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MASTER'S DEGREE IN

ARCHITECTURE CONSTRUCTION CITY

TITLE:

SOUNDSCAPE APPROACH: SURVEY OF SOUND ENVIRONMENT IN A PUBLIC SQUARE IN LONDON AND ANALYSIS OF THE RELATIONSHIPS WITH URBAN CONTEXT AND PERCEIVED SAFETY

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TABLE OF CONTENTS

INTRODUCTION

1.1 PERCEIVED SAFETY IN THE CITIES

The topic of safety has always been at the center of the debate about the cities and citizen's request, therefore it occupies an important role for the administration that try to face it[iii]. Furthermore, this problem is also considered very important in daily journals and scientific journals, where reasercher and journalist work on a possible solutions for the dangerous events that surround the citizens everyday.

The feeling of unsafety, that everyday people lived, is it true or not? Analyzing databases of ISTAT[i], the Italian national institute of statistics, it is possible to find a data section relatives to crime and feeling of safety. The data are related with number of crime in Italy, and these are decreased in the last two years, also the number of thefts and homicides are decreased in last two years (Fig.1.1).

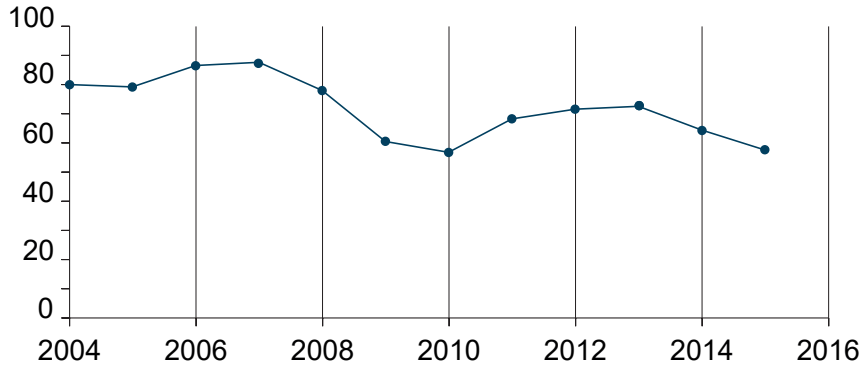


Fig.1.1 Datas of this graphic represent the number of robberies on 100.000 citizens.

However, the percentage of families who declare an high feeling of unsafety in the place where they live are increased in the last two years(Fig.1.2), just over the period where there is a general decrease of crime[ii].

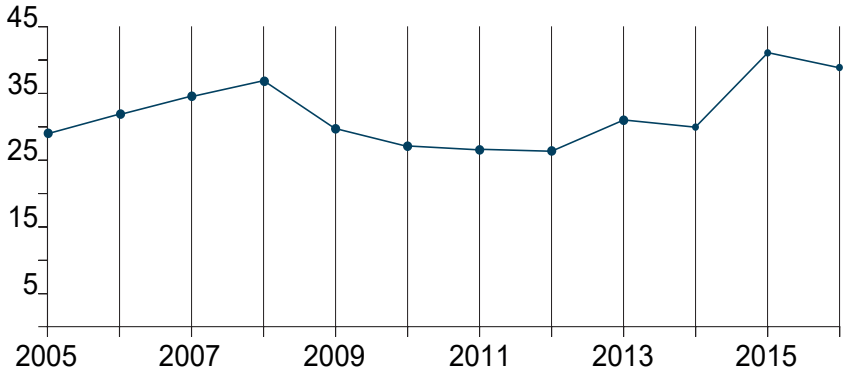


Fig 1.2 The data of this graphic represent the number of families on 100 who claim an high or high enough criminality risk in areas where they live.

These data demonstrate how it is important for administrations develop new strategy to increase the human perception of the cities and safety, analyzing in which areas of cities people perceived less safety and what are the possible solutions.

Public spaces are the arenas where public life unfolds, in a dynamic urban environment, public spaces should satisfy the needs and expectations of different, multicultural, and connected users[7]. Sometimes these spaces are not able to response to citizens' request of safety, and become a transition areas where none would like to stop and these quickly turn in the "no-go" areas.

There are several features that describe a "no-go area", the presence of abandoned or dilapidated buildings, with broken windows, dirty streets and wild vegetation. Another ambient cue that can characterize the no-go areas is light, a bad lightscape can increase the feeling of unsafety. Also Soundscape could increase a feeling of unsafety, when people can't listen any sound the perceived unsafety grows up[9]. It is this last ambient cue, the soundscape, that will be the protagonist of this paper review, and the relationship between soundscape and feeling of unsafety.

The feeling of fear and unsafety is closely connected with feeling of solitude, absence of people[9]. This is the reason why this paper analyzes several study recently published, that talk about the no-go areas and its soundscape. This research tries to find a way to increase the sense of being together with another, namely the feeling of social presence, in no-go areas, through the manipulation of soundscape[10].

