gokce demonstrated that sounds influence characteristics of place experience physically and emotionally. The influence of sound seemed to manipulate and alter other senses' perception by feeling physically colder, windier, or sunnier than it was. Moreover, sound influenced attention, behavior, and movement within the environment. When visual cues were strongly present in the environment, sounds were weak for orientation. However, when the visual environment lacked some orienting characters, sound was the provider for a proper orientation. Additionally, the perception of human sounds was mainly related to the social construct of the environment. For example, when noises of people were missing from the augmented soundscape used in the study, and with the presence of actual people, the participants felt a bodily and social isolation from the place (2009).

When a place or an environment is perceived for a second time, a particular part of this environment will be recognized (Lengen & Kistemann, 2012). Its sound is likely to be one of the most distinguishable features to be recalled. Based on this recognition, and due to the multisensory fact of perceiving and experiencing environments, the undesired features can be ignored and masked out to achieve an emplacement within the place.

However, if the sound feature was inappropriate within the given environment, ignoring or enhancing it may be difficult. Any alien sound in a space can lead to the sense of disconnectedness with the experienced environment, a lacked ability of orientation, and possibly a mistaken evaluation of other objects within the environment—an observed influence on other senses. This is due to sound's importance in identifying the space in terms of enclosure, density, and volume, and due to the ability to scan it 360 degrees unlike the other senses.

2.2.8 Place constructs and room acoustics

After reviewing the literature, it was found that place attachment, place identity, and place dependence are efficient for understanding and measuring users' relation with the place. They denote this relation from an emotional, cognitive, and functional level. Thus, these constructs are chosen to find the corresponding descriptors and those related to objective room acoustics parameters.

Place attachment and room acoustics

Place attachment refers to the emotional experience users have in the place. Emotions result from an integrated perception of external stimuli with the perception of body reactions (Haverkamp, 2013). They are affected by different physical, social, and task environment factors; and in turn, they affect and get affected by the user's actions (Kuller, 1991).

Being a physical aspect, acoustics can play an essential role in influencing emotions. Indicators, such as reflection, result in the pleasantness of the space's atmosphere. Thus, the place can be perceived as inviting, friendly, or simply the opposite. Furthermore, the feeling of embracement within the space and being welcomed by sound resulted from diffusion can influence emotions toward the place. Feelings are the sensation stimulated by the emotions in the first place (Haverkamp, 2013). Room acoustics can influence annoyance and its degree. This annoyance may result from fear caused by space's physical attributes—fear is one of the four cores of emotions set by Paul Ekman (1999). The other cores are anger, sadness, and enjoyment (cited in: Haverkamp, 2013; Kang, 2007).

Knowing that feelings are stimulated by emotions, positive and negative feelings—such as the sense of alienation and displacement— those which create a place attachment are equally influenced by the room acoustics. Thus, the satisfaction of the place will emerge. Satisfaction is the outcome of attributes that are considered important factors in space by a user. This outcome reflects the valued end state or purpose of the place. It is assumed to include other perspectives such as safety, maintenance, or a place's quality (Garling & Evans, 1991b). Accordingly, place attachment's security outcomes (Altman & M. Low, 1992), satisfaction, and closeness (Boerebach, 2012) can be influenced by the previously mentioned acoustic indicators.

Table 2.3. Place attachment-acoustic indicators correlation (Al-bayyar & Kitapci, 2020)

Acoustic indicators	**Acoustic descriptors**	**Place attachment descriptors**	**Place attachment indicators**
Reverberation time	Pleasant/ unpleasant space (Blesse & Salter, 2007) Responsive/unresponsive space (Blesse & Salter, 2007) Inviting/uninviting space (Blesse & Salter, 2007) Friendly/hostile space (Ballou, 2008)	Emotional experience (Altman & M. Low, 1992; Boerebach, 2012) Positive/negative feelings (Vanclay et al., 2008) Results security (Altman & M. Low, 1992) Results satisfaction/closeness (Boerebach, 2012)	Emotions
	Information about spatial relations (Truax, 1984) Clear/distorted sense of space (Truax, 1984)	Results clear spatial setting/orientation (Norberg-Schulz, 1976) Behavioral experience (Altman & M. Low, 1992; Boerebach, 2012)	Orientation/clear spatial relation
Diffusion	Welcoming amplifying (Blesse & Salter, 2007) Users' embracement within space (Egan, 2007)	Emotional experience (Altman & M. Low, 1992; Boerebach, 2012) Positive/negative feelings (Vanclay et al., 2008) Results security (Altman & M. Low, 1992) Results satisfaction/closeness (Boerebach, 2012)	Emotions
Diffraction	Tonal distortion/alien tone (Egan, 2007)	Emotional experience (Altman & M. Low, 1992; Boerebach, 2012) Positive/negative feelings (Vanclay et al., 2008) Results security (Altman & M. Low, 1992) Results satisfaction/closeness (Boerebach, 2012)	Emotions
Sound intensity	Comfort/discomfort (Egan, 2007) Satisfaction/dissatisfaction (Long, 2006)	Emotional experience (Altman & M. Low, 1992; Boerebach, 2012) Positive/negative feelings (Vanclay et al., 2008) Results security (Altman & M. Low, 1992) Results satisfaction/closeness (Boerebach, 2012)	Emotions

Table 2.4. Place attachment-acoustic indicators common descriptors

Place attachment indicators	Acoustics indicators	Common descriptors
Emotions	Sound intensity	Comfort/discomfort Satisfaction/dissatisfaction
	RT	Feelings about the space/place
Orientation	RT	Information about spatial setting

Place attachment results from a clear spatial setting and the proper meaning of orientation within the place (Norberg-Schulz, 1976). This critical outcome is obtained by clearly identified occurrences with stability in the temporal domain. They have a set of characteristics of identity, location, magnitude, and temporal existence. Thus, these occurrences have unique physical characteristics and existence within the built environment (Garling & Evans, 1991b). Accordingly, the acoustic characteristics of these occurrences can render the spatial setting clear and oriented. The reflection indicator plays this important role clarifying spatial relations within the space due to the reflective and absorptive surfaces. This feature results a clear or distorted sense of space as well (Truax, 1984). Therefore, user's thinking and behaviors can be influenced due to this spatial comprehending (Kuller, 1991). Table 2.3 presents the correlation between place attachment and acoustics indicators. Table 2.4 presents the common descriptors between place attachment indicators and acoustic indicators: RT and sound intensity.

Place identity and room acoustics

Place identity reflects users' cognition in places (Boerebach, 2012). The cognition of the place is determined by how the spatial properties of the space are organized. Similar to place attachment, the environment's physical attributes can influence aesthetic, functional, and social dimensions of the built environment; thus, affecting the spatial and social behavior of users within the space and accuracy of cognitive representations of the spatial information in the space (Garling & Evans, 1991a). The cognitive evaluation of places is usually determined subjectively by judging which attributes of the environment should be present wherein space, and by deciding the suitability of the place for its designed category (Garling & Evans, 1991b). Accordingly, the listening and acoustic performance of those affected by room reflection and diffusion can create a different subjective determination of the space's suitability for a specific function. Furthermore, the reverberation from the enclosure's reflection which creates an impression of the enclosure's acoustic authority (Schafer, 1977) is a possible to-be-judged attribute regarding its existence in the space—similar to the tonal distortion which is resulted from sound diffraction, and the perceived loudness within spaces.

Experiencing a characteristic environment results in place identity (Norberg-Schulz, 1976). Reflections within the space can create a characteristic environment through resulting in an interactive responsive friendly space, or an unresponsive hostile space—depending on the degree of reflection and absorption in the space (Ballou, 2008; Blesse & Salter, 2007; Egan, 2007). Similarly, the welcoming amplifying sound that is created by sound diffusion can create a characteristic place that may influence the evaluation of place identity. The character of the environment can also be created by the perceived loudness of the sound intensity in the space and whether it is compatible with the space's function and place's use or not.

Table 2.5. Place identity-acoustics indicators correlation (Al-bayyar & Kitapci, 2020)

Acoustic indicators	Acoustic descriptors	Place identity descriptors	Place identity indicators
Reverberation time	Impression of acoustic authority (Schafer, 1977) Listening/acoustic enhancement (Ballou, 2008; Egan, 2007)	Reflects user cognitions (Boerebach, 2012)	Cognition
	Friendly/hostile space (Ballou, 2008) Interactive space/experience (Blesse & Salter, 2007)	Experiencing characteristic environment (Norberg-Schulz, 1976)	Characteristic space
	Information about spatial relations (Truax, 1984) Clear/distorted sense of space (Truax, 1984)	Linking place to meaning (Boerebach, 2012)	Meaning
Diffusion	Listening enhancement (Ballou, 2008)	Reflects user cognitions (Boerebach, 2012)	Cognition
	Welcoming amplifying (Blesse & Salter, 2007)	Experiencing characteristic environment (Norberg-Schulz, 1976)	Characteristic space
Diffraction	Tonal distortion/alien tone (Egan, 2007)	Reflects user cognitions (Boerebach, 2012)	Cognition
Sound intensity	Perceived loudness (Egan, 2007)	Reflects user cognitions (Boerebach, 2012)	Cognition
		Experiencing a characteristic environment (Norberg-Schulz, 1976)	Characteristic space

Table 2.6. Place identity-acoustic indicators common descriptors

Place identity indicators	Acoustics indicators	Common descriptors
Meaning	RT	Spatial relations Listening enhancement Acoustically characteristic space
Characteristics	RT	Acoustically characteristic space
	Sound intensity	Perceived loudness

Another attribute of the place identity construct is linking place to meaning (Boerebach, 2012). Meaning is given to spaces after experiencing elements and aspects of the environment and obtaining sufficient information about them. Comprehending these elements and aspects is linked to identifiable apparent properties of the space and the possible meaning of these elements (Garling & Evans, 1991b). Accordingly, the opportunity to comprehend the spatial setting and relations within the space provided by reflection and the sense of a clear space can be influential in experiencing the environment's aspects and hence determining the attachment of meaning to place. Table 2.5 presents the correlation between place identity and acoustics indicators. Table 2.6 presents the common descriptors between place identity indicators and acoustic indicators: RT and sound intensity.

Place dependence and room acoustics

Place dependence occurs when users perceive the advantage of a spatial setting and when this setting achieves their expectations. The expectation is matching the general rules users have about a setting and applying those rules to the real-world spaces (Garling & Evans, 1991b). Confusion and lower confidence in the place occur when the schematic expectations are violated and not corresponded to the perceived reality (Garling & Evans, 1991b).

Table 2.7. Place dependence-acoustic indicators correlation (Al-bayyar & Kitapci, 2020)

Acoustic indicators	**Acoustic descriptors**	**Place dependence descriptors**	**Place dependence indicators**
Reverberation time	Listening/acoustic enhancement (Ballou, 2008; Egan, 2007) Speech perception (Egan, 2007)	Advantageous spatial setting (Boerebach, 2012)	Advantageous spatial setting
	Information about spatial relations (Truax, 1984) Impression of acoustic authority (Schafer, 1977) Friendly/hostile space (Ballou, 2008) Interactive space/experience (Blesse & Salter, 2007) Clear/distorted sense of space (Truax, 1984)	Achieving aims/needs/expectations (Boerebach, 2012)	Expectations
Diffusion	Listening enhancement (Ballou, 2008)	Advantageous spatial setting (Boerebach, 2012)	Advantageous spatial setting
		Achieving aims/needs/expectations (Boerebach, 2012)	Expectations
Sound intensity	Speech perception (Egan, 2007)	Advantageous spatial setting (Boerebach, 2012)	Advantageous spatial setting
	Perceived loudness (Egan, 2007)	Achieving aims/needs/expectations (Boerebach, 2012)	Expectations

Table 2.8. Place dependence-acoustic indicators common descriptors

Place dependence indicators	**Acoustics indicators**	**Common descriptors**
Expectations	RT	Acoustically characteristic space
	Sound intensity	Perceived loudness
Advantageous	RT	Speech perception Listening enhancement
	Sound intensity	Speech perception

Acoustics in enclosures can increase or decrease the degree of confidence, or dependence, the user may have towards space. The users may expect an interactive responsive space, with clear identification of space's functions and spatial relation for a specific aim, which sound reflection and absorption can provide or inhibit (Blesse & Salter, 2007). Likewise, they may perceive an advantageous listening or speech experience in space regarding the aim they have to use the space. Thus, room acoustics can provide this advantage and create a place dependence and functional attachment—users would compare the advantageous acoustic performance to alternative places and determine their dependence on matching their expectations (Boerebach, 2012; Pretty et al., 2003). Table 2.7 presents the correlation between place dependence and acoustics indicators. Table 2.8 presents the common descriptors between place dependence indicators and acoustic indicators: RT and sound intensity.

2.3 Case study: Private offices

A private office is often highly concentrated and independent. It is a space occupied by one or two people where each person's equipment is in the room. Every office has access to a window and a corridor. Users of enclosed offices control the environment regarding ambient factors, noise, and privacy conditions (Danielsson & Bodin, 2019).

Employees may prefer private offices due to the provided personal space for each person and the increased job satisfaction. This type of environment offers its users the ability to control the time and means of interacting with others, the visual exposure to others, and restricting the amount of acoustic distraction from people and equipment (B. P. Haynes, Suckley, & Nunnington, 2019). Thus, users of private offices may perceive a higher level of security and lower level of perceived noise and distracting conversations (Eberhard & Kraft, n.d.). This increases productivity and decreases distraction from conversations and visual distractions (B. Haynes, Suckley, & Nunnington, 2017). However, this enclosure is found as an obstacle regarding social aspects of reinforcing interaction and collaboration (Danielsson & Bodin, 2019). Private offices may increase the sense of individualism and introversion and affect the teamwork. Moreover, from a financial perspective, private offices cost more for furnishing and to get occupied (Eberhard & Kraft, n.d.).

It is found that enclosed private offices outperform other office layouts regarding indoor environmental quality, especially in acoustics, privacy, and proximity (Delle Macchie, Secchi, & Cellai, 2018). Acoustically, private offices provide privacy for standing or seated user due to the full height walls and solid core doors (Long, 2006). Speech privacy in this space depends on the signal-to-noise ratio between intruding speech level and the steady background sound—signal and noise respectively. The signal is determined by how loud the voice of the speaker is, and by the noise reduction between enclosed spaces (Egan, 2007). Speech privacy there is affected by several factors such as room absorption, speech effort, privacy expectations, and background noise. Thus, it is analyzed in terms of source, path, and receiver. The path in enclosed offices is direct and flanking. It is represented by the common walls and doors, flanking, and leaks—such as ceiling plenums and construction's cracks and holes respectively (Egan, 2007).

For an optimum speech privacy in enclosed private offices, it is better to locate both speaker and listener at 0.5 to 1 m away from the common barrier. Additionally, the background noise levels from adjacent rooms should be enough to mask the intruding speech signals. It should be plain, continuous, and unnoticeable by users (Egan, 2007). The source of the background noise should not be depended on the activities taking place in the office. It is found that internal noise caused by equipment, telephones, conversations, and people's movement has a negative effect on productivity (B. Haynes et al., 2017). Accordingly, such unpredictable noise should be masked by a more reliable and consistence sound source such as airflow noise at air diffusers or neutral noise from electronic masking system (Egan, 2007). However, background noise levels in private offices are usually low, even with masking included. Thus, conversations may occur at raised voice levels even at confidential requirements (Long, 2006).

Private offices, dependent on tasks to be performed, are preferred layouts for the privacy and control provided in the space. Users have the freedom to personalize the office and reflect their preferred spatial arrangement and identity-indicating atmosphere. Revealing the influence of room acoustics on the sense of place in private offices is essential to attach the preference of this layout to the physical properties of sound in the space in addition to the subjective preference of it.

2.4. Conclusion

This chapter has reviewed the literature about acoustics and sense of place, and has linked the possible descriptors and indicators of both in a suggested framework. Room acoustics is dependent on the geometrical objective extent of the space. This extent determines the space’s reverberation time, speech privacy, sound intensity, signal-to-noise ratio, and other acoustics parameters. Furthermore, these parameters render the place character and define its suitability for its designed function. For instance, reverberation time creates space’s pleasantness, responsivity, and sense of space through providing information about spatial relations.

When users experience a space and link meaning to it, this geometrical objective extent turns to a subjective human construct: a place. The relation users now have with the place is known as sense of place. As this phenomenon is linked to experiencing the space, room acoustics is to shape this relation.

From the literature, it was found that there are common indicators between physical parameters of sound and sense of place that describe both. It was found that place attachment indicators and acoustic indicators have common descriptors that may influence each other. Emotions and sound intensity share descriptors of feeling comfortable and satisfied towards the place. Orientation and reverberation time indicators correlate with rendering the spatial setting clear and by providing specific auditory feelings towards the place (Figure 2.15).