1.2 SOUNDSCAPE AND PERCEIVED SAFETY

The soundscape, defined by international organization of standardization (ISO) [24] like, "The acoustic environment as perceived or experienced and\or understood by a person or people, in context", is the research areas where the relationship between acoustic environment, human perception and human responses or reaction are analyzed. It is very important evoke the strong relationship between acoustics and perceived sound, and how the human perception of sound can influence their behaviour[17].

There is also a relationship between soundscape and lightscape, that can influence the human perception of space and sound, in other words, the lightscape can influence the soundscape itself. For this reason, during the study about the soundscape, every groups or researchers use multi-sensory stimuli to investigate the soundscape of an area.

There are a lot of ways in which soundscape can influence people's behaviours, indeed since 1980 in economic studies areas several researchers analyzed the relationship between background music and client behaviour and worker behaviour in the shop. Ronald E. Milliman[2], during his research, demonstrated how background music can increase the aesthetic perception of shopping center, how that music can increase the number of purchases, and creates a better quality of workplace. Milliman also demonstrated that people move more slowly with slower music in a retail environment and hence spend more time there and purchase more. Subsequently he tested the effect of musical tempo in a restaurant, and he demonstrated that diners eat more quickly when the fast music is playing. All these studies can demonstrate the relationship between soundscape and people behaviour, but also between people behaviour and tempo and rhythm of background music.

Moreover, Tansik and Routhieaux in 1999[11], demonstrated that music

reduces pre-surgical anxiety. Taking into consideration the effect of music on people perception and anxiety levels, probably the music can be effective in manipulating perceived safety in public areas.

1.3 LITERATURE REVIEW

This literature review was performed in in three parts: the first part starts with the reaserch of perceived safety data in Italy, related with perceived safety of Italian family, and data related with criminality in Italy, the results compare in the introduction, and confirm that there are not a relationship between perceived safety and criminality. The second part consists in a study on soundscape, what is it and which is the relationship between human perception and acoustical environment. The third part consists in an array of principal study on the relationship between feeling of safety and soundscape.

1.4 SOUNDSCAPE POLICY

Tab 2.1 Numbers of articles find on engine research ScienceDirect.com

	Filter (Title, key words, abstract)
Search keywords	Total documents
“safety”, “noise”	6
“safety”, “acoustics”	3
“perceived safety”, “acoustics”	2
“social presence”, “noise”	1
“soundscape”, “safety”	7
“soundscape”, “lightscape”	1

Tab. 2.2 Numbers of articles find on engine research biblio.polito.it

	Filter (Title, key words, abstract)
Search keywords	Total documents
“safety”, “noise”	1
“safety”, “acoustics”	0
“perceived safety”, “acoustics”	1
“social presence”, “noise”	0
“soundscape”, “safety”	1

The concept of soundscape was born in 1977[14], when R.M. Schafer published the book with the first description of this point of view about acoustics environment. This book, namely "The tuning of the world", described how the soundscape investigated the perception of acoustics environment by people and their response, with acoustical traditional parameters, but also with new parameters that try to describe the feeling of people who perceived the soundscape.

Soundscape involve a lot of different study areas, like Architecture, Acoustics, Environment Health, Psychology, Sociology and several of other urban studies. All these disciplines study the human behaviour and how human experiences the environment, this is the reason why the soundscape study must be a multidisciplinary field of study[17].

Sound is usually considered like a noise, and the environmental policies of cities are focused on noise control[15], but it isn't necessarily true that reducing sound level improve quality of life in urban areas. Whit the theory of soundscape the sound can be considered not as a waste, rather as a resource. The soundscape can characterize the perception of quality life in the cities, and increase the aesthetics perception of the cities by citizens.

Then, soundscape is a new point of view about the acoustical environment because it is a construct of human perception, and it is influenced by acoustical parameters like sound pressure level and reverberation time, but also from socio-cultural background, listener's attitude, expectations, context of people who perceived that acoustical environment[20]. For example, previous research shows that people who grow up in little cities or rural areas have a different perception of sound than people who grow up in big city[21].

Also the context it is very important for the perception of sound, different conditions of lightscape or the form of the cities can change the perception of soundscape, because the study of environments underline how it is important analyze the soundscape as a part of overall environment[22].

In other word soundscape is represented by entire acoustic environment resultiting from natural and man-made sound source [17], and its assessments should include visuals aesthetics, geographic, social,

psychological and cultural aspects.

1.5 SOUNDSCAPE POLICY FOR THE PERCEIVED SAFETY

To investigate the soundscape and relationship between human perception and sound is not easy, but there are several framework and protocol that try to describe this relation. In previous studies the reasearch introduce different parameters that can describe the soundscape, the most important and used are: The noise annoyance, the pleasantness, quietness or tranquillity, music likeness, perceived affective quality, restorativness, soundscape quality, and appropriatness[18].

All these indices could be used for describe the soundscape, but there aren't indices that can describe the relationship between the feeling of safety and the soundscape. For this reason several new studies introduce a new kind of questionnaire, and it is based on a perception of safety related with soundscape.

In these questionnaires there is this new topic, which is the relationship between soundscape and feeling of safety. There are three most important indices that can collegue soundscape and feeling of safety: Perceived safety, Social presence, appropriatness[9]. All of these questionnaires introduce also the relationship between lightscape and feeling of safety, because soundscape and lightscape are closely related.

There is a study about livingscape[22], developed in turin, that demonstrated how the human perception of cities it is influenced by several cues, and it is always necessarily to considerate all of these cues, and they are soundscape, lightscape, thermalscape and airscape.

1.6 STUDIES ABOUT SOUNDSCAPE WITH QUESTIONNAIRE

Previous studies presented some example of a questionnaire used to investigate the relationship between soundscape and perceived safety[18].

In a study on a pedestrian passage in Sheffield[3], a group of researchers used a questionnaire to investigate the perception of safety and social presence of users, the study was developed in a laboratory, and they put in relation the soundscape and lightscape of the passage with immagine and audio record. This study underline that music can increase the feeling

of safety and social presence, and different types of music can change the perception of passage. In this case with jazz music people felt highest feeling of safety (graph 3.3.1, graph 3.3.2).

The second part of this experiment analyzed the difference between the human perception of safety with or without the traffic noise barrier over

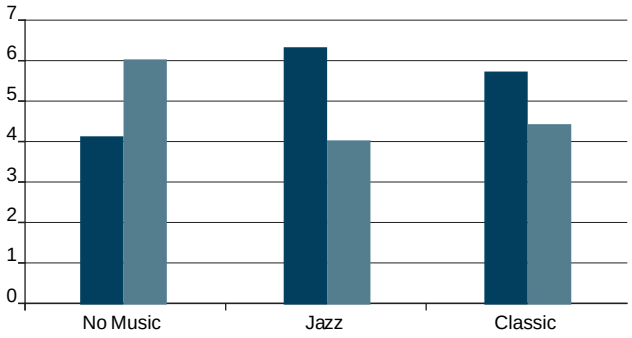


Fig.3.3.1 Number of people who use the pedestrian passage and which are feelings of these people (positive vibes, negative vibes) in relation with type of music.

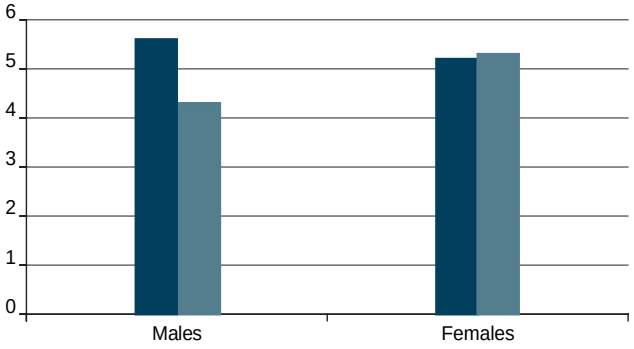


Fig.3.3.2 Number of people who use the pedestrian passage and which are feelings of these people (positive vibes, negative vibes) in relation with their gender.

the pedestrian passage. The result of the second part of the study was that traffic noise barrier decrease the feeling of social presence and then decrease also the feeling of safety (graph 3.3.3).

Another study was made on the relationship between the feeling of safety and soundscape using questionnaire, in a car park in Paris and in a metro

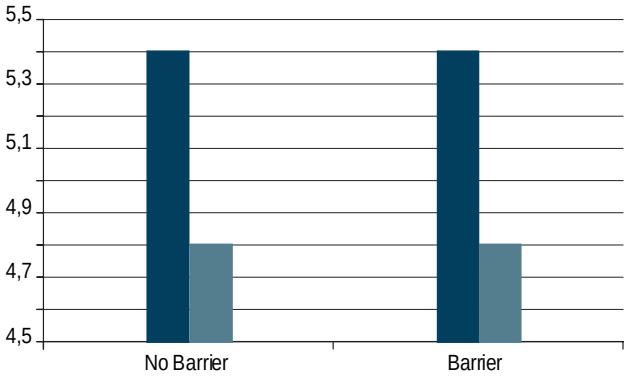


Fig.3.3.3 Number of people who use the pedestrian passage and which are feelings of these people (positive vibes, negative vibes) in relation with the presence or absence of traffic noise barrier.

station in Istanbul[9], a group of researchers manipulated the soundscape of these spaces using an audio tape of human vocal sound, animal vocal sound, and instrumental sound. In both case, the sound increased the feeling of safety and feeling of social presence, but in Paris with animal vocal sound and human vocal sound people felt the highest feeling of safety, in Istanbul the highest feeling of safety came from human vocal sound. Also these experiments confirm how the manipulation of sound, related with lightscape conditions, can increase the feeling of safety.