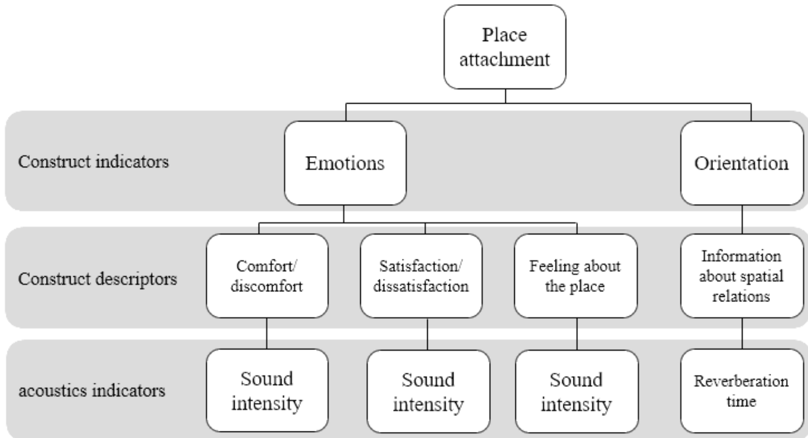

Figure 2.15. Common indicators and descriptors of place attachment construct and acoustic indicators (Al-bayyar & Kitapci, 2020)

A similar relation was found between place identity indicators and acoustics indicators. Meaning and reverberation time indicators correlate in providing spatial relations, enhancing the listening experience, and create an acoustically characteristic place. Cognition and sound intensity indicators share the perceived loudness descriptor. Along with reverberation time, sound intensity correlates with space characters by influencing perceived loudness, and RT by creating characteristic place (Figure 2.16).

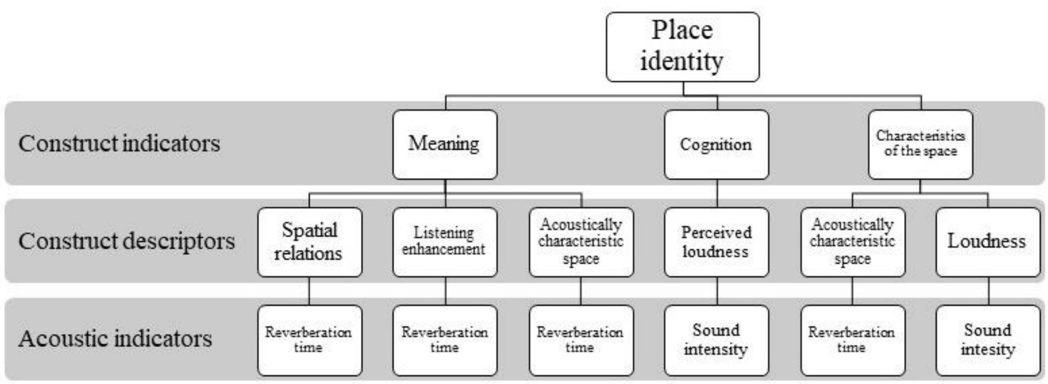

Figure 2.16. Common indicators and descriptors of place identity construct and acoustic indicators (Al-bayyar & Kitapci, 2020)

Finally, place dependence shares common descriptors with acoustic indicators as well. Expectation indicator correlates with reverberation time in experiencing an acoustically characteristic environment, and correlated with sound intensity in perceived loudness. Place's advantageous spatial setting correlates with both sound intensity and reverberation time regarding speech perception. Additionally, reverberation time creates an advantageous space/place by enhancing the listening experience (Figure 2.17).

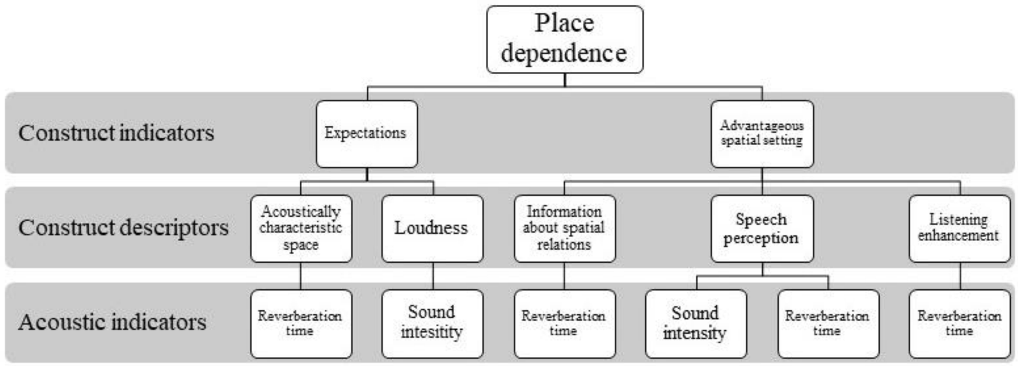

Figure 2.17. Common indicators and descriptors of place dependence construct and acoustic indicators (Al-bayyar & Kitapci, 2020)

Thus, place attachment, place identity, and place dependence constructs are efficient for understanding and measuring users' relation with the place. They denote this relation from an emotional, cognitive, and functional level, respectively. Thus, these three constructs and their indicators are identified in this study as the dependent variables those can be influenced by room acoustics parameters.

CHAPTER 3

METHODOLOGY

This study investigates the influence of room acoustics parameters on sense of place and its constructs. Accordingly, the common descriptors and indicators between room acoustics parameters—reverberation time and sound intensity—and place constructs—place attachment, place identity, and place dependence—are searched and found from the literature (Figure 3.1) (see section 2.2.8).

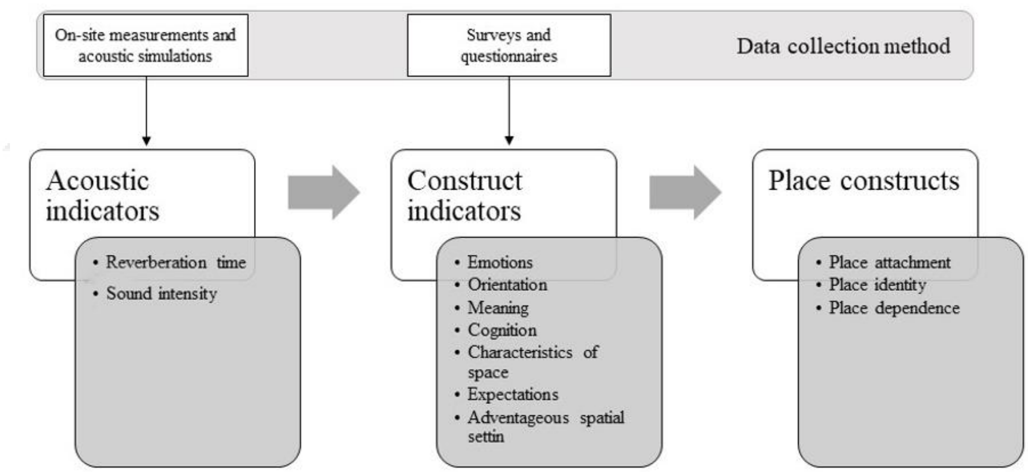

Figure 3.1. Data collection methods and the relationships between the acoustic descriptors, the construct descriptors, and the place constructs (Al-bayyar & Kitapci, 2020)

After determining the descriptors and corresponding indicators, the following steps were taken to test the hypothesis which claims that room acoustic parameters have direct influence on users' sense of place and experiencing spaces:

3.1 Experimental setting

The spaces used for the experiment were private offices of 15 academic members from the Faculty of Architecture in Çankaya university. The participants have been using their offices for at least one year. The offices are designed for one user, and sometimes for two or more. The offices faced northern and southern directions. Each office has access to a window and a corridor. The spaces were illuminated naturally; occasionally, artificial lighting was used. The experiment consisted of 3 phases. The first phase was field recordings. The sound recordings were used to test the effects of sound source composition on the sense of place. Phase 2 was taking acoustics measurements from the offices to obtain the original values of acoustic parameters. Phase 3 was auralization, where audio samples were designed by combining background noises obtained from field recordings and some sound signals.

3.2. Field recordings

The first phase of the study was taking field recordings from the offices. The purpose was to obtain offices' background noises that users would later identify in terms of familiarity—background noise is a component of the sound source composition. The field recordings were conducted by using a Zoom X/Y microphone connected to a Zoom H6 high-quality 6-channel sound recording device. The recordings were monitored through a Beyer Dynamic DT-770 high fidelity headset. The field recordings were taken from private lecturer offices in the morning (between 9 am to 1 pm). The headphones' SPLs were adjusted 9.5 dB below the actual background sound levels of the private offices (Sudarsono & Sarwono, 2019). The calibration for the headphones' SPLs was done by using a Testo 815 sound level meter. A silicon baffle was installed around the measurement microphone—5 mm below the diaphragm. Thus, the air between the sound level meter and the earpads was sealed.

The offices were recorded twice: once when doors were open, and once when doors were closed. The windows were left open or closed according to the user's preference. Some users are used to work when windows are open, and some are not. This was important to achieve a recording that is familiar to the user's ears when they would later listen to the recording modified. The offices were classified under two groups: south-oriented offices and north-oriented offices.

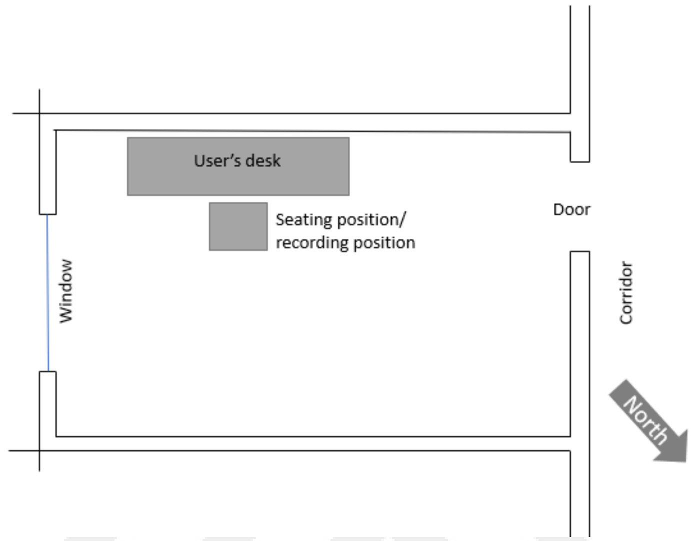

Figure 3.2. A schematic drawing of an office from the south group

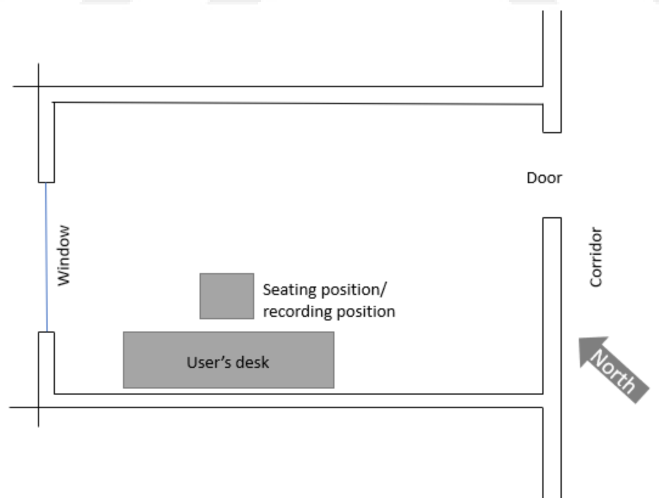

Figure 3.3. A schematic drawing of an office from the north group

The recordings were done by placing the device at the height and position of a seated user at the desk (Figure 3.2 and 3.3). Each recording was approximately 2 minutes long.

The obtained recordings from southern offices had clear sounds of birds chirping in the background, a faint speech, walking sounds, doors being opened and closed, computer fan noise, and different activities from nearby offices and people in the corridor. As for the northern offices, walking, birds, and computer fan noise sounds were present. The speech was more intelligible than that in southern recordings. Different activities' sounds from nearby offices and people in the corridor were recorded, such as cellphones ringing and occasional clanking sounds.

3.3 Acoustics measurements

The second phase of the study was taking acoustic measurements from the offices. The acoustics values of the original office were thus obtained (Table 3.1).

The international standards of ISO 3382-1 and ISO 3382-2 were fulfilled for office space measurements (3382-1:2009, 2009; BS EN ISO 3382-1:2009, 2009). An omnidirectional microphone was used, and the output was taken by a signal recorder. It was positioned at least 1.5m to 2m away from the nearest reflective surface (depends on the space's usage regarding the seating area). A sine-sweep sound source was used to measure room impulse response. Its advantage is that the frequency spectrum of the excitation signal can be modified in the time domain while the amplitude of the signal remains constant over time (Richard, Christensen, & Koutsouris, 2020).

Table 3.1: Acoustic measurements obtained from private offices

Office	*1*							
Group	South							
Band Hz	63	125	250	500	1000	2000	4000	8000
T(20)	0.51	0.50	0.62	0.57	0.51	0.44	0.45	0.44
STI	0.71							
D(50)	0.84	0.77	0.66	0.80	0.80	0.78	0.76	0.77
C(80)	12.5	6.6	5.8	9.5	10.2	10.7	9.9	10.3
Office	*2*							
Group	South							
Band Hz	63	125	250	500	1000	2000	4000	8000
T(20)	0.55	0.58	0.62	0.56	0.54	0.54	0.50	0.45
STI	0.73							
D(50)	0.56	0.52	0.67	0.68	0.78	0.79	0.77	0.76
C(80)	9.0	5.0	7.3	8.3	9.9	9.8	9.7	9.6
Office	*3*							
Group	South							
Band Hz	63	125	250	500	1000	2000	4000	8000
T(20)	0.70	0.61	0.59	0.54	0.51	0.44	0.46	0.42
STI	0.71							
D(50)	0.65	0.54	0.72	0.84	0.81	0.77	0.77	0.77
C(80)	11.2	8.0	7.4	10.2	9.9	11.1	10.2	10.7
Office	*4*							
Group	North							
Band Hz	63	125	250	500	1000	2000	4000	8000
T(20)	0.61	0.69	0.65	0.71	0.75	0.69	0.67	0.71
STI	0.70							
D(50)	0.55	0.64	0.66	0.66	0.61	0.69	0.67	0.71
C(80)	11.3	6.8	7.5	7.2	6.2	7.3	6.7	7.7
Office	*5*							
Group	South							
Band Hz	63	125	250	500	1000	2000	4000	8000
T(20)	0.39	0.70	0.67	0.43	0.42	0.39	0.35	0.35
STI	0.68							
D(50)	0.92	0.79	0.88	0.83	0.81	0.85	0.87	0.89
C(80)	15.6	8.2	12.3	11.9	12.1	12.5	13.9	14.8
Office	*6*							
Group	South							
Band Hz	63	125	250	500	1000	2000	4000	8000
T(20)	-	0.39	0.47	0.43	0.39	0.37	0.39	0.37
STI	0.76							
D(50)	0.83	0.79	0.84	0.86	0.89	0.86	0.86	0.85
C(80)	17.8	10.2	10.3	13.0	13.7	13.2	13.5	13.0

Using ODEON software as an output reader, sine-sweep was selected for being the adapted approach of measurement in ODEON. It derives the acoustics parameters from the room's impulse response at a given receiver point to an impulse at a given source point (Richard et al., 2020). The sine-sweep sound source was placed in the position of using the room (on the user's desk, close to the seating area). Approximately, 1.5m was the distance between the omnidirectional microphone and sound source. The space was emptied from any occupant except for the experimenter, and doors and windows were closed. As the sine-sweep gave the sound source, the output was read by Room Acoustics software (ODEON).

3.4 Auralization setup

Auralization is the technique used for creating audible sound fields from numerical data (Vorlander, 2008). Auralization was used to create eight simulated acoustic conditions with different reverberation times and sound sources compositions. The simulated conditions would reveal how different acoustics parameters could change the reported sense of place.

Two groups of audio samplings were identified: South Group and North Group. For South Group samples, the background ambiences of Southern field recordings were used and identified as "Familiar background ambience". The Northern field recordings were identified as "Unfamiliar background ambience". The same was applied for North Group samples: the background ambiences of Northern field recordings were identified as "Familiar background ambience"; the Southern field recordings were identified as "Unfamiliar background ambience".