1.7 STUDIES ABOUT SOUNDSCAPE WITH VIDEO RECORDER

The questionnaire is not only one method used to analyze the soundscape, it is possible investigate human behaviours related to soundscape using a video recorder. In this case it is possible analyze if feeling of safety grow up or down related with soundscape, analyzing the human behaviour, for example, the walk velocity or how long they stay in analyzed area[18].

In a study based in Sheffield on West street tunnel[1], the reaserchers used a video recorder to investigate the human behaviour inside the tunnel after the manipulation of the soundscape, using a music reproduction

system with three different types of music, jazz, classic and contemporary music. They compared the walking velocity with and without music, and walking velocity related with type of music. They supposed that walking velocity was high when people felt unsafe. The result of experiment was that with music people walked slowly then no music, and that confirme the relationship between soundscape and feeling of safety, and how analyze this relationship without using questionnaire (graph 3.4.1).

Another study based in Sheffield worked on a pedestrian passage[4]. Also in these case the, reaserchers used a video recorder to investigate the human behaviour related with soundscape, they used the same three types of music of the previous study. Also in this case they registered a

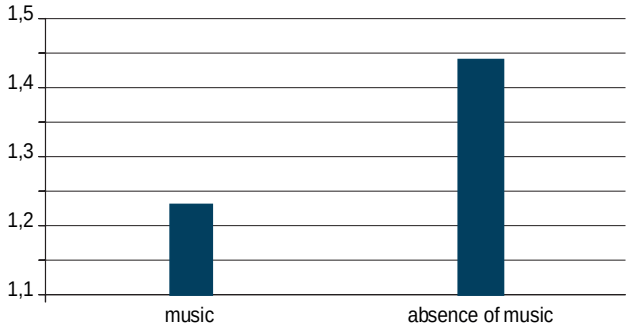


Fig.3.4.1 Difference in walking speed during music and silence in the West Street Tunnel experiment.

relationship between a soundscape and feeling of safety analyzing the walking velocity of users (graph 3.4.2, grapg3.4.3).

1.8 LITERATURE ANALYSIS

In the tab below there are a synthetic resume of analyzed experiments

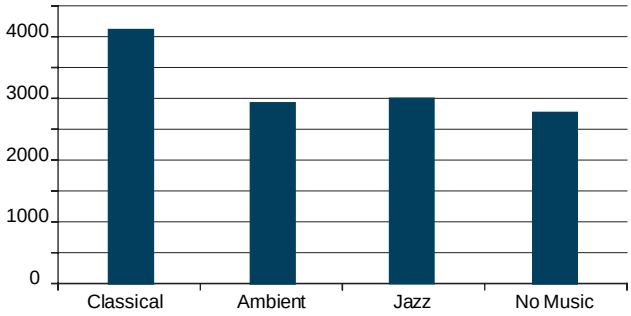


Fig.3.4.2 Number of people who use the pedestrian passage in relation with type of music during the experiment.

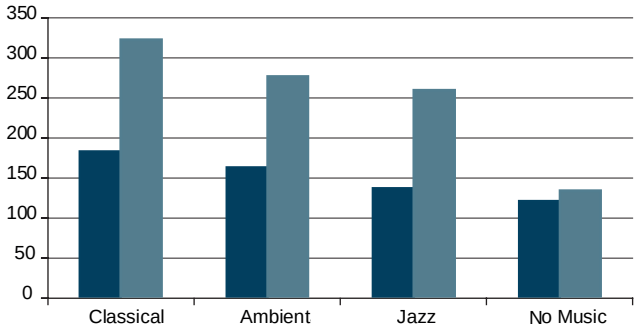


Fig.3.4.3 Number of people who stop in the pedestrian passage and how long they stop in the passage (s) in relation with type of music during the experiment.

in this literature review. The tab shows that Questionnaire is most used method to investigate soundscape. The experiments has been conducted in outdoor and indoor spaces, but always in public spaces. All experiments has been played in Europe, and in urban areas. Three experiments has been played in field, and other four has been played in laboratory, but the results are always the same and comparable to each other.