Table 3.2. Sound sample composition for the *south group* (**2* indicates two similar but different sound signals were used)

Final mix	RT (sec)	Background	Signals used
AC_1	1.2	Unfamiliar	Door Footsteps Knocking Chair
AC_2	0.8	Familiar	Door *2 Locker
AC3	0.8	Unfamiliar	Locker Footsteps *2 drawer
AC_4	0.8	Unfamiliar	Footsteps Chair Door
AC_5	0.8	Familiar	Door Footsteps *2 Chair
AC_6	1.2	Familiar	Door *2 Locker Chair
AC_7	1.2	Familiar	Knocking Footsteps Chair
AC_8	1.2	Unfamiliar	Locker Footsteps Chair Door

Table 3.3. Sound sample composition for the *north group* (**2* means two similar but different sound signals were used)

Final mix	RT (sec.)	Background	Signals used
AC_1	0.8	Familiar	Door Footsteps Knocking
AC_2	1.2	Familiar	Footsteps *2 Door Chair Locker
AC_3	0.8	Unfamiliar	Footsteps *2 Chair
AC_4	1.2	Unfamiliar	Chair Door Drawer Knocking Locker
AC_5	1.2	Unfamiliar	Drawer Chair Door Footsteps Lock
AC_6	1.2	Familiar	Door Footsteps Chair Drawer
AC_7	0.8	Unfamiliar	Footsteps Door Chair
AC_8	0.8	Familiar	Chair Footsteps Drawer Knocking

To make the acoustic environment sound more of a daily-use condition, sound signals were added to the background ambience. Generally, sound sources in a workplace are determined by work type and user habit (Reinten, Braat-Eggen, Hornikx, Kort, & Kohlrausch, 2017). In a sufficient number of studies, sound sources are selected as distractors or essential part of a performed task. However, these sound sources may not be present in the natural work setting (Reinten et al., 2017). Accordingly, selected sound signals in this study were footsteps/walking, door knocking, door/cabinet locking and unlocking, drawer, and chair dragging. The selection is based on the observed sound signals obtained from field recordings (see section 3.2).

Sound signals were downloaded from the *freesound.org* website. “Dry” signals were chosen, since they are free from any reverberation or other cues introduced by sound transmission (Vorlander, 2008). For preparing the audio samples, Steinberg Cubase LE software was used. Background ambiences were normalized to set the volume to maximum based on the loudest point in recordings. A minimum of four audio channels were digitally mixed for creating each acoustic condition: one audio channel for the background ambience sound obtained from field recordings, and at least three audio channels for the signals.

The reverberation plug-in was connected to signals’ audio channels. Reverberation times obtained from the acoustic measurement phase were approximately 0.4 to 0.7 seconds in southern offices and 0.8 seconds in northern offices (Table 3.1). Accordingly, two values of RT with noticeable differences were assigned: 0.8 seconds that mimics a volume of an office with a soft absorbent surface, and 1.2 seconds that mimics a volume of a larger space and a reflective surface (Berg & Stork, 2005; Perham, Banbury, & M. Jones, 2006). The sound level of the background ambient was increased to maximum value, while signals were decreased to -15dB. The audio samples were set to 30-second duration (Asakura, Tsujimura, Yonemura, Hyojin, & Sakamoto, 2019; Pheasant, Fisher, Watts, Whitaker, & Horoshenkov, 2010; Yi & Kang, 2019). The final sample was saved in high-quality (.wav) format.

The eight audio samples were randomized in sequence in MS Excel. A PowerPoint presentation was made where solid black backgrounded slides were used with audio samples. Slides were organized according to the randomization list (Table 3.2 and 3.3).

3.5. Questionnaire

A two-section questionnaire was designed to test participant's evaluation of sense of place with different acoustic conditions. The first section investigated room acoustic parameters effects on sense of place indicators by using the Absolute Magnitude Estimation scale (AME) (see Chapter 5).

Absolute Magnitude Estimation scale "derives from the notion that for an individual observer, at any moment in time, there is an absolute connection between the observer's conception of the magnitude of a number and the observer's perception of sensory magnitudes. If so, then observers behave as though scale values defined by these numbers are absolute and, unlike ratio scales, cannot be transformed even by multiplication by a positive constant." (Pashler & Wixted, 2002; p. 119).

In this part of the questionnaire, three place constructs were chosen: Place Attachment, which reflects the emotional experience with the place; Place Identity, which reflects user's cognition of the place; and Place Dependence, which reflects user's perception of the advantageous physical and spatial setting of the place. Two indicators for each place construct were chosen: Emotions and Orientation indicators of Place attachment, Meaning and Character indicators of Place identity, and Expectations and Advantage indicators of Place dependence. These indicators played the role of the perceptual magnitude that is caused and/or affected by room acoustics indicators (the stimuli), reverberation time and sound source composition.

The second section of the questionnaire was a sense of place questionnaire corresponding to a 7-point Likert scale. Three questions regarding each construct—Place attachment, Place identity, and Place dependence—were chosen from the examined literature. Determining these three questions for each construct was done by choosing questions that were as relevant as possible to working/using an office space (rewording was applied as well to achieve this purpose).

Both sections were translated to participants' native language (Turkish), as well as the PowerPoint presentation.

3.5. Experiment

The experiment took place between 9.30am to 1.00pm. Each participant used his/her own office during the experiment. On the participant's desk, a computer with a connected headphone was set. The PowerPoint presentation was opened. Doors and windows were closed when participants were about to start the experiment. Nine evaluation forms were given to the participants. The participants were instructed to fill the first questionnaire without headphones—to evaluate their offices' sense of place under its original current acoustical and environmental condition. Later, instructions about the simulations were given to the participants. They were instructed to sit on their usual used working position while putting on the headphone and listing to the eight different acoustics simulations. Participants were told to imagine as if they were using their offices with the listened-to acoustic environment. Simulations were randomized in order as obtained from MS Excel. Each recording lasted for 30 seconds. After that, a slide was shown to the participants telling them to fill the questionnaire according to the acoustic condition they had listened to. The average time spent to fill the questionnaire was 36 minutes.

3.6. Data analysis

The statistical analysis methods used in this study were applied to the five data sets gathered from the filled questionnaires (Table 3.4). The first data set was the effects of sound source composition familiarity and reverberation time on place constructs obtained by sense of place questionnaire. The second data set was the effects of sound source composition familiarity and reverberation time on place indicators obtained by AME scale. The third and fourth data sets were the effects of sound signals on place constructs and place indicators. The fifth data set was a comparison of place constructs evaluation in original and simulated acoustic conditions.

Table 3.4. Methods and statistical analysis of data applied to each research question

Research questions	Methods	Statistical analysis method
Can reverberation time influence place attachment, identity, and dependence?	SoP questionnaire	One-way ANOVA
Can background noise in a sound source composition influence place attachment, identity, and dependence?	SoP questionnaire	One-way ANOVA
Can sound signals in a sound source composition influence place attachment, identity, and dependence?	SoP questionnaire Spectrogram	Spearman's correlation analysis
Can Absolute Magnitude Estimation scale (AME) be used as a prediction tool for place indicators?	SoP questionnaire AME	Spearman's correlation analysis comparing the results of SoP questionnaire and the AME for place constructs-place indicators Comparison of means
Can reverberation time influence place indicators?	AME	One-way ANOVA
Can background noise in a sound source composition influence place indicators?	AME	One-way ANOVA
Can sound signals in a sound source composition influence place indicators?	AME Spectrogram	Spearman's correlation analysis

Initially, AME normalization was done to bring into common the scale that participants used. Modulus equalization was used for this purpose. The principle of this equalization is that all participants must have evaluated the same set of stimuli. Their ratings are each multiplied by a fixed, constant multiplier in order to a geometric mean that equal to the geometric mean of the group data. It requires that all participants have evaluated the stimuli an equal number of times, and the absence of 0 rating in evaluating (Howard R. Moskowitz, 1978). Having these conditions fulfilled, this study normalized AME data by using modulus equalization.

As AME is not usually used in earlier studies for evaluating sense of place, a comparison between AME and sense of place questionnaire was obtained to validate the appropriateness of using AME in this study. For this purpose, Spearman's correlation coefficient was used. It is a non-parametric statistic that represents the degree of closeness between two variables. Thus, it indicates of how strong the relation between these variables is (Field, 2009; Peers, 1996). Accordingly, the significance levels of correlation between AME and sense of place questionnaire for Place attachment, AME and sense of place questionnaire for Place identity, and AME and sense of place questionnaire for Place dependence were obtained by using SPSS software, at a confidence interval of 95%, $p < 0.05$.

Investigating the effects of sound source composition and reverberation time on both place constructs (sense of place questionnaire) and place indicators (AME) were analyzed by using the analysis of variance method (ANOVA), at a confidence interval of 95%, $p < 0.05$. One-way ANOVA is used to compare more than two conditions—when a continuous variable is paired with a nominal variable with more than two categories (Field, 2009; Stockemer, 2019).

Original, familiar, and unfamiliar background noise; and original reverberation time, 0.8s reverberation time, and 1.2s reverberation time were the independent variables. Place constructs (Place attachment, Place identity, and Place dependence) and place indicators (emotions and orientation, character and meaning, and advantage and expectations) were the dependent variables. The null hypothesis stated that 'There is no effect of reverberation time and sound source composition on the sense of place'. The alternative hypothesis was 'Reverberation time and sound source composition affect users' sense of place'. One-way ANOVA was applied by using SPSS software.

The effects of sound signals on the reported sense of place were analyzed by applying Spearman's correlation coefficient for both the SoP questionnaire and AME method. Furthermore, a spectrogram analysis of sound signals was applied by obtaining the spectrograms of sound signals by Raven Lite 2 software.

The comparison of evaluating place constructs and place indicators in original and simulated conditions was done by obtaining the mean of each dependent variable in each acoustical condition and then calculating the percentage increase or decrease for each mean.

Furthermore, a reliability analysis was carried out on the questionnaire comprising a total of fifteen items. Cronbach's alpha showed the questionnaire to reach high reliability (α = 0.90). All times appeared to be worthy of retention, resulting in a decrease in the alpha if deleted.

CHAPTER 4

THE EFFECTS OF REVERBERATION TIME AND SOUND SOURCE COMPOSITION ON PLACE CONSTRUCTS: SENSE OF PLACE QUESTIONNAIRE

4.1 Introduction

This chapter presents the effects of reverberation time and sound source composition on the sense of place (SoP). These interacting effects will clarify the influence of the physical acoustic parameters on participants' subjective interpretation of spaces. Fifteen participants' sense of place was measured and analyzed under three place constructs: Place attachment (PA), place identity (PI), and place dependence (PD).

The results were obtained by implementing two types of data collection methods: the Absolute Magnitude Estimation method (AME), and the sense of place questionnaires. In the AME, participants assigned an absolute number to the place construct indicators that corresponded with the acoustic condition they were listening to. In the sense of place questionnaires, participants responded to the questions on a 7-point Likert scale. (see Chapter 3.5).

The results were analyzed statistically by using the SPSS software. Analysis of Variance methods (one-way ANOVA) was applied to analyze the effects of familiarity of sound source composition and reverberation time on the sense of place. Spearman's correlation was used to validate the use of AME as a scale of sense of place and to analyze the influence of sound signals (see Chapter 3.6).

The following sections present the results obtained from the experiment and the data analysis applied.

4.2. Effects of sound source composition on place constructs

This section presents the effects of sound source composition on place constructs: place attachment, place identity, and place dependence. The sound source composition of this study consists of familiar and unfamiliar background sounds. The familiarity of sound source composition was defined according to the original orientation of the participant's office and the background noises presented to participants during the experiment. More detailed information on the production of the sound source composition used in the experiment can be found in Chapter 3.2.

4.2.1. Background noise

One of the main aims of this study is to clarify the effects of the familiarity of sound sources on participants' sense of place. Therefore, during the experiments, 15 participants were exposed to personalized sound environments in which the sound sources were tagged as familiar or unfamiliar to them. The one-way ANOVA results revealed that the effects of familiarity with the background noise on the average of the three place constructs evaluated was statistically significant ($F(2, 24)= 21.45$, $p= 0.00$).

However, not all nine statements were significantly affected by the familiarity with the background noise. As presented in table 4.1, PA's "I am happy being in this place", $p= 0.00$; PI's "I would like to work here for a long time", $p= 0.02$, and "Working in this place is more important than working elsewhere", $p= 0.03$; and PD's "I would miss this place if I were no longer working in it", $p= 0.02$, and "There is a congruence between this place and myself identity", $p= 0.00$, statements are those showed significant differences with the familiarity to the background noise.

Table 4.1. One-way ANOVA results, showing the effects of background sound source composition on place constructs (SoP questionnaire).

		Original	Unfamiliar	Familiar	Sig.
I am happy being in this place.	Mean	2,33	0,70	0,65	**0,00***
	Std.	0,81	1,41	1,31	
I am willing to make this place even better.	Mean	2,20	1,42	1,37	0,15
	Std.	1,26	1,61	1,42	
I would not substitute this office for another.	Mean	1,20	0,43	0,32	0,08
	Std.	1,32	1,39	1,29	
I would like to work here for a long time.	Mean	1,60	0,52	0,37	**0,02***
	Std.	1,40	1,56	1,51	
Everything in this place is a reflection of myself.	Mean	1,20	0,37	0,23	0,07
	Std.	1,37	1,48	1,40	
Working in this place is more important than working elsewhere.	Mean	1,07	0,15	0,20	**0,03***
	Std.	1,52	1,36	1,08	
I would miss this place if I were no longer working in it.	Mean	1,47	0,50	0,27	**0,02***
	Std.	1,30	1,50	1,48	
There is congruence between this place and my identity.	Mean	1,80	0,33	0,00	**0,00***
	Std.	1,01	1,52	1,54	
This place is the best to have the work properly done.	Mean	1,20	0,33	0,30	0,08
	Std.	0,77	1,51	1,44	

The initial results of the study indicated that in eight out of nine questions, the unfamiliar background sound compositions showed increased SoP compared to the familiar background sound composition (Figure 4.1). The unfamiliar background sound source composition showed an increase by 7% in “I am happy being in this place”, 40% in “I would like to work here for a long time”, 85% in “I would miss this place if I were no longer working in it”, and 33% in “There is a congruence between this place and my identity”. However, “Working in this place is more important than working elsewhere” showed an opposite relation between familiar and unfamiliar background sound source compositions, by having the unfamiliar mean decreased 25% from the familiar mean.

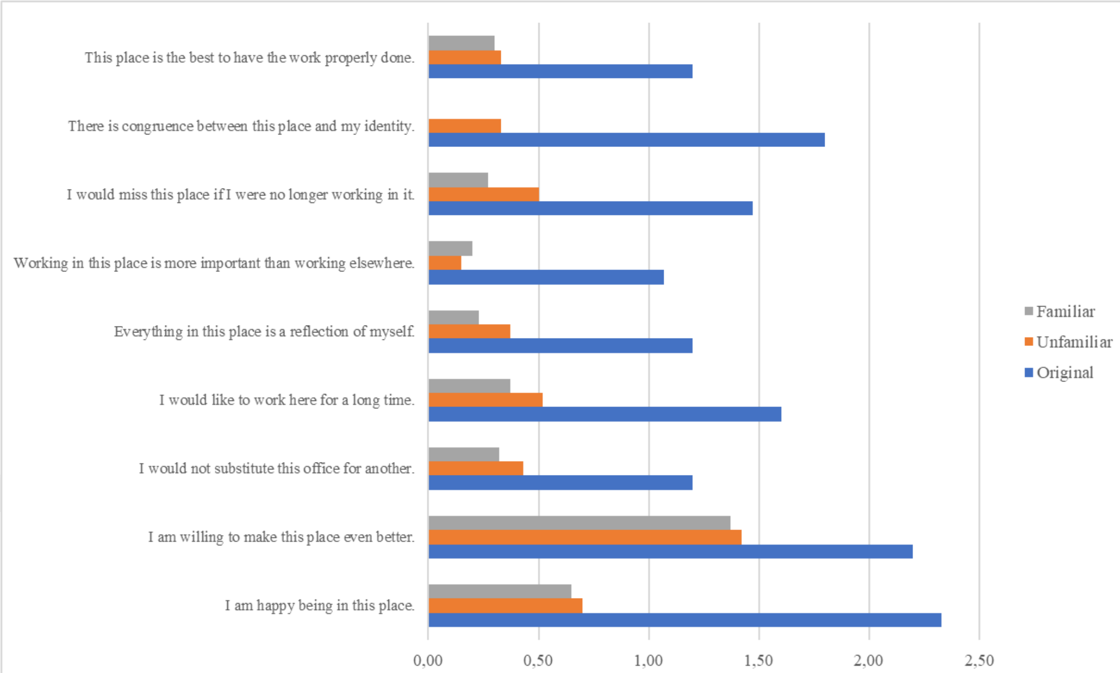

Figure 4.1. The comparison between place constructs under different background sound source compositions (SoP questionnaire).

The attention effect might cause the higher SoP caused by the unfamiliar background sound source composition: the more the listener is familiar with an aural structure, the easier to focus attention towards other dimensions—especially novel dimensions of that structure (Pashler & Yantis, 2002). Furthermore, it can be due to the lower sensory detection threshold users have towards familiar stimuli (Pashler & Yantis, 2002). However, participants' expectations from the place might have played this role of effectiveness, since expectations are related to familiarity and users' previous knowledge of the place, its stimuli, and their experience (Bild, Pfeffer, Coler, Rubin, & Bertolini, 2018).