1.9 RESEARCH QUESTIONS

This thesis is a research about the soundscape of a square in London and

	Study cases	Where	In field or laboratory	Questionnaire or Video analysis	Type of music compared to silence	Indoor or Outdoor	Best sound conditions
1	West Street tunnel in Sheffield	UK	In field	Video analysis	-Classical -Jazz -Ambient	Otudoor	Classical music
2	Pedestrian passage in Sheffield 1	UK	In field	Video analysis	-Classical -Jazz -Ambient	Outdoor	Classical music
3	Pedestrian passage in Sheffield 2	UK	In laboratory	Questionnaire	-Classical -Jazz -Ambient	Outdoor	Jazz music
4	Car Park in Paris 1	FR	In field	Questionnaire	-Classical -Animal vocal sound	Indoor	animal vocal sound
5	Car Park in paris 2	FR	In laboratory	Questionnaire	-Classical -Animal vocal sound	Indoor	animal vocal sound
6	Car Park in Paris 3	FR	In laboratory	Questionnaire	-Classical -Animal vocal sound -human vocal sound	Indoor	Human vocal sound
7	Metro station in Istanbul	Turkey	In laboratory	Questionnaire	-Classical -Animal vocal sound -human vocal sound	Indoor	Human vocal sound

Tab 4.1 Summary of analysed studies

there are several factors that will be considered

How the users of the square perceive the general quality of acoustic environment, how they perceive the loudness in the square, using several attributes to investigate the pleasantness and calmness of the square, or its annoyance.

What are the perceived sound sources in a square, which is the relationship between these sound sources, when one of them is dominant or when their perceived level are equivalent. Moreover, the analysis highlights the relationship between the sound sources heard by people and their assessment of soundscape, looking for a possible predictive model of soundscape based on the sound sources of the city.

What are the assessments of the maintenance and cleaning of the square by the users, what is the relationship between of these aspects and the human perception of sound environment, moreover the research is focused on the appropriateness of the urban context of the square and its soundscape, defining a relationship between the soundscape and the architectural environment, also in this case this relationship could allow to develop a predictive model to control the human perception of soundscape through the manipulation of urban context.

What is the level of perceived safety by people in the square and which is the relationship between the soundscape and the human perception of safety. Through this analysis, investigated also in the previous described studies, could be possible to understand if the soundscape is useful to increase the perceived safety of citizens.

Using the WHO-protocol about people well-being, the research tries to define a relationship between soundscape and well-being, and, if there is a relationship between these two factors, the analysis will be focused on how the soundscape can increase the well-being.

How the socio-cultural background of people influences their assessment of soundscape and how this relationship could be used during a design

process of public outdoor spaces.

Finally, what is the relationship between physical acoustics indices and the soundscape, but also what is the relationship between the objective descriptors of architectural context, like percentage of vegetation in the square or percentage of buildings, and the perception of sound environment.

STATE OF ART

2.1 SOUNDSCAPE DEFINITION

"Soundscape is the acoustic environment as perceived or experienced and/or understood by a person or people, in context; acoustic environment is the sound at the receiver from all sound sources as modified by the environment; sound sources are the sounds generated by nature or human activity".[1] This definition of soundscape given by the International Organization for Standardization (ISO) makes it possible to understand how the soundscape approach is based on the human perception of sound and, in particular, the acoustic environment.

The soundscape approach proposes to investigate the acoustic environment not as a waste but as a resource [2]. Indeed, acoustic policies in all countries consider sound like a waste and try to reduce noise by any means, without considering the possibilities behind an acoustic environment design, which could increase the well-being and quality assessment of any given city when carefully studied. The soundscape approach investigates how people perceive an acoustic environment. It not only reduces the acoustic level as a response of acoustic discomfort but tries to identify which are the conditions and sound sources that create this discomfort; and which are the factors and the sound sources that can increase the quality assessment of an acoustic environment without necessarily reducing the sound level.

2.1.1 EUROPEAN POLICY ABOUT DEFINITION AND MANAGEMENT OF ENVIRONMENTAL NOISE

European policy aims to achieve a high level of protection for the well-being

of citizens and for the environment, therefore the issue of environmental noise is very important and absolutely urgent [3].

The analysis and the management of this problem start with the definition of the sensitive areas that need particular attention, like residential areas, public parks, and big cities; but also quiet areas such as rural areas, schools, hospitals and other buildings that require the utmost silence. Traffic is the central sound source that a national policy needs to decrease, the regulation does not talk about sound from human beings or other types of sound sources.

To reach the goal of protecting the population from risks related to environmental noise and protecting the environment itself, the regulation proposes a strategy based on three parts.

The first part is based on the mappings of the country using acoustic parameters, focusing on the sensitive areas previously described. The acoustic parameters used for the maps have to be shared and recognized by each country so that the data collected can be properly compared by everyone. There are two indicators used during the mapping of acoustic parameters. The first indicator, Lden, is a sound level equivalent index which measures a specific area during the day, evening and night. The second, Lnight, is a sound level equivalent index which measures a specific area during the night, highlighting the problem of noise during a person's sleep, a time in which noise could be more harmful to a person's physical and mental health.

The second part of the strategy is a design from each country of a strategic plan through which they try to solve the noise-related problems highlighted on the acoustic maps of cities and rural areas. Each country can develop solutions to be implemented internally to manage the issue of environmental noise.