4.2.2. Signals

The second component of the sound source composition presented to participants during the experiments were sound signals (i.e. footsteps, door knocking, chair, door, locker, and drawer). The sound signals were put together to create an aural composition that participants experience during a regular day in their offices. The correlation between the signals and the SoP questionnaire results are presented in Table 4.2. The Spearman's correlation analysis indicated that footsteps and knocking signals were the ones that affected the overall sense of place of the participants.

The statistical analysis revealed that there were significant correlations between footsteps sound signal and "I am happy being in this place" statement (p=0.01), "I would not substitute this office for another" statement (p= 0.05), "I would like to work here for a long time" statement (p= 0.02), "Working in this place is more important than working elsewhere" statement (p= 0.07), "There is congruence between this place and my identity" statement (p= 0.03), and "This place is the best to have the work properly done" statement (p=0.05).

Table 4.2. Spearman's correlation analysis results, showing the effects of signal sounds on place constructs (SoP questionnaire).

		PA_1	PA_2	PA3	PI_1	PI_2	PI_3	PD_1	PD_2	PD_3
Footsteps	Cor. Coef.	-0,21	-0,08	-0,16	-0,19	-0,08	-0,15	-0,11	-0,17	-0,16
	Sig. (2-tailed)	**0,01***	0,31	**0,05***	**0,02***	0,32	**0,07***	0,18	**0,03***	**0,05***
Knocking	Cor. Coef.	-0,28	-0,15	-0,16	-0,20	-0,16	-0,18	-0,20	-0,19	-0,22
	Sig. (2-tailed)	**0,00***	0,07*	**0,05***	**0,01***	**0,05***	**0,03***	**0,02***	**0,02***	**0,00***
Chair	Cor. Coef.	-0,07	-0,02	-0,00	-0,01	-0,02	-0,02	-0,02	-0,08	-0,04
	Sig. (2-tailed)	0,39	0,78	0,92	0,90	0,74	0,74	0,74	0,31	0,62
Door	Cor. Coef.	-0,00	-0,04	-0,09	-0,07	-0,01	-0,06	-0,01	-0,01	0,11
	Sig. (2-tailed)	0,93	0,58	0,29	0,39	0,89	0,46	0,89	0,83	0,18
Locker	Cor. Coef.	-0,00	-0,06	-0,07	-0,05	-0,03	-0,01	-0,01	-0,01	-0,13
	Sig. (2-tailed)	0,95	0,48	0,38	0,56	0,66	0,90	0,86	0,89	0,11
Drawer	Cor. Coef.	-0,11	-0,17	-0,12	-0,08	-0,07	-0,11	-0,14	-0,14	-0,08
	Sig. (2-tailed)	0,20	**0,04***	0,14	0,32	0,37	0,17	0,10	0,09	0,34

Knocking sound signal also showed significant negative correlations with "I am happy being in this place" statement (p= 0.00), "I would not substitute this office for another" statement (p= 0.05), "I would like to work here for a long time" statement (p= 0.01), "Everything in this place is a reflection of myself" statement (p= 0.05), "Working in this place is more important than working elsewhere" statement (p= 0.03), "I would miss this place if I were no longer working in it" statement (p= 0.02), "There is congruence between this place and my identity" statement (p= 0.02), and "This place is the best to have the work properly done" statement (p= 0.00).

Other signals showed no significant correlation with place constructs, except for the 'drawer' signal with a significant negative correlation with "I am willing to make this place even better" statement (p= 0.04).

The effect of footsteps and door-knocking signals might be related to participants' attracted attention towards further activities happening inside or around their offices. Having a second party acting in the experienced aural environment might have led them to expect the entry of someone, or the perception of someone approaching and occupying their private territory. Furthermore, frequency and amplitude patterns might have a further influence, as it is explained in section 4.2.3.

4.2.3. Further analysis- Spectrograms

To further understand the effects of sound signals on the sense of place, a spectrogram of signals was examined. A spectrogram represents frequencies on the vertical axis, time on the horizontal axis; and amplitude is represented by brightness (the brighter the region, the higher the amplitude) (Wyse, 2017).

Initially, the significantly influential signals (footsteps and knocking) were examined. The spectrograms of footstep signals (Figure 4.2) show that the frequencies of high amplitudes are approximately at 4-5 kHz. The exception is found with footsteps on concrete signal which reached approximately 12 kHz. Footsteps signals are distributed in approximately equal time intervals at each amplitude and frequency range.

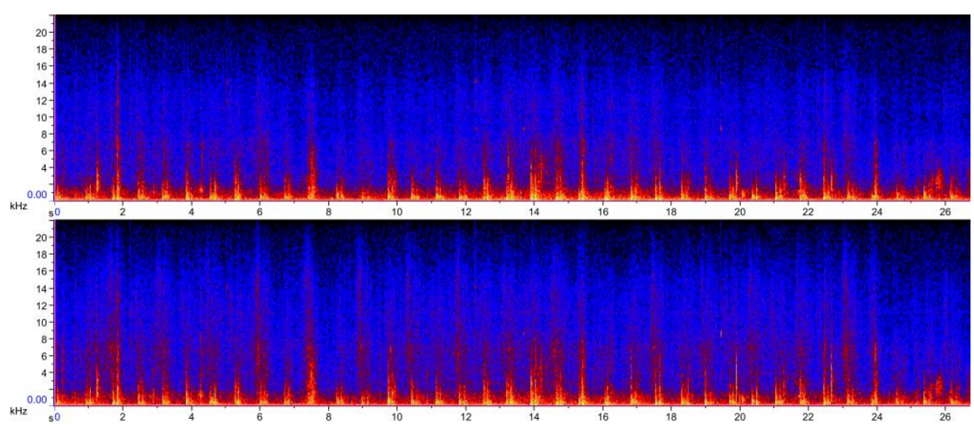

Figure 4.2a. Spectrogram analysis of the *footsteps on wooden floor* sound signal

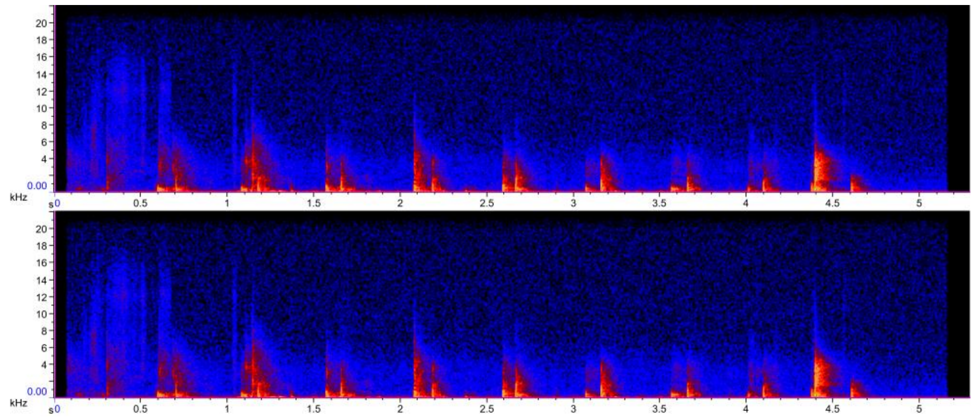

Figure 4.2b. Spectrogram analysis of the *footsteps indoor* sound signal

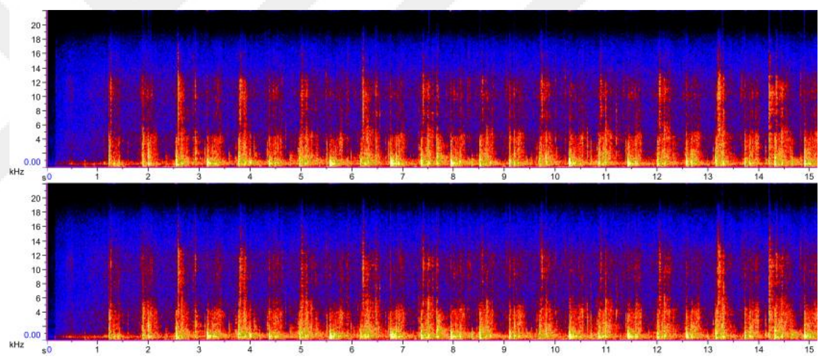

Figure 4.2c. Spectrogram analysis of the *footsteps on concrete* sound signal

High amplitudes shown on knocking signal spectrogram (Figure 4.3) were found at approximately 5 kHz, and 10 kHz within less than 10 ms. The frequency distribution is equally interval at each amplitude and frequency, as well.

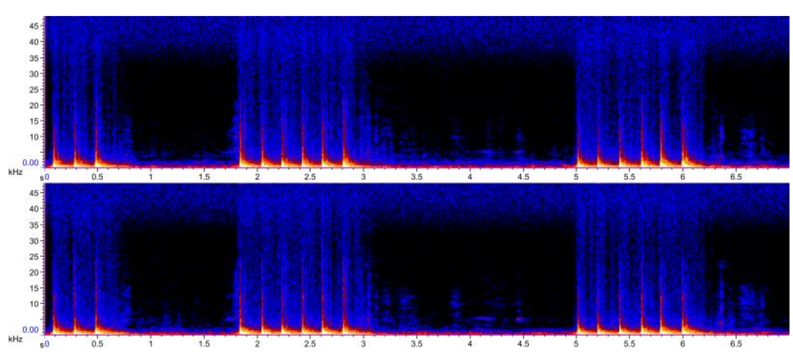

Figure 4.3. Spectrogram analysis of the *knocking* sound signal

The chair signals’ spectrograms showed that high amplitudes were approximately at 4 kHz, distributed uniformly within a 1-second duration. Lower amplitudes exceeded 14 kHz (Figure 4.4).

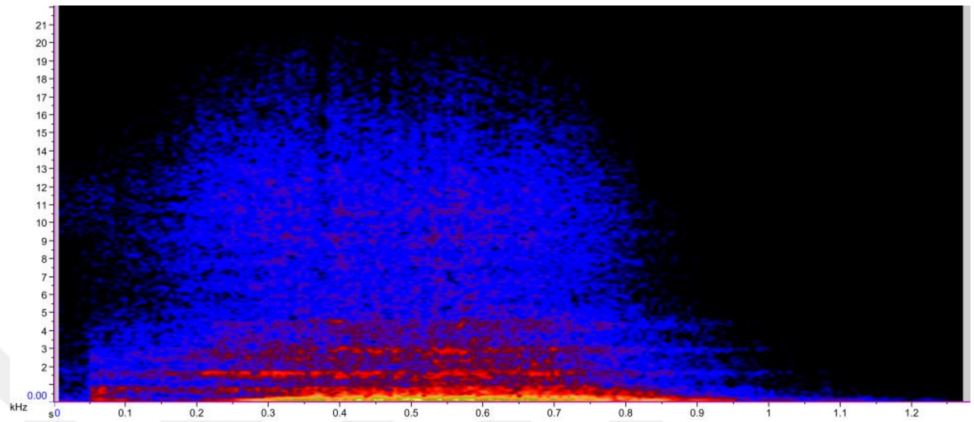

Figure 4.4a. Spectrograms analysis of the *chair* sound signal

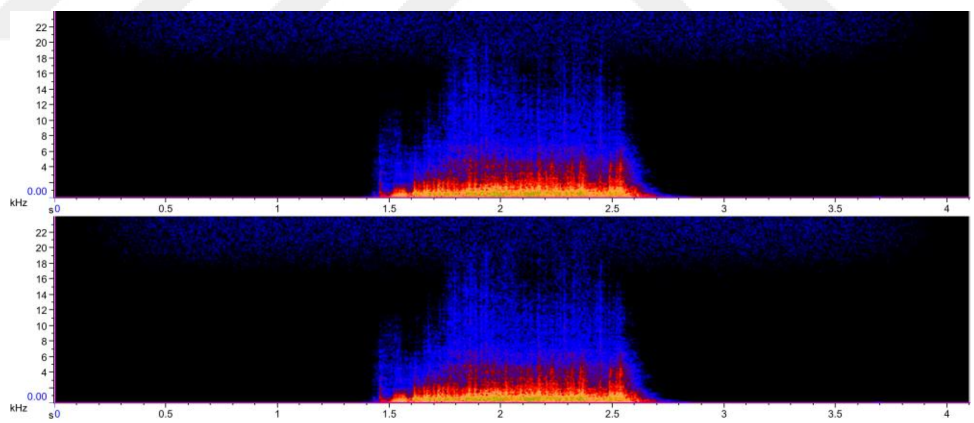

Figure 4.4b. Spectrograms analysis of the *chair* sound signal

The signal used for the door being closed showed a minor region of high amplitude at approximately 2 kHz when the door signal indicated a full closing. The other two signals indicated door opening. Their high amplitude regions were approximately at 12-14 kHz. At full closing indication, the frequency peaked approximately to 18 kHz at high amplitude regions (figure 4.5).

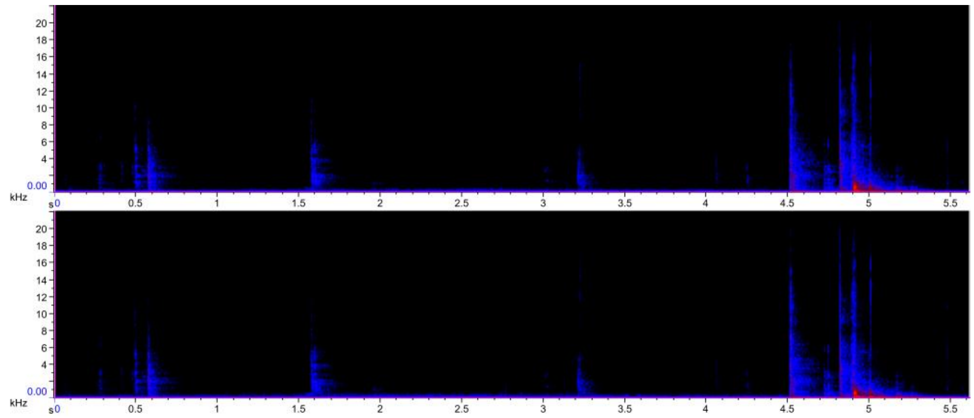

Figure 4.5a. Spectrogram analysis of the *door* sound signal

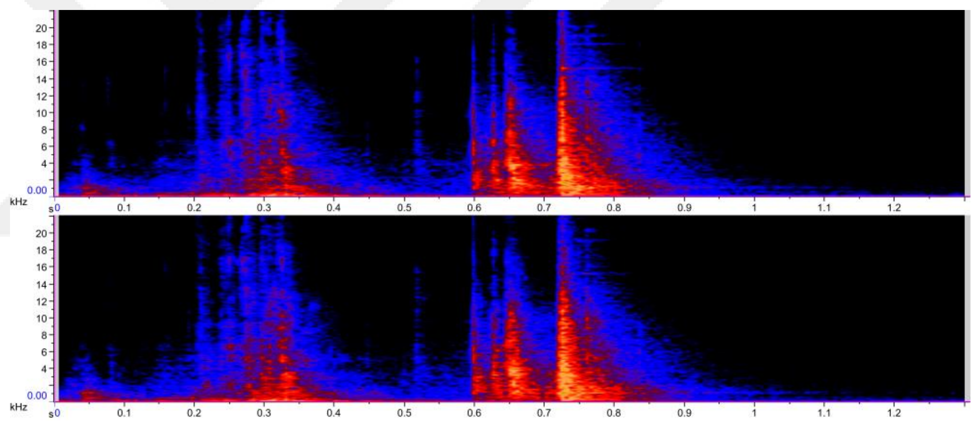

Figure 4.5b. Spectrogram analysis of the *door* sound signal

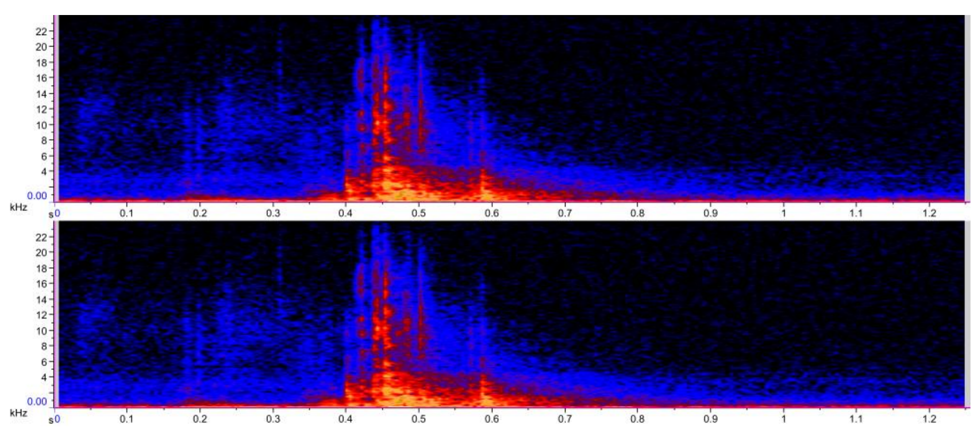

Figure 4.5c. Spectrogram analysis of the *door* sound signal

Locker sound signals reached approximately 16 kHz at high amplitudes (figure 4.6). However, the sound signal that indicated unlocking the locker peaked to 20 kHz within 100 ms.