The third part of the strategy has to develop simultaneously with the previous two, and it is based on the education and formation of the

citizens about the problems and risks related to environmental noise. The people must be informed about the country's acoustic mapping and the strategic plans proposed to solve the noise-related problem. In this way, the sensitivity of the people regarding this issue will increase and would allow us to understand how people perceive sound and environmental sound. The data collected permits us to have information about which is the most dangerous sound sources perceived by the people.

This regulation does not study the sound environment as a resource, but only as a waste, and its main goal is to try and solve the problem by reducing noise pollution. At the end of the law, however, there is a paragraph that leaves researchers the possibility to investigate new descriptors and develop new strategies for applying the soundscape approach, which includes the possibility to investigate sound as a resource.

Thanks to this last possibility, several research teams have done experiments on quiet areas, like rural areas, and they have developed a new indicator about quietness that will be analysed in the later paragraph. But, in 2014, "Good Practice on Quiet Areas" was published by the European Environment Agency (EEA) and, in 2016, "Quiet Areas in Europe – the European Unaffected by Noise Pollution" was published by the European Council, where both documents still treat sound like a waste. Despite these articles, the "Quietness Suitability Index (QSI)" has been developed through soundscape study. Use of this new sound index makes it possible to describe and protect the quiet areas, like rural areas.

2.1.2 SOUNDSCAPE STUDY FIELD

Several studies demonstrate how the acoustic levels below a certain value, for instance, 55 dB in general urban areas and 65 dB in urban open space, are not related to a people's acoustic comfort [2]. In these cases, there are no acoustic factors that can increase or decrease the quality

of an acoustic environment and people's perception of it. Moreover, the recreational and restoration areas are not related only to the acoustic level, the study about the factors that produce one of these kinds of areas can't focus only on the acoustic level, but also include the analysis of sound sources, context, users, etc.

Soundscape involves many different study areas, such as architecture, acoustics, environmental health, psychology, sociology, and several other urban studies. All of these disciplines study human behavior and human experience with the environment, giving reason to why the study of soundscape must be a multidisciplinary field of study [2].

Furthermore, soundscape is a new point of view to the acoustical environment because it is a construct of human perception, and it is influenced by acoustical parameters like sound pressure level and reverberation time, but also by socio-cultural background, the listener's attitude and expectations, and the context of people who perceived that acoustical environment [4]. For example, previous research shows that people who grow up in small cities or rural areas have a different perception of sound than people who grow up in big cities [5].

Also, context is an important aspect for defining the perception of sound; different conditions of lightscape or the forms of cities can change the perception of the soundscape. Therefore, the study of environments highlights the importance of including soundscape as part of the overall environment [6].

In other words, soundscape is represented by an entire acoustic environment resulting from natural and man-made sound sources [2], and its assessments should include visual aesthetics and geographical, social, psychological and cultural aspects.

2.2 SOUNDSCAPE BORN

The concept of soundscape was born in 1977 when R. Murray Schafer published his book, "The soundscape: our sonic environment and the

tuning of the world", which included the first description of this point of view about the acoustic environment [7]. The book starts with the description of the problem of noise pollution in the contemporary era, when the sound environment is changing very fast. Later on, it describes the fast development of cities and industries and the changes related to society. The human acoustic comfort must be protected therefore noise pollution has become a fundamental problem to solve by each country because of its direct correlation with mental and physical health.

Schafer proposed an interdisciplinary approach between acoustics and psychoacoustics, analyzing solutions that allowed to control noise pollution and to protect and boost positive sounds that characterize urban and rural areas. The intention of this study and the related book was to create a new interdisciplinary called Acoustic Design, through which was possible to help the acoustic urban planners and designers, with the help of music experts, to identify and control the characteristics that define the soundscape.

Moreover, Schaffer proposed a new tool for noise pollution control; he highlighted the need of to educate and inform citizens about their surrounding sound environment, in this way the people could become the composers and performers of the soundscape of their cities.

The first thing that Schafer proposed to do was to analyze and define the features of soundscape by introducing four main categories: keynote sounds, signals, soundmarks, and archetypal sounds.

Keynote sound is derived from a musical term meaning the tonality of a sound composition. The keynote sounds of soundscape are created by geography and climate, for example, water, wind, plains, and forest. The keynote sound is a feature of soundscape not consciously heard.

The signal is a foreground sound and is heard consciously; examples of signals are bells, whistles, horns, and sirens.

Soundmark is derived from the word landmark and refers to a group of

sounds of that are related to a specific community or group of people and their memories. The primary purpose of a soundscape policy is to protect these particular kinds of sounds.

The archetypal sound is a mysterious ancient sound, related to remote antiquity or prehistory, and possessing felicitous symbolism.

Starting from these studies by Schafer, several research teams all over the world began working on soundscape, the number of studies related to acoustical environment have increased particularly in the last fifteen years; highlighting Schafer's foresight, when in 1977 he wrote, that noise pollution would become one of the primary problems for the environment.