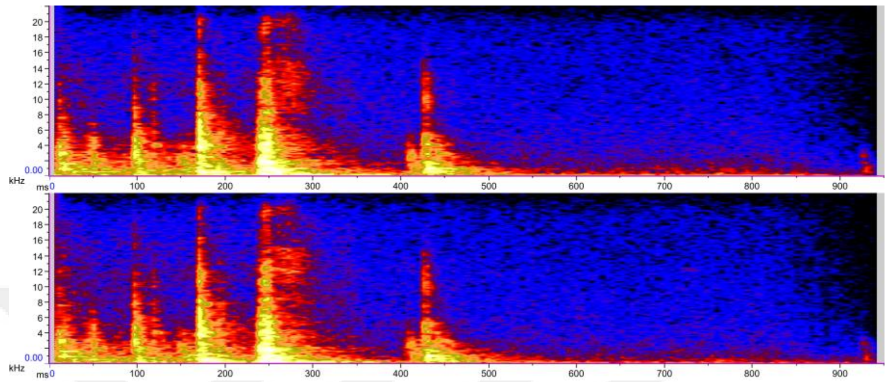

Figure 4.6a. Spectrograms analysis of the *locker* sound signal

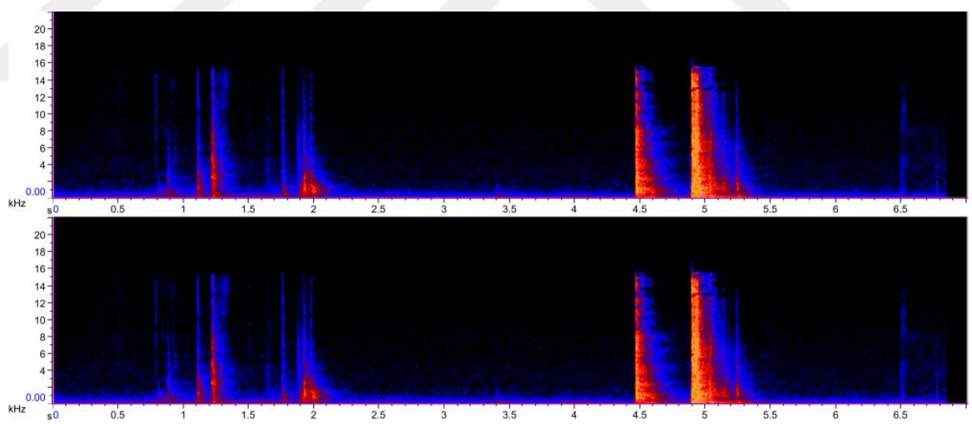

Figure 4.6b. Spectrograms analysis of the *locker* sound signal

Finally, the drawer signal showed a uniformly distributed region of high amplitude at approximately 500 Hz that lasted for 80 ms. It was followed by higher frequencies at approximately 7 kHz. Lower amplitudes exceeded 20 kHz (Figure 4.7).

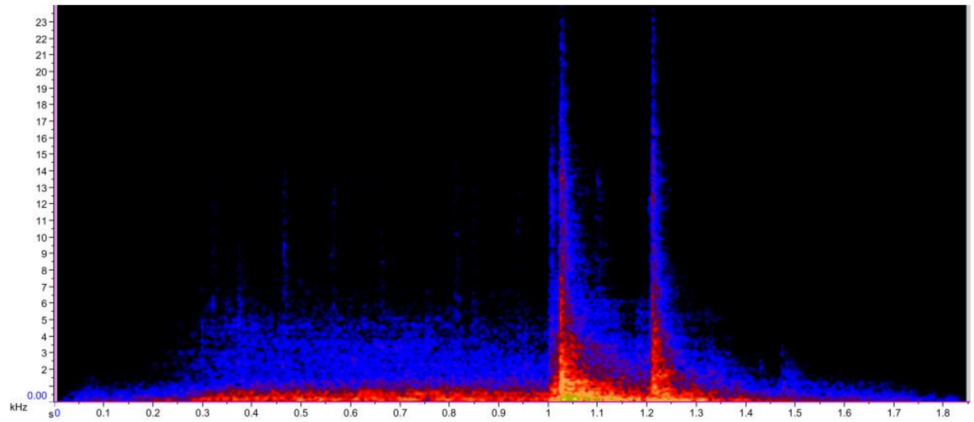

Figure 4.7. Spectrograms analysis of the *drawer* sound signal

The spectrograms analysis shows that the influential sound signals (footsteps and knocking) have two things in common. Firstly, both signals have a rhythm of amplitudes that are uniformly distributed in equal time intervals at each amplitude and frequency range. Second, both signals show high amplitudes regions at approximately 5 kHz frequency. This suggest that rhythmic signals have a negative influence on the sense of place. Furthermore, pitch perception may influence these results due to the observed frequency of 5 kHz. Pitch perception depends on phase-locking to the repetition of the travelling wave on the basilar membrane for pure tones. This perception degrades rapidly beyond 4kHz (Serences & Wixted, 2018).

4.3. Effects of reverberation time on place constructs

In this section, the effects of reverberation time on place constructs are analyzed. During the preparation of the aural environments, two different reverberation times (0.8 seconds and 1.2 seconds) were applied to the final sound source composition mix to test the influence of reverberation time on the sense of place (see Chapter to 3.5). The participants also evaluated the original aural environment of their offices, resulting in three different room acoustic conditions to be analyzed within this section. The resulting data set was statistically analyzed with one-way ANOVA and the results are presented in Table 4.3. The statistical analysis results indicated that the effects of reverberation time on the average of nine SoP statements were statistically significant ($F(2, 24)= 21.81$, $p= 0.00$).

However, the statistical analysis of the effects of reverberation time on the individual statements revealed that the range of influence differ based on the place constructs. It was seen that the effects of the RT are statistically significant for PA's "I am happy being in this place", *p*= 0.00; PI's "I would like to work here for a long time", *p*= 0.01, and "Working here is more important than working elsewhere", *p*= 0.03; and the three statements of PD, *p*= 0.03, p= 0.00, p= 0.03 respectively.

Table 4.3. One-way ANOVA results, showing the effects of reverberation time on place constructs (SoP questionnaire)

		Original	0.8 sec.	1.2 sec.	Sig.
I am happy being in this place	Mean	2,33	0,62	0,73	**0,00***
	Std.	0,21	0,16	0,18	
I am willing to make this place even better	Mean	2,20	1,28	1,50	0,11
	Std.	1,26	1,55	1,49	
I would not substitute this office for another	Mean	1,20	0,30	0,45	0,07
	Std.	1,32	1,29	1,39	
I would like to work here for a long time	Mean	1,60	0,33	0,55	**0,01***
	Std.	1,40	1,43	1,64	
Everything in this place is a reflection of myself	Mean	1,20	0,25	0,36	0,07
	Std.	1,37	1,43	1,45	
Working in this place is more important than working elsewhere	Mean	1,07	0,13	0,22	**0,03***
	Std.	1,53	1,21	1,25	
I would miss this place if I were no longer working in it	Mean	1,47	0,38	0,38	**0,03***
	Std.	1,30	1,37	1,60	
There is a congruence between this place and my identity	Mean	1,80	0,17	0,22	**0,00***
	Std.	1,01	1,38	1,68	
This place is the best to have the work properly done	Mean	1,20	0,15	0,48	**0,03***
	Std.	0,77	1,43	1,50	

The results presented in Figure 4.8 revealed that participants' SoP was enhanced with longer reverberation times (1.2 seconds) compared to the shorter reverberation times (0.8

seconds). It showed an increase by 17% for PA's "I am happy being in this place" statement, 66% for PI's "I would like to work here for a long time" statement, 69% for PI's "Working in this place is more important than working elsewhere" statement, 29% for PD's "There is a congruence between this place and my identity" statement, and 220% for PD's "This place is the best to have the work properly done" statement. The means were equal for both reverberation times in PD's "Working in this place is more important than working elsewhere".

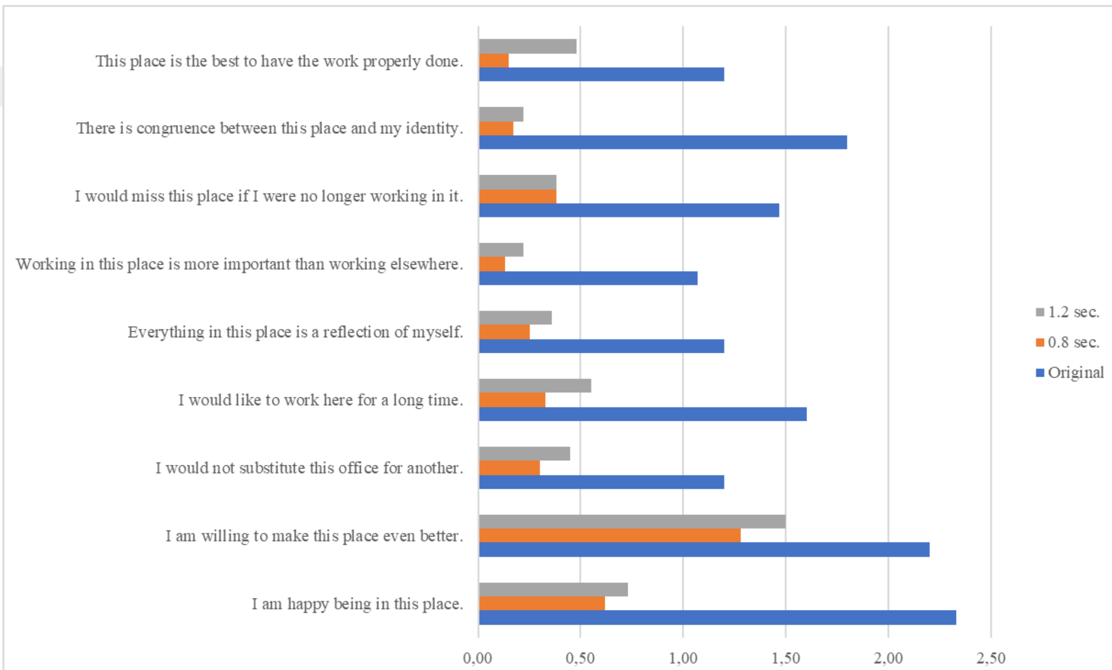

Figure 4.8 The comparison between place constructs under different reverberation times (SoP questionnaire)

The increase in SoP can be explained by the more responsive and active sound composition achieved by the longer reverberation time. This may have facilitated a better perception of the aural environment regarding an educational space; especially that the place was relatively quiet and inactive due to the current situations of online education and the absence of students on the campus.

4.4 Conclusion

This study conducted an experiment where 15 participants had to listen to different acoustic conditions with varying reverberation times and sound source compositions to test their sense of place while using their private offices. The results of the study showed that there is a direct influence of reverberation time and sound source composition on place constructs: place attachment, place identity, and place dependence.

It is concluded that longer reverberation time is more influential in enhancing the participants' sense of place. Furthermore, sound source composition enhancement of the sense of place differed according to the method of testing place constructs. Background sound familiarity was evaluated diminishing when the sense of place questionnaires was used. Footsteps and knocking sound signals showed an apparent negative effect on the sense of place. These two signals' spectrograms showed a rhythm in their frequency and amplitude distribution over time and a maximum amplitude at approximately 5 kHz.

CHAPTER 5

THE EFFECTS OF REVERBERATION TIME AND SOUND SOURCE COMPOSITION ON PLACE INDICATORS:

ABSOLUTE MAGNITUDE ESTIMATION METHOD

This study used the Absolute Magnitude Estimation scaling method to examine the influence of room acoustics parameters as perceptual stimuli on users' sense of place presented as place indicators—perceptual magnitude. Accordingly, this section is dedicated to explaining the magnitude estimation methods, the results of the study by using it, and the results of a comparison between using common sense of place questionnaires and AME in evaluating sense of place.

5.1 Magnitude estimation

Being a subjective phenomenon that has deep roots in phenomenology, sense of place is almost immeasurable. It is an abstract, intangible, complex phenomenon that it cannot be observed or lend itself to psychometric measurements easily (Boerebach, 2012; Manzo, 2005; Shamai & Ilatov, 2005). However, several measurement methods were introduced and suggested to understand the emergence and effect of this phenomenon (see section 2.2.6). These methods usually did not consider the effects of environmental stimuli changes on sense of place. Through examining the definition of the magnitude estimation method, the effect of these changes is hypothesized to be measurable.

Magnitude estimation method is one of psychophysical scaling methods. It is pointed out that this kind of scaling can serve two main purposes (Marks & Algom, 1998; cited in:

Pashler & Wixted, 2002). The first purpose is to reveal the relation between the mental realm and the physical one. The other purpose is that psychophysical scaling methods play a major role in studying sensory and perceptual processes—this scaling method investigates how sensory experiences vary under different stimulations (Pashler & Wixted, 2002).

Magnitude estimation method measures the ratio of physical properties to the estimation of the perceptual correspondence (Pashler & Wixted, 2002). Thus, it obtains numerical values of perception caused by environmental factors (Huang & Griffin, 2014). Accordingly, subjective quantities become as measurable as physical ones (Wixted & Wagenmakers, 2018). Magnitude scaling can tell how the perception of subjective attributes depends on—along with the intensity of the stimulus—the duration, the spatial distribution, the presence of another stimulus, and more countless variables (Pashler & Wixted, 2002). Concerning time and efficiency of the measurement, methods of directly yielding estimation—which magnitude estimation is one of them—are very time efficient (Fastl & Zwicker, 2007). Accordingly, the Magnitude Estimation scale was chosen for this study.

Steven's power law, whose name is most related to the early use of this method, shows that the subjective magnitude grows as a power of the stimulus magnitude (Huang & Griffin, 2014):

$$\psi = k\varphi^n \tag{3.1}$$

Where ψ is sensation magnitude that grows as a power of the stimulus magnitude, φ,

k is a constant that depends on units of measurements, and

n is the rate of growth of subjective sensation.

In magnitude estimation method, observers are asked to respond with a number that estimates the perceptual magnitudes caused by various stimuli (Pashler & Wixted, 2002). Observers can assign a number of their own choice that appears to match the magnitudes of perceived stimuli. However, bias may arise when observers are asked to refer to a standard stimulus and modulus chosen by the experimenter (Hellman & Zwislocki, 1961;

cited in: Pashler & Wixted, 2002). Therefore, it is generally better to allow the observer to choose the modulus rather than designating one (Pashler & Wixted, 2002).

Accordingly, the Absolute Magnitude Estimation scale is decided for this study. This method "derives from the notion that for an individual observer, at any moment in time, there is an absolute connection between the observer's conception of the magnitude of a number and the observer's perception of sensory magnitudes. If so, then observers behave as though scale values defined by these numbers are absolute and, unlike ratio scales, cannot be transformed even by multiplication by a positive constant." (Pashler & Wixted, 2002; p. 119). AME hypothesizes that subjects can judge psychological magnitudes numerically in an unbiased way when they are allowed to assign their own number (Gescheider & Hughson, 1991). This technique seems to minimize certain biases because of providing the subjects consistency with their own tendency to match subjective magnitudes (Gescheider & Hughson, 1991).

5.2 Validating AME as a sense of place measurement tool

AME is not a commonly used scale for the sense of place evaluation. Hence, validating the appropriateness of using AME for the sense of place evaluation is crucial. In the scope of the thesis, the implementation of the tool was validated by comparing AME results with the results of a commonly used sense of place questionnaire. The comparison of the data set was statistically analyzed with the Spearman's correlation test.

Table 5.1 presents the comparison between the AME and SoP questionnaire results for the PA construct. It was defined that PA reflects users' emotions towards a place (Altman & M. Low, 1992; Boerebach, 2012) and it is a result of the integrated perception of body reactions (Haverkamp, 2013). Additionally, PA results from a clear spatial orientation with the place (Norberg-Schulz, 1976), which is an outcome from clearly identified occurrences with stability in the temporal domain (Garling & Evans, 1991b). Hence, emotions (PA_E) and orientation (PA_O) are the two indicators identified to measure PA by AME. The comparison between the results of AME and SoP questionnaires were statistically analyzed by the Spearman's correlation analysis.

Table 5.1. Spearman's correlation analysis comparing the results of questionnaire and the AME for place attachment.

Place attachment		Emotions (PA_E)	Orientation (PA_O)
I am happy being in this place.	Correlation Coefficient	0,10	0,63
	Sig. (2-tailed)	0,21	**0,00***
I am willing to invest more time and effort to make this place better.	Correlation Coefficient	0,00	0,34
	Sig. (2-tailed)	0,91	**0,00***
Because of the experience I had in this place, I would not substitute it for another.	Correlation Coefficient	0,06	0,52
	Sig. (2-tailed)	0,47	**0,00***

The results of the Spearman's correlation analysis indicated that there was no statistically significant correlation between PA_E and SoP questionnaire results ($r(135)= 0.10$, $p= 0.21$ with "I am happy being in this place"; $r(135)= 0.00$, $p= 0.91$ with "I am willing to invest more time and effort to make this place better"; $r(135)= 0.06$, $p= 0.47$ with "Because of the experience I had in this place, I would not substitute it for another"). However, there was significant and robust positive correlation with PA_O and SoP questionnaire results ($r(135)= 0.63$, $p= 0.00$ with "I am happy being in this place" statement; $r(135)= 0.34$, $p= 0.00$ with I am willing to invest more time and effort to make this place better" statement; $r(135)= 0.52$, $p= 0.00$ with "Because of the experience I had in this place, I would not substitute it for another" statement).

The results suggest that using the AME to test users' emotions towards a place is not viable. However, testing users' place attachment is appropriate from the perspective of orientation. Other indicators of place attachment—such as feeling secured in the place (Norberg-Schulz, 1976), feeling alienated in the place (Relph, 1976), behavior affected by the place (Altman & M. Low, 1992)—should be tested as well in investigating users' place attachment by AME method.

Table 5.2 shows the comparison between the AME and SoP questionnaire results for the PI construct. Regarding PI, it is attained when users experience a characteristic environment, and thus they start linking meaning to it (Boerebach, 2012; Norberg-Schulz, 1976). Accordingly, character (PI_C)and meaning (PI_M)—which is given to spaces after experiencing elements and aspects of the environment and obtaining sufficient information about them (Garling & Evans, 1991b)—were identified as PI indicators. PI results of AME and SoP questionnaires were compared by applying the Spearman's correlation analysis.

Table 5.2. Spearman's correlation analysis comparing the results of the questionnaire and the AME methods for place identity.

Place identity		Meaning (PI_M)	Character (PI_C)
I would like to work here for a long time.	Correlation Coefficient	0,41	0,14
	Sig. (2-tailed)	**0,00***	0,10
Everything in this place is a reflection of myself.	Correlation Coefficient	0,37	0,10
	Sig. (2-tailed)	**0,00***	0,23
Working in this place is more important than working elsewhere.	Correlation Coefficient	0,46	0,22
	Sig. (2-tailed)	**0,00***	**0,00***

The results of Spearman's correlation analysis indicated that there was statistically significant and robust positive correlation between PI_M indicator and SoP questionnaire results ($r(135)= 0.41$, $p= 0.00$ with "I would like to work here for a long time" statement; $r(135)= 0.37$, $p= 0.00$ with "Everything in this place reflects me" statement; $r(135)= 0.46$, $p= 0.00$ with "Working in this place is more important than working elsewhere" statement). PI_C showed a significant positive correlation with only "Working in this place is more important than working elsewhere" statement ($r(135)= 0.22$, $p= 0.00$).

The results showed that the AME is appropriate to test PI for both PI_M and PI_C indicators; even though PI_C showed significance only once. This can be linked with the place's acoustical features which made the participants rate it as suitable for their office; hence, suggesting working in this office is more important than working elsewhere. This statement of PI is approximate in indicating users' dependence as well. The result leads to the possibility that place constructs do overlap with each other at more cognitive levels. This suggestion is to some extent supported by PD indicators results.

Table 5.3 presents the comparison between the AME and SoP questionnaire results for the PD construct. PD is described as the perceived advantage of a spatial setting that achieves user's expectations from a place (Boerebach, 2012) and matching the general rules users have about a setting to the real-world spaces (Garling & Evans, 1991b). Thus, advantage (PD_A) and expectation (PD_E) were identified as PD indicators. The PD results of AME and SoP questionnaires were compared by applying the Spearman's correlation analysis.

Table 5.3. Spearman's correlation analysis comparing the results of the questionnaire and the AME methods for place dependence.

Place dependence		Expectation (PD_E)	Advantage (PD_A)
I would miss this place if I were no longer working in it.	Correlation Coefficient	0,53	0,55
	Sig. (2-tailed)	**0,00***	**0,00***
There is a congruence between this place and my identity.	Correlation Coefficient	0,49	0,48
	Sig. (2-tailed)	**0,00***	**0,00***
This place is the best to have the work properly done.	Correlation Coefficient	0,51	0,54
	Sig. (2-tailed)	**0,00***	**0,00***

The results of the Spearman's correlation analysis indicated that there was statistically significant and robust positive correlation between PD_E and SoP questionnaire results ($r(135)= 0.35$, $p= 0.00$ with "I would miss this place if I were no longer working in it" statement; $r(135)= 0.49$, $p= 0.00$ with "there is a congruence between this place and my identity" statement; $r(135) = 0.51$, $p= 0.00$ with "This place is the best to have the work properly done" statement).

Furthermore, PD_A showed statistically significant and robust positive correlation with SoP questionnaire results, as well ($r(135)= 0.55$, $p= 0.00$ with "I would miss this place if I were no longer working in it" statement; $r(135)= 0.48$, $p= 0.00$ with "there is a congruence between this place and my identity" statement; $r(135)= 0.54$, $p= 0.00$ with "This place is the best to have the work properly done" statement).

The AME is suitable and efficient in testing PD for both indicators. This result supports the hypothesis that the physical setting and user's behaviors once interacted can create a dependence relation between place and user (Boerebach, 2012). Hence, behaviors and attitudes towards interpreting this place regarding their aims and needs are affected.

5.3 Effects of sound source composition on place indicators

This section presents the effects of sound source composition on place indicators. The sound source composition of this study consists of familiar and unfamiliar background sounds. The familiarity of sound source composition was defined according to the original orientation of the participant's office and the background noises presented to participants during the experiment. More detailed information on the production of the sound source composition used in the experiment can be found in Chapter 3.2.

5.3.1 Background noise

One of the main aims of this study is to clarify the effects of the familiarity of sound sources on participants' sense of place. Therefore, during the experiments, the participants were exposed to personalized sound environments in which the sound sources were tagged as familiar or unfamiliar to them. The results of the analysis are presented in Table 5.4. The one-way ANOVA indicated significant differences between the average scores of place indicators and background noise familiarity, ($F(15, 2)= 13.60$, $p= 0.00$). However, the individual scores of place indicators were affected differently. As it is mentioned in Section 5.2, PA_E and PI_C indicators showed no significant correlation with PA and PI constructs when the AME scale was implemented. Similarly, there are no significant differences between PA_E with background sound source familiarity ($p= 0.13$) and PI_C indicator ($p= 0.96$). PA_O indicator was significantly affected by the background noise familiarity ($p= 0.00$). Additionally, PI_M ($p= 0.00$), and both PD_E ($p= 0.00$) and PD_A ($p= 0.00$), showed significant differences with the background sound source familiarity.

Table 5.4. One-way ANOVA results, showing the effects of background sound source composition on place indicators (AME method).

Place indicators		Original	Unfamiliar	Familiar	Sig.
Emotions (PA_E)	Mean	5,94	5,37	6,42	0,13
	Std.	2,73	2,2	3,38	
Orientation (PA_O)	Mean	8,12	4,5	5,04	**0,00***
	Std.	4,54	2,31	5,06	
Meaning (PI_M)	Mean	8,35	4,25	4,16	**0,00***
	Std.	3,95	1,85	2,41	
Character (PI_C)	Mean	5,57	5,47	5,58	0,96
	Std.	2,86	2,4	2,44	
Expectation (PD_E)	Mean	7,33	3,92	4,4	**0,00***
	Std.	5,39	1,99	4,02	
Advantage (PD_A)	Mean	7,91	3,54	4,67	**0,00***
	Std.	5,22	1,97	5,86	

Results showed that the familiar background sound source composition showed an increased effect on place indicators compared to the unfamiliar background sound source composition. These results are contradicting to those obtained from the SoP questionnaire results. PA_O and PD_E were increased by 12% and PD_A was increased by 31% when the background sound source composition was familiar to the participants. However, PI_M showed an opposite evaluation: a decrease by 2% in the familiar background sound source composition (figure 5.1).

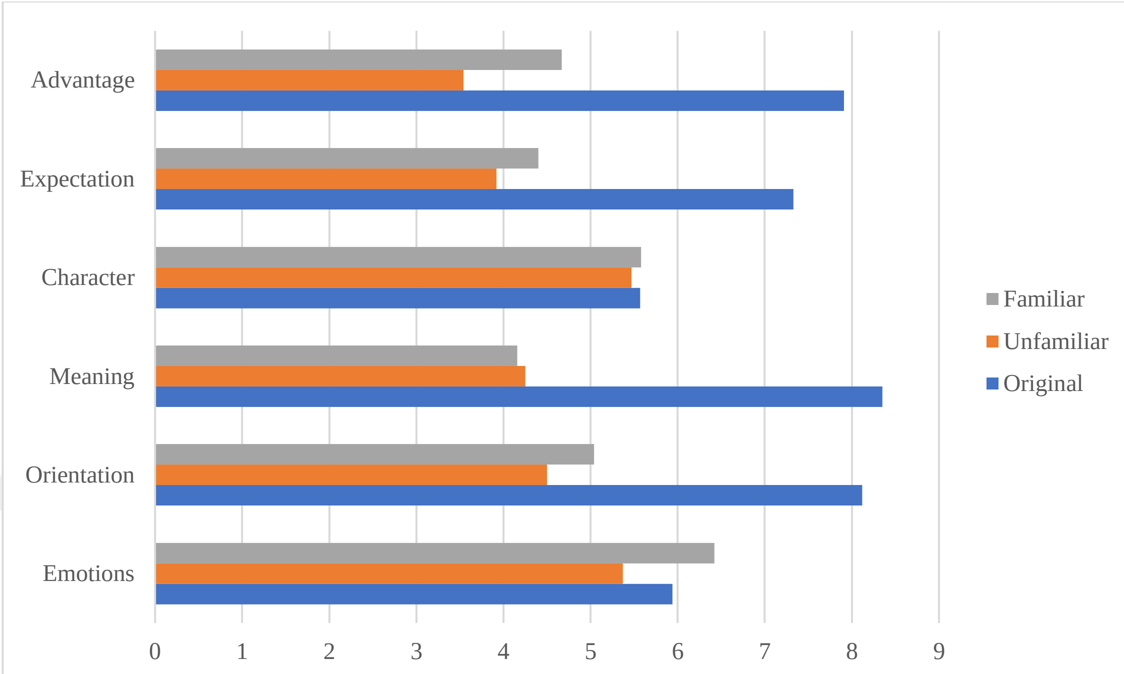

Figure 5.1. The comparison between place indicators under different background sound source compositions (AME method).

Place construct statements used in SoP questionnaires reflected the participants' sense of place more generally in comparison with place indicators used in the AME method Hence, the contradicting results suggest that specifying place indicators might have shown the advantage of familiar background sound source composition over the unfamiliar one regarding the given indicators. This emphasizes the importance of using the AME method in similar studies where physical stimuli effects are sought upon the subject response. The AME method showed more adaptivity to the experimental method by specifying the indicators that achieve the sense of place. However, the SoP questionnaire is more suitable for experiencing stimuli for a relatively sufficient time.

5.3.2 Signals

The second component of the sound source composition presented to participants during the experiments were sound signals (i.e. footsteps, door knocking, chair, door, locker, and drawer). The sound signals were put together to create an aural composition that the participants experience during a regular day in their offices. Place indicators obtained from AME method were affected mainly by footsteps and knocking sound signals (Table 5.5). The Spearman's correlation analysis revealed that the effects of footsteps were negatively correlated with the PAo indicator (p= 0.00), PD_E indicator (p= 0.00), and PD_A indicator (p= 0.04). The knocking signal also showed significant correlations with the same indicators (p= 0.00). There was a significant correlation between the chair signal and PA_E indicator (p= 0.04). Lastly, the drawer signal had a significant correlation with PD_A indicator (p= 0.04).

Table 5.5. Spearman's correlation analysis results, showing the effects of signal sounds on place indicators (AME method).

		PA_E	PA_O	PI_M	PI_C	PD_E	PD_A
Footsteps	Cor. Coef.	-0,14	-0,20	-0,22	-0,03	-0,29	-0,26
	Sig. (2-tailed)	0,10	**0,01***	**0,00***	0,72	**0,00***	**0,00***
Knocking	Cor. Coef.	-0,05	-0,27	-0,31	-0,12	-0,25	-0,31
	Sig. (2-tailed)	0,56	**0,00***	**0,00***	0,16	**0,00***	**0,00***
Chair	Cor. Coef.	0,17	-0,14	-0,10	0,04	-0,10	-0,10
	Sig. (2-tailed)	**0,04***	0,10	0,22	0,59	0,25	0,23
Door	Cor. Coef.	0,10	0,02	0,02	0,08	0,10	0,04
	Sig. (2-tailed)	0,24	0,77	0,77	0,30	0,22	0,58
Locker	Cor. Coef.	-0,04	0,00	0,03	0,00	0,00	0,04
	Sig. (2-tailed)	0,62	0,98	0,68	0,94	0,98	0,61
Drawer	Cor. Coef.	0,01	-0,10	-0,10	-0,11	-0,14	-0,17
	Sig. (2-tailed)	0,86	0,24	0,21	0,19	0,09	**0,04***

Footsteps and knocking effects on place indicators are approximately similar to that with the SoP questionnaire. The reason behind that effect can be interpreted the same as well. However, the effect on PA_O should be analyzed more. Orientation is an attribute obtained by occurrences those are clearly identified along stability in temporal domain (Garling & Evans, 1991b). These are two characters for the two affective sound signals. Yet, they showed a negative effect on orientation indicator and diminished the participants' orientation when sounded. The same can be applied to PI_M: meaning is given to spaces after comprehending identifiable clear properties of the space and the possible meaning can be attached to these properties (Garling & Evans, 1991b). The possible explanation of this effect is that participants' concentrating on the acoustic stimulus during the experiment led to interpreting these signals' effect acoustically, i.e., auditory-biased. This emphasizes the correcting and enhancement of different modalities integrated during experiencing an environment. Thus, place indicators could have been evaluated differently if participants had a holistic experience of the office along with hearing these signals—assigning a task or using VR can be used to validate this assumption. Furthermore, frequency and amplitude patterns might have a further influence, as it is explained in section 4.2.3.

5.4 Effects of reverberation time on place indicators

During the preparation of the aural environments, two different reverberation times (0.8 seconds and 1.2 seconds) were applied to the final sound source composition mix to test the influence of reverberation time on the sense of place and indicators (see Chapter to 3.5). The participants also evaluated the original aural environment of their offices, resulting in three different room acoustic conditions to be analyzed within this section. One-way ANOVA results indicated significant differences between average place indicators measured by the AME method, ($F(15, 2)= 13.61$, $p= 0.00$). The results of the analysis are presented in Table 5.6. When the individual indicators were investigated, it was observed that not all indicator showed statistically significant differences. PA_O ($p= 0.01$) and PI_M ($p= 0.00$) indicators showed significant differences. Both PD indicators, PD_E and PD_A, showed significant differences with varying reverberation times ($p= 0.00$).

Table 5.6. One-way ANOVA results, showing the effects of reverberation time on place indicators (AME method)

		Original	0.8 sec.	1.2 sec.	Sig.
Emotions (PA_E)	Mean	5,94	5,68	6,11	0,71
	Std.	2,73	2,86	2,92	
Orientation (PA_O)	Mean	8,12	4,58	4,95	**0,01***
	Std.	4,54	2,22	5,11	
Meaning (PI_M)	Mean	8,35	4,2	4,21	**0,00***
	Std.	3,95	1,91	2,37	
Character (PI_C)	Mean	5,57	5,63	5,41	0,88
	Std.	2,86	2,1	2,69	
Expectation (PD_E)	Mean	7,33	3,89	4,42	**0,00***
	Std.	5,39	1,91	4,05	
Advantage (PD_A)	Mean	7,91	3,76	4,45	**0,00***
	Std.	5,22	1,85	5,93	

Participants' response to place indicators (i.e., their SoP) was increased with higher reverberation times. There was an increase of 8% in PA_O indicator, 13% in PD_E indicator, and 18% in PD_A indicator. PI_M indicator also showed a marginal increase of 0.2% (Figure 5.2).