All of the studies from the new research teams collected several solutions and tools for the analysis of soundscape. Today there are many factors, methodology, and descriptors that make it possible to further investigate soundscape, and with the following three paragraphs these soundscape features will be described. Moreover, some of these studies are based on the behavioral response of people to a soundscape, and how soundscape influences the quality of human life and health.

There are many ways in which soundscape can influence people's behavior. Since 1980, several researchers have performed economic studies analyzing the relationship between background music and in-store client and employee behavior. Ronald E. Milliman [8], during his research, demonstrated how background music can increase the aesthetic perception of a shopping center, increase the number of purchases, and create for a better quality workplace. Milliman also demonstrated that people move more slowly with slower music in a retail environment and hence spend more time there and purchase more. Subsequently, he tested the effect of musical tempo in a restaurant, and he demonstrated that diners eat more quickly when the fast music is playing. All these studies can demonstrate the relationship between soundscape and people behavior, but also between people behavior and tempo and

rhythm of background music. Moreover, Tansik and Routhieaux in 1999 [9], demonstrated that music reduces pre-surgical anxiety. Taking into consideration the effect of music on a person's perception and anxiety level, it is probable that music can be effective in manipulating perceived safety in public areas.

2.3 SOUNDSCAPE FACTORS

Many different factors characterize the human perception of an acoustic environment. All these factors are generally organized in four main categories [10]:

1. Physiological/biological factors: related to human perception of a soundscape, their cultural background, their usual conditions of life, their well-being and their hearing ability. These factors are not very easy to investigate, but in recent years, a greater number of studies have focused on such factors and can often relate several indicators which describe the perception of soundscape quality.
2. Physical/psychoacoustical factors: related to physical parameters that are measurable through the analysis of technical and objective physical factors. The acoustic environment is directly measurable through this data, but it is hard to find a direct relationship between soundscape perception and acoustic environment.
3. Psychological factors: related to people and their feelings and psychological attitude during the assessment of acoustic environment.
4. Contextual factors: related to context assessment and characteristics, for example, temperature, the presence of vegetation, water and also to the appropriateness of context and acoustic environment.

During the analysis of an acoustic environment there are five types of data that define the human perception of soundscape related to the factors which describe the soundscape.

2.3.1 SOUND SOURCE

The assessment of a given acoustic environment is influenced by different factors, and sound plays an essential role [12]. The acoustic environment is perceived as a collection of individual sounds, for this reason, an evaluation of the overall acoustic environment requires the identification of every individual sound.

The identification of different sound sources can describe an important factor that defines the human perception of a soundscape, but also identifying the dominant sound is a crucial feature for investigating the soundscape. Indeed, many authors have written that the evaluation of soundscape is strongly related to the evaluation of the dominant sound perceived in the study site.

Therefore, the first step to identifying the human perception of a sound environment in the investigated study site is to define the different sound sources that can be heard in the area and their dominance.

2.3.2 PERCEIVED AFFECTIVE QUALITY

To describe the perceived affective quality of a sound environment there are several soundscape descriptors. The first part of descriptors is related to psychoacoustics indices, these indices are loudness, sharpness, roughness, and tonality; and they are related to acoustic indices as, for example, sound level [12].

There are also soundscape descriptors used to describe the human perception of an acoustic environment that are not related to an acoustic index, and in recent years there have been many studies that try to develop new descriptors [13]. Noise annoyance, pleasantness, quietness or tranquility, music-likeness, perceived affective quality [14], restorativeness, soundscape quality, and appropriateness are the more commonly used descriptors for soundscape assessment. Some of these descriptors were originally developed for environmental noise, but are likely relevant to soundscape assessment.

2.3.3 PEOPLE

It is necessary to know if the participants are residents of or visitors to the study site, if they are lay people or experts in a field that is relevant to the study, their age, gender, and general information on their hearing ability [2].

Age and education are factors that generally influence the assessment of sound preference. For example, older people generally prefer natural sounds, coming from human beings or nature, like birdsong; on the contrary, young people tend to prefer music or mechanical sounds.

Also, the culture of people who live in a different country or in different areas of the same country (urban area or rural area) can influence the assessment of a sound environment.

The assessment of the sound environment also depends on how long a person has been at the study site. How often a person frequents an investigated area can influence his/her assessment of the acoustic environment.

2.3.4 CONTEXT

A soundscape is closely related to the perception of a visual environment of an urban space [15]. In particular, there are several factors of visual environment that can influence the soundscape, such as aesthetic quality, spatial impression, quality and maintenance of public space equipment.

The aesthetic quality of a visual environment is the most important factor affecting human perception of soundscape because a good and pleasing visual environment enhances the quality of the soundscape [2].

The harmony between landscape and soundscape is also very important because the congruity between these two factors affects the perception of environmental quality, therefore also soundscape perception [6].

Appropriateness is a semantic descriptor that can define the relationship between landscape and soundscape, or better, it can describe the harmony perceived between a sound environment and a visual environment [16].

2.3.5 PSYCHOACOUSTICAL INDICATORS

Psychoacoustic indicators are the magnitudes which allow us to know how people perceive an acoustic stimulus, and how the human hearing system processes this acoustic stimulus. These indicators do not represent the physical value of sound only, but they also represent how people perceive a sound and are calculated through a combination of different acoustic parameters [12-17].

2.3.5.1 LOUDNESS LEVEL

The loudness level, introduced by Barkhausen in the twenties, can be measured for every sound. This level is not only related by a magnitude of sensation, but also by physical value. This parameter indicates the difference of loudness between a narrowband noise compared to a broadband noise; and loudness is also related by spectral sensitivity (frequency weighting), masking, critical bands, and nonlinearities. The unit of measure for loudness is "sone" and the calculation of loudness is standardized in DIN 45631, ISO 532 and ANSI/ASA S 3.4.

2.3.5.2 SHARPNESS

Sharpness is an indicator that can be related to the sensations called "density" and "timbre". The sharpness indicators of a sound are considered separately from another sound. The most important variables of sound that influence the sharpness are the spectral content and the centre frequency of narrow-band sounds. The unit of measure for sharpness is the "acum" and the calculation of sharpness is standardized in DIN 45692 (German Institute for Standardization).

2.3.5.3 FLUCTUATION STRENGTH

With low modulation frequencies, up to a modulation frequency of about 15-20 Hz, the loudness slowly changes up and down, generating a sensation of fluctuation strength. The unit of measure for fluctuation strength is "vacil" but there is not a standardization for the calculation of

fluctuation strength. An example of the sensation of fluctuation strength is an ambulance siren, the sound with greater fluctuation strength usually has greater power to attract attention.

2.3.5.4 ROUGHNESS

When modulation frequencies exceed the value of 15-20 Hz, the phenomenon of fluctuation strength turns into a sensation of roughness. The indicator of roughness is influenced by the modulation frequency of the sound pressure level, carrier frequency and the degree of modulation. The unit of measure for roughness is "asper". Like fluctuation strength, there is no standardized calculation for roughness, an example of the sensation of roughness is the noise generated by a scooter engine.

2.3.5.5 TONALITY

Tonality is an indicator of the sensation of the timbre of a sound; this indicator defines if the perceived sound consists mainly of tonal components or broadband sounds. The unit of measure for tonality is "ratio" and the standard for the calculation of this indicator is collected in the regulations DIN 45681 and ANSI/ASA S 1.13.

2.3.6 WELL-BEING

During the analysis of soundscape and how people perceive their surrounding sound environment, it is very important to define what are the conditions of well-being and mental health that influence the participants' answers to the questionnaire about the soundscape quality assessment. For this reason, in the latest research around the world, the role of a person's well-being has gained more and more importance, and in particular the self-evaluation of said person. To investigate this factor there are several published protocols, one of the most widely used and useful is the WHO-5, realized by the World Health Organization; it is composed of five items that are able to assess the well-being of the people who take the test. In this way, it is possible to analyse what the relationship is that connects the assessment of soundscape and the

perceived well-being of a person, and how the focus on this relationship is fundamental to define the indicators that characterize the soundscape [18].

2.3.7 PERCEIVED SAFETY

Recently, interesting studies demonstrate the relationship between the sound environment and perceived safety in open public spaces. These studies investigated the possible influence of sound environment on anti-social behaviors and how the sound environment can increase or decrease the human perception of safety [19]. These particular studies are proving to be very important because of the general decline in perceived safety over the last several years in all parts of the world, and this decline seems to have very little correlation to the true criminality [i].

There is also a strong relationship between social presence and feeling safe. Several studies have demonstrated that feeling lonely can lessen one's feeling of being safe and that the sound environment plays an important role in decreasing this feeling of loneliness [16].

Some places are considered dangerous by the general public and are often avoided; these spaces quickly turn into no-go areas [20].

A relationship has also been found between perceived safety and environmental characteristics of neighborhoods, such as abandoned buildings with broken windows or littered streets lined with broken benches. These environmental features produce fear regardless of the area in which where they are found [16].

The last environmental cue that could influence human perception of safety is lightscape. People commonly report fear when they are in a dark place; for this reason, artificial lighting is very important to increase perceived safety in public spaces [21].

2.4 SOUNDSCAPE METHODOLOGY

During an investigation of soundscape in a specific location, there are

several methods with which it is possible to collect data regarding human perception of the surrounding acoustic environment and physical and psychoacoustical data about the sound environment. Every method answers to the peculiar needs of each specific soundscape analysis and changes according to the types of indicators that have been chosen to perform the analysis. At this moment, researchers who have studied