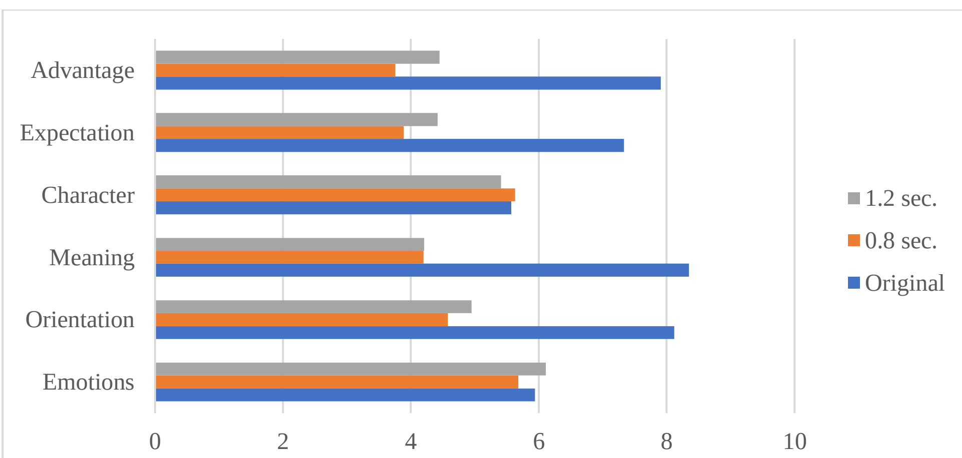

Figure 5.2. The comparison between place indicators under different reverberation times (AME method)

As orientation is an environmental attribute that requires temporality-stable identity-characteristic occurrences, it was more affected by the reverberation time, which may have enhanced perceiving these two requirements. Hence, these occurrences were rendered identifiable and had a meaning attached by the participants to the place. Furthermore, the higher ambient noise resulted from longer reverberation time may have the space perceived more suitable and matching for an educational space, thus meeting the participants' expectation from their offices. Accordingly, longer reverberation time rendered the office more advantageous for its function.

5.5 Comparison of sense of place in original and simulated environments

As expected, the sense of place was reported differently among the fifteen participants when they experienced the original environment of their offices and when the environment was digitally simulated. As a final analysis, the comparison between the original and simulated aural environments was analyzed both for the SoP questionnaires and the AME method. The comparison results for the SoP questionnaires are presented in Figure 5.3 and the results of the comparison for the AME method are presented in Figure 5.4.

First, SoP questionnaire results were analyzed (Figure 5.3). In original condition, the PA_1 "I am happy being in this place" had a 5% higher mean (Mean= 2.33) than the PA_2 "I am willing to make this place even better" (Mean= 2.2) and an 80% higher mean than the PA_3 "I would not substitute this office for another" (Mean= 1.2). In the simulated condition, the PA_2 had a 105% higher mean (Mean= 1.4) than the PA_1 (Mean= 0.68) and a 268% higher mean than the PA_3 (Mean= 0.38).

In the original condition, PI_1 "I would like to work here for a long time" indicated the highest mean (Mean= 1.6); and was 34% higher than PI_2 "Everything in this place is a reflection of myself" (Mean= 1.2) and 49% higher than PI_3 "Working in this place is more important than working elsewhere" (Mean= 1.07). The same comparison was found in the simulated condition: PI_1 had the higher mean (Mean= 0.45); and was 5% higher than PI_2 (Mean= 0.3) and 150% higher than PI_3 (Mean= 0.18).

Finally, PD_2 "I would miss this place if I were no longer working in it" was indicated with the highest mean (Mean= 1.8) in the original condition. It was 22% higher than PD_1 "There is congruence between this place and my identity" (Mean= 1.47), and 50% higher than PD_3 "This place is the best to have the work properly done" (Mean= 1.2). In simulated condition, PD_1 showed the higher mean (Mean= 0.39). It was 22% higher than PD_3 (Mean= 0.32) and 129 % higher than PD_2 (Mean= 0.17).

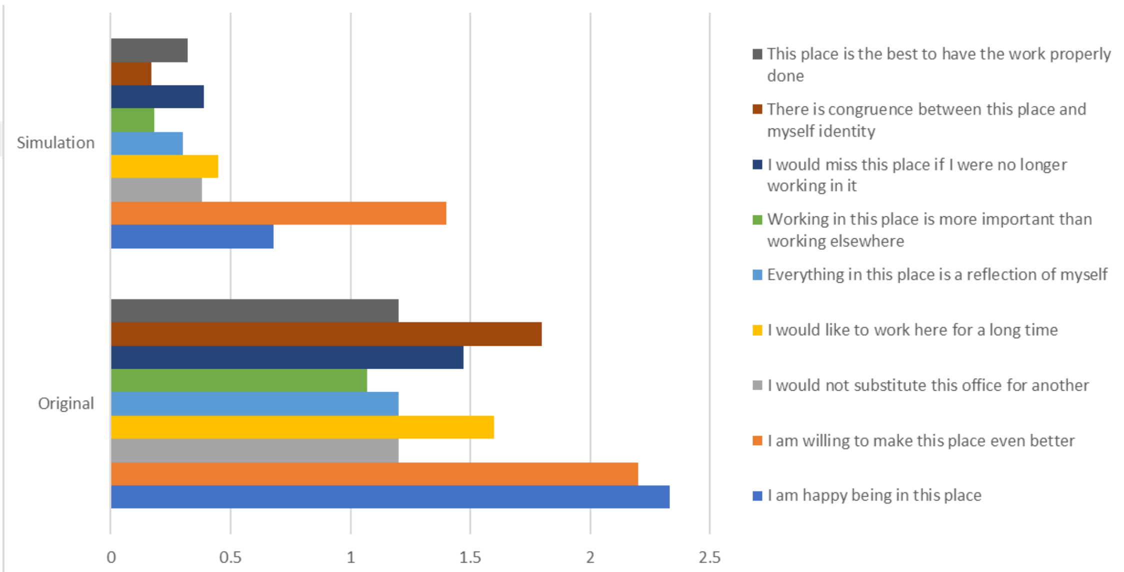

Figure 5.3. Comparison of place constructs evaluation in original and simulated conditions (SoP questionnaire)

Place constructs were evaluated more uniformly in the original condition. The higher mean of PA_1 "I am happy working in this place" is competing with other means from other statements in each construct. However, simulated conditions showed an obvious prerogative of place attachment's PA_2 "I am willing to make this place even better". This observation can be linked to the time spent by the participants experiencing the office and the bias they may have towards the original conditions of their offices. Furthermore, the fact that the participants were headset-free during evaluating the original condition may have its important contribution to this result.

The comparison of the results of the AME method between the original and simulated environments was also examined. The results of the comparison are presented in Figure

5.4. Regarding place attachment indicators in the original condition, PA_O showed the highest mean (Mean= 8.12) and was higher than PA_E mean by 37 % (Mean= 5.94). The simulated condition showed an opposite relation between the two indicators. PA_E indicator showed the highest mean (Mean= 5.9). It was higher than PA_O by 23% (Mean= 4.77).

PI_M showed the highest mean in the original condition (Mean= 8.35). It was higher than PI_C by approximately 50% (Mean= 5.57). Interestingly, the relationship between these indicators was the opposite in the simulated conditions. The PI_C indicator had the highest mean (Mean= 5.53). It was 31% higher than PI_M (Mean= 4.21).

PD_A indicator showed the highest mean in the original condition (Mean= 7.91). It was 7% higher than PD_E indictor (Mean= 7.33). PD_E had the highest mean in the simulated condition (Mean=4.16). It was 1% higher than PD_A indicator's mean (Mean= 4.11).

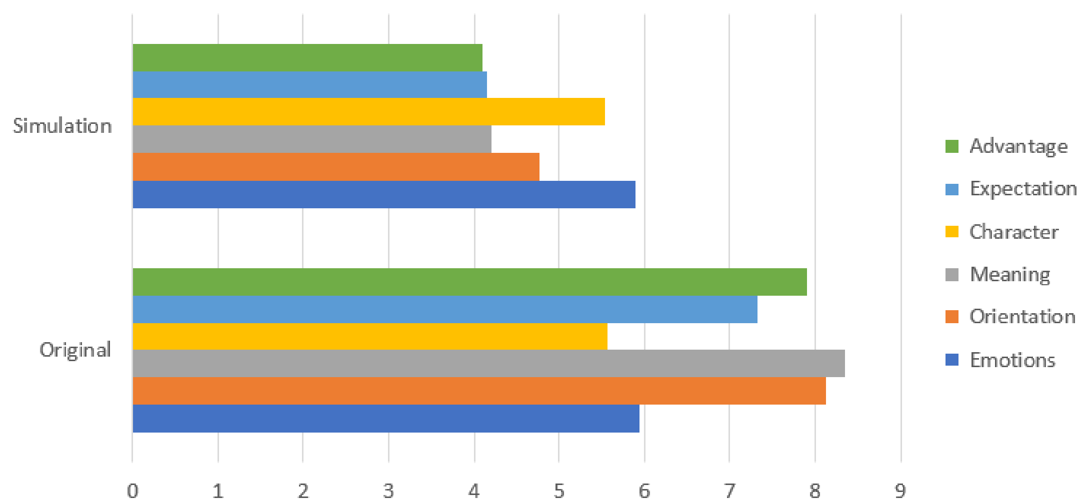

Figure 5.4. Comparison of place indicators evaluation in original and simulated conditions

Compared with place constructs evaluated by the sense of place questionnaire, the results of the place indicators measured by the AME method are more homogenous in both conditions. The highest mean in the original condition was obtained for the PI_M indicator. Its relation to other indicators of other place constructs was not as prerogative as in the sense of place questionnaire. The same is observed in the simulation, which had the highest mean for PA_E indicator. This observation emphasizes the possibility that specifying place constructs by indicators directed participants' attention, and accordingly influenced their evaluation, to different aspects of their experienced environment; unlike the sense of place survey which dealt with place constructs more generally.

The difference between the SoP questionnaire and AME methods suggests that the AME and similar psychophysical scaling methods are more adaptable with experimental studies when sense of place is investigated. The literature has shown that the SoP questionnaire is mainly used to investigate the sense of place of users who experienced the different aspects of the environment for a relatively sufficient time. When an environmental stimulus (acoustical condition) was changed in this study, the AME showed advantage regarding the short time participants had to experience and adapt to the new acoustic condition.

5.6 Conclusion

The study used the AME scale in testing participants' sense of place. This method was not used before for these kinds of studies. However, the study could validate the appropriateness of using the AME method for investigating the sense of place.

Background sound familiarity was evaluated diminishing when the sense of place questionnaires was used. However, this familiarity showed its enhancement effect when the AME method was used. This suggests that using place indicators directs users' attention to those indicators. Accordingly, the evaluation becomes focused on different aspects of the experienced environment, unlike the general evaluation obtained by using the SoP questionnaire.

The differences in using the sense of place questionnaire and AME suggest that AME and similar psychophysical scaling methods are more adaptable with experimental research. The SoP questionnaires are so far used to investigate the sense of place of users who had a sufficient time experiencing the environment's different aspects.

CHAPTER 6

DISCUSSION

Places are formed by the physical setting, social dynamics, and socio-cultural factors (Park & Evans, 2016). The physical setting is one of the main and initial components to form a place. Users experience a space overtime in a holistic way that space's aspects and features influence their interpretation of and relation to the emerged place. Accordingly, sense of place is not limited to an effect from a specific factor. Rather, sense of place is a holistic experience that users form with places. Nevertheless, investigating how the aural setting plays a role in forming sense of place is important. The fact that both experiencing a place and the acoustic space require a temporal domain to reveal their features indicates an interwoven relation between these two phenomena.

After reviewing the relevant studies that investigate the relation between sense of place and objective room acoustics parameters, it was found that the number of studies that integrated the two concepts is limited. There is an imbalance between objective parameters in environmental analysis and their subjective interpretation. Objective parameters merely provide physical measurements. They cannot distinguish between different sounds and their subjective impact (Truax, 1984). Thus, involving the holistic experience of sense of place is necessary to understand the impact of the physical sound on the subjective interpretation and action rendered by it in spaces. Reviewing the literature regarding both concepts and those related to environmental studies facilitated linking room acoustics parameters to sense of place and indicators (see section 2.2.8).

The following sections present the discussion of the main findings from this study.

6.1 Effects of reverberation time on the sense of place

This study revealed a direct influence of reverberation time and sound source composition on the sense of place of the participants. Although all three place constructs were affected by the change in reverberation times and changing aural composition at some level, the most affected place constructs are place dependence and place attachment. Being a temporal stimulus, room acoustics influence on users' interpretation of the place—sense of place—is agreeable with another study which found that time-varying stimuli tend to have a greater influence on evaluating indoor environmental comfort under steady-state conditions (W. Yang & Moon, 2019). Regarding the reverberation time, the resulted pleasant aural environment and provided information about the spatial relations from reverberation (Ballou, 2008; Blesse & Salter, 2007; Truax, 1984) have a direct influence on users' feelings towards the place and having the proper means of orientation (Altman & M. Low, 1992; Norberg-Schulz, 1976). This finding is in line with a previous study (Koumura & Furukawa, 2017) that suggested the existence of an auditory mechanism adaptive to reverberation. Thus, users can recognize different sound sources in a reverberant environment (Koumura & Furukawa, 2017).

Longer reverberation times (1.2 sec) had a more significant influence on the participants' sense of place thanthe shorter reverberation times (0.8 sec), and it enhanced their sense of place in most cases. This is similar to a previous study (Wu, Kang, Zheng, & Wu, 2020) that found an increased acoustic comfort with higher reverberation times. However, their results occurred with long reverberation time in correspondence to lower SPL. Still, this study suggests that longer reverberation times enhanced participants' perceived aural environment is more suitable for an office within an educational institute. The reason is that long reverberation times create a more active, responsive, and higher-ambient-noise spaces—a scheme the participants may expect from their offices.

6.2 Effects of background noise on the sense of place

As part of the sound source composition, the background noise is influential for the sense of place. The study revealed that listening to and experiencing an unfamiliar background noise enhanced participants' sense of place. This effect can be interpreted from the perspective of attention effect: the more the listener is familiar with an aural structure, the easier to focus attention towards other dimensions; especially novel dimensions of the structure (Pashler & Yantis, 2002). It can also be related to the lower sensory detection threshold users have towards familiar stimuli (Pashler & Yantis, 2002). Furthermore, participants' expectations from the place might have created this effect. Expectations are related to familiarity and users' previous knowledge of the place, its stimuli, and the experience in it (Bild et al., 2018). Yet, participants' attached importance to place, which is linked to place identity construct, was diminished with unfamiliar background noise. These results suggest that importance is given to a place after a long emersion and experiencing each aspect of it. Thus, the participants need to spend a longer time with the new acoustic condition to determine the importance of the place.

Even though the earlier-mentioned study by Koumura and Furukawa (2017) concentrates on the perception of materials of sound sources in reverberant spaces, it is a supplement to the findings of this study which observed a direct influence of sound source composition. Along with the sound source's reverberation influence, the background sounds and sound signals were similarly influential. Sound sources are claimed to be influential factors affecting users' subjective evaluation of acoustic comfort and the overall environment (Kang et al., 2012). Their influence on the sense of place can be due to the fact that users tend to compare sound properties to determine sound source's size, form, material, and actions set it to vibration (Pashler & Yantis, 2002). These attributes render occurrences in the space identifiable. Thus, users' ability to orient in the place, linking meaning to these occurrences and hence to the place, and matching their expectations from the place are rendered. Accordingly, place attachment, place identity, and place dependence, respectively, are affected. This finding supports another study (T. Yang & Kang, 2020) which concluded that evaluating the place's aspects, such as annoyance or spaciousness, is influenced by the sound sources. Furthermore, it found that perceived reverberation is influenced by sound sources as well. These findings emphasize the importance of both parameters combined in evaluating users' sense of place.

When place indicators were investigated, a contradicting relation was observed. Participants' sense of place enhanced when they listened to a familiar background noise. This result suggests that specifying the indicators of each place construct can eliminate the attention effect mentioned earlier. Participants' attention was no longer attracted by novel dimensions in the space. Instead, the mentioned indicator influenced their attention to an attribute or two linked to it that exists in the original environment. Thus, the evaluation of the place and sense of place were influenced.

6.3 Effects of sound signals on the sense of place

Although sound source composition directly influenced the sense of place, sound signals—which are part of the composition—did not have an equal influence on the sense of place evaluated by the participants. Despite the different sound signals used in this study, only footsteps and door-knocking signals directly influenced the constructs, and could diminish participants' sense of place; thus, affecting their behavioral attitudes towards the place. This effect suggests that participants' attention was drawn to further activities happening inside or around the place. They might have indicated an approaching and/or penetration of their personal and private territory. Amplitude increase and frequency change are associated with approaching sound sources (Wilkie & Stockman, 2020), which is observed from signals' spectrogram analysis. Orientation, which is obtained by temporal domain-stable occurrences, could not be enhanced by these two signals—even though their spectrograms showed a stability in temporal domain and frequency distribution. This result suggests the importance of other modalities to enhance the perception of similar sound signals and correct their function and expected results (Bregman, 1994). Using VR and AR methods is expected to show a different result from similar signals.

6.4. AME as a prediction tool for place indicators

Comparing the experiment results in original and simulated acoustic conditions could reveal the importance of using Absolute Magnitude Estimation and similar psychophysical scaling methods in experimental studies regarding sense of place. Place constructs results evaluated by the SoP questionnaire were more uniform in the original condition than those obtained in the simulating conditions. The homogeneity of the original condition's results can be linked to the time spent experiencing the space. Thus, a bias towards the original condition resulted. Furthermore, the fact that participants evaluated the original condition headset-free may contribute to this result. Place indicators evaluated by the AME method in both original and simulated conditions showed a homogenous result. This emphasizes the possibility that specifying sense of place by indicators directs users' attention to different aspects of their experienced environment; accordingly, it influences their evaluation. This is unlike the sense of place questionnaire which deals with place constructs more generally. Furthermore, this result suggests that the AME and similar psychophysical scaling methods are more adaptable with experimental research regarding investigating the sense of place. SoP questionnaire is shown to be used with investigating sense of place of users who experienced each aspect of the place within a sufficient time. When an environmental stimulus (acoustical condition) in this study was changed, the AME method showed an advantage regarding the short time participants had to experience the new condition and evaluate the place after adapting to it within 30 seconds. It revealed participants' sense of place from directing the influence towards the constructs' indicators rather than investigating their general relation towards the place.

6.5 Further analysis

Reverberation time and sound source composition and other acoustics properties in the space are part of the place's genius loci. This is supported by genius loci's definition: It is the integration of physical and spiritual elements that give meaning, value and emotions to places (Campolo, 2014). This study revealed that physical room acoustics added to the place various characteristics and affected participants' attachment, identity, dependence, and the holistic experience in the place. The physical features of sound in space and users' interpretation accordingly accentuate the idea that each place is a being that desires to become and to give life, character, and essence to people and places (Norberg-Schulz, 1976). The finding of this study suggests that there are acoustic genius loci in the light of this proposed integration. The space's acoustics are potentials to form a place that need the user to interact with them. Similarly, the user needs the potentials of the space to form a place and to achieve the sense of place. Both beings are required to evoke the other.

Analyzing the spectrograms of the sound signals indicated the importance of psychoacoustics in investigating physical sounds' influence on the sense of place. The variations of signals' amplitudes, frequency range, and temporal distribution significantly influenced the sense of place. The two most influential signals had a rhythm of amplitudes that are uniformly distributed in equal intervals at each amplitude and frequency range. They also marked the highest amplitude at approximately 5 kHz. Amplitude is related to loudness perception (Fastl & Zwicker, 2007); which is associated with estimating the intensity of a sound source and its location (Ballou, 2008; Serences & Wixted, 2018). These attributes are linked to feelings of satisfaction of and comfort in the place and judging its suitability for its designed function. Furthermore, they are linked to sense of distance related to the direct-to-reverberant ratio in the space (Ballou, 2008). Thus, orientation and meaning indicators of place can be influenced by loudness.

Frequency is related to pitch perception—the higher the frequency, the higher the pitch and vice versa (Goldstein, 2010). Furthermore, pitch is related to periodicity perception, thus it helps to perceive the properties of sound sources and identifying them (Serences & Wixted, 2018). Furthermore, pitch perception depends on phase-locking to the repetition rate of the wave reaching the basilar membrane. This perception degrades rapidly beyond 4 kHz (Serences & Wixted, 2018). The influential sound signals differed in pitch, which possibly affected the perception of occurrences in the place, influencing the sense of place.

The temporal characteristics of sound signals are associated with timbre—along with other properties, such as the spectrum, waveform, sound pressure, and frequency location

(Ballou, 2008). Events recognition is influenced by timbre (McAdams & Drake, 2002). Thus, this parameter is essential for orientation, meaning, and emotions of listeners. These parameters help identify sound sources as they are aided with the enclosure's acoustics (Pashler & Yantis, 2002). The variance in sound intensity and power, frequency distribution, and amplitude of sound sources in the place creates different perception and interpretation of the space/place due to the perceived loudness, pitch, timbre, and other psychoacoustical parameters. As these parameters can render occurrences in the space more clearly, space experience and place forming are influenced.

Even though the study showed the auditory stimulus effect on the sense of place, other modalities should be considered since sense of place is a holistic experience. The effect of reverberation time and sound sources may be influenced by the presence of other stimuli, such as the room's temperature, the visual setting, lighting, and other possible stimuli in the place. The results of background noise effects on participants' SoP support this claim. Higher SoP caused by unfamiliar background noise can be the result of the multisensory perception. When the participants consciously experience a setting in a multisensory way, the attention span is affected and the judgment of the place is influenced at social, emotional, and cognitive levels (Haverkamp, 2013; Spence, 2020). Attention is mainly multisensory, and the stimuli can be attached to a single percept even before attention. Thus, for instance, the visibility of the source and the visual context is significantly important for attention (Kang et al., 2016). Furthermore, the effects of sound signals on place indicators suggest the influence of multisensory integration. Despite the physical properties necessary for orientation and meaning indicators in footsteps and knocking signals, a diminished sense of place was observed. In this case, the correcting from other modalities during the experience was needed. This correcting was partly missing since the experiment focused on the acoustic stimuli and had the interpretation of these signals auditory-biased. Participants were using headphones to evaluate the overall place. Like other experimental tasks, participants were asked to identify, discriminate, or locate the auditory stimulus. Thus, an emphasis on perceptual judgments occurred. Accordingly, their predictions of the upcoming stimulus facilitated the judgment and was highly adaptive (Serences & Wixted, 2018). They were expecting a change in the auditory stimulus—expectation plays a crucial role in auditory perception

(Sloos & McKeown, 2015). Thus, multisensory experience is important to eliminate or decrease this bias.

The results of this study can add a further objective-subjective correlation between physical acoustics and soundscape. Room acoustics is energy-based, whereas soundscape is subjectivity-based research (A. L. Brown, 2014). The study highlighted the importance of the indirect outcomes of the acoustic environment (see Section 2.1.6). This revealed the influence of space's acoustic attributes on forming participants' experience and hence the place. However, using place indicators seemed to raise the conscious attendance to the different acoustic conditions and evaluating sense of place. Thus, this study recommends considering the space's design and the absolute room acoustics outcomes to emerge, in addition to time investment and experience which facilitate interpreting these outcomes subjectively. This can be considered as a contribution to soundscape research which treats the consciously experienced sound in the already-experienced space. Briefly, this study investigates sound in space-place construct. Soundscape investigates sound in a place-place construct. Thus, the results of this study which supports the correlation between physical sound properties and subjective forming of sense of place can facilitate the planning of soundscape in an environment since it considers the places to be formed due to space's acoustics.

6.6 Limitations and suggestions for future studies

The results and the findings of this study are subjected to several limitations. Due to the recently emerged health problems during this study, the sample size is considered in the minimum range. Only fifteen participants could take part in conducting this study. A larger sample is expected to lead to further results and more reliable data. Another limitation that concerns the sample is that all participants were from the faculty of architecture. The concept of sense of place is more likely well known to them. A bias may have occurred in inquiring about their sense of place. Having the study conducted on other users is important in this case for future studies. Furthermore, there was a limitation in using the type of spaces for the study. A comparison with other spaces is suggested to be carried for future studies. In this regard, spaces with special acoustic demands should be investigated and compared to further understand users' expectations from and emotions towards the place.

The questionnaire used in this study used SoP statements and place indicators translated from the English language to the Turkish language. The translation was almost literal since there were limited numbers of studies regarding sense of place questionnaires available in Turkish language. Accordingly, the translation may have missed or added some aspects to the sense of place concept. Further studies about cultural differences and language-usage regarding sense of place are suggested.

This study faced a lack of time and usage of equipment. Accordingly, the physical parameters investigated in this study were limited to reverberation time and sound source composition. Other parameters are equally essential to be included in future studies and to understand their influence on the sense of place. Similarly, psychoacoustics parameters were analyzed generally by simple observation of sound signals' spectrograms. The literature suggests the importance and direct influence of psychoacoustics on sense of place. Thus, a more in-depth study on psychoacoustics role in forming places is to be considered in future studies.

The importance of multisensory perception in sensing the place is addressed in this study. However, due to the lack of time and equipment, the experiment was generally auditory-biased—users used headsets to evaluate the place with the new acoustic conditions. It is recommended to conduct a more holistic experience to investigate the influence of physical acoustics on sense of place. For instance, using VR, AR, or a similar setting to Soundlab (Choong, 2018).

To summarize, this study found that reverberation time and sound source composition directly influenced the sense of place of fifteen participants. It revealed that room acoustics could enhance and/or diminish participants' attachment to place, given meaning to place, and dependence on place. the contribution of room acoustics created participants' attitudes towards the experienced space/place and their evaluation.

Furthermore, this study could validate the appropriateness of using the AME method as a predicting tool for the sense of place.

CHAPTER 6

CONCLUSION

This study aimed to reveal the influence of physical acoustic parameters on sense of place. Based on a quantitative analysis of an experiment that used different acoustic conditions to test the resulted report of sense of place by participants, it can be concluded that changing reverberation time and sound source composition in a space influences the relationship users to have with the place—i.e., their sense of place. The results indicated that longer reverberation times enhance the sense of place, background sounds influence the sense of place, and certain sound signals diminish the sense of place.

The main findings of the study are:

- There is a direct influence of reverberation time and sound source composition on the sense of place.
- Among the three sense of place constructs, place attachment is the one that was the most affected by the room acoustic parameters.
- Longer reverberation times tend to create an increased sense of place compared to shorter ones.
- Background noise is influential in enhancing/diminishing the sense of place. Unfamiliar background sound compositions tend to increase the sense of place, especially place attachment and place dependence constructs.
- Sound signals' psychoacoustical properties affect the sense of place. The signals that require another person to be generated (i.e., footsteps and knocking sounds) tend to decrease the sense of place.
- The AME scaling method proved valid for assessing the sense of place.

- Place indicators evaluated by the AME give more specific and homogenous results than using the SoP questionnaire.

Using the AME method in this study indicated that sense of place can be measured using psychophysical scaling methods. Furthermore, it suggested that the sense of place questionnaires investigate users' sense of place generally. In contrast, the AME could direct the evaluation to the indicators that create the relationship with the place. This approach provides a new method into the sense of place studies and encourages more experimental investigation regarding it.

Based on these conclusions, other room acoustics parameters are considered to be investigated—SPL, SNR, and other parameters are of equal importance to be investigated. Furthermore, it is advised to use more immersive auralization and visualization methods in future studies. For instance, VR environments, AR environments, and task-based studies are expected to conclude that other dimensions of physical parameters influence the sense of place.

As an imbalance exists between objective parameters in environmental analysis and its subjective interpretation, this study could contribute to change this fact by focusing on objective parameters of sound and its subjective interpretation and influence in creating users' relation to places and sense of place. The findings of the study revealed that there are interactions and correlations between the two realms of room acoustics and sense of place which should be taken in consideration in architectural design.

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APPENDIX

This appendix presents the questionnaire (Turkish and English version) that was used in the study to evaluate the sense of place under different acoustic conditions. The same questionnaire was repeated 9 times: once for the original condition and 8 times for the 8 simulations.

TURKISH VERSION

Ofis mekanlarında oda akustiğinin yer duygusu üzerindeki etkisi

Bu çalışmanın amacı, oda akustik parametrelerinin kullanıcıların yer duygusu üzerindeki etkilerini incelemektir.

Katılımınız için teşekkür ederiz.

1- Lütfen sizin için uygun seçeneği işaretleyiniz:

Cinsiyetiniz ☐ Erkek ☐ Kadın

Eğitiminiz ☐ Ortaokul veya altı

☐ Lise

☐ Lisans derecesi

☐ Yüksek lisans ve üzeri

Uyruğunuz ☐ T.C. ☐ Yabancı

Yaşınız ☐ 24 yaş altı ☐ 25-34 ☐ 35-44 ☐ 45-59 ☐ 60 ve üzeri

Çalışma şekliniz ☐ İşveren ☐ Yarı zamanlı çalışan

☐ Tam zamanlı çalışan

☐ Diğer (Lütfen belirtin) … … … … …

İşe nasıl gidip geliyorsunuz?

☐ Otomobil ☐ Toplu Taşıma ☐ Bisiklet

☐ Yürüyerek ☐ Diğer (Lütfen belirtin) … … … … …

Ne zamandan beri burada çalışıyorsunuz?

… … … … … … … …

Ne zamandan beri bu mekanı kullanıyorsunuz?

… … … … … … … …

Bölüm 1

Bu bölümde oda akustiği koşullarının yer duygunuzu nasıl etkilediğini öğrenmek istiyoruz. Bu amaçla, bu mekanda ve benzer mekanlarda alınan ses kayıtlarını dinleyeceksiniz. Sizden beklentimiz, her Açıklayıcıya (kalın/bold olarak yazılan kelime) bir sayı atamaktır. Atadığınız sayının büyüklüğü, dinlediğiniz kaydın yargılarınızı nasıl açıkladığını gösterir. Tam sayılar, ondalık sayılar veya kesirler gibi size uygun görünen pozitif sayıları kullanabilirsiniz.

Bu mekandaki **duygularınızın** yoğunluğunu açıklayan bir sayı yazın.	
Bu mekana ne kadar iyi **uyum** sağladığınızı açıklayan bir sayı yazın.	
Bu mekanın sizin için ne kadar **önemli** olduğunu açıklayan bir sayı yazın.	
Bu mekanın akustik **karakteristiğinin** yoğunluğunu açıklayan bir sayı yazın.	
Bu mekanın **beklentilerinizi** ne kadar karşıladığını açıklayan bir sayı yazın.	
Mekanın sizin için ne kadar **avantajlı** olduğunu açıklayan bir sayı yazın.	

Bölüm 2

Lütfen aşağıdaki ifadelere ne ölçüde katıldığınızı belirtiniz.

	Kesinlikle katılmıyorum	Tamamen katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Tamamen katılıyorum	Kesinlike katılıyorum
	1	2	3	4	5	6	7
Burada olmaktan mutluyum.							
Burayı daha da iyi hale getirmek için daha fazla zaman ve çaba harcamaya hazırım.							
Burada edindiğim tecrübeler nedeniyle, burayı başka bir yerle değiştiremem.							
Burada uzun süre çalışmak istiyorum.							
Buradaki her şey benim bir yansımamdır.							
Burada çalışmak başka bir yerde çalışmaktan daha önemlidir.							
Artık burada çalışmasaydım burayı özlerdim.							
Burasıyla kimliğim arasında bir uyum var.							
Burası işin uygun bir şekilde yapılması için en iyi yerdir.							

ENGLISH VERSION

Questionnaire

The purpose of this questionnaire is investigating the effects of room acoustic parameters on users' sense of place.

Thank you for your participation.

1- Please check your answer:

Gender ☐ Male ☐ Female

Education ☐ Middle school or under

☐ High school

☐ Undergraduate degree

☐ Postgraduate and above

Place of birth ☐ Native ☐ Non-native

Age ☐ under 24 ☐ 25-34 ☐ 35-44 ☐ 45-59

☐ 60and above

You are a/an ☐ Employer ☐ Part-time employee

☐ Full-time employee

Other (Please specify) … … … …

You commute to work by

☐ Car ☐ Public transportation ☐ Bike
☐ Walking ☐ Other (Please specify) … … … …

2- How long have you been working here/ using this space?

… … … … … … … …

3- Questionnaire

Section 1

In this experiment we would like to find out how various conditions of room acoustics affect your sense of place. For this purpose, you are going to listen to recordings taken in this space. Your task is to assign a number to every Descriptor (written in bold) in such a way that your impression of how large the number is matches your impression of how the recording you are listening to describes your judgment of the mentioned descriptors. You may use any positive numbers that appear appropriate to you—whole numbers, decimals, or fractions. Do not worry about numbers you assigned to preceding stimuli.

Assign a number that describes the intensity of your **Emotions** in this space.	
Assign a number that describes the intensity of how well you can **Orient** in this space.	
Assign a number that describes the intensity of how much this space **Means** to you.	
Assign a number that describes the intensity of how much this space is acoustically **characteristic**.	
Assign a number that describes the intensity of how much this space meets your **expectations**	
Assign a number that describes the intensity of how much **Advantageous** the space is for its function	

Section 2

Please specify to what extent you agree with the following statements

	Very strongly disagree 1	Strongly disagree 2	disagree 3	Neutral 4	Agree 5	Strongly agree 6	Very strongly agree 7
I am happy being in this place							
I am willing to invest more time and effort to make this place even better							
Because of the experience I had in this place, I would not substitute it for another							
I would like to work here for a long time							
Everything in this place is a reflection of myself							
Working in this place is more important than working elsewhere							
I would miss this place if I were no longer working in it							
There is congruence between this place and myself identity							
This place is the best to have the work properly done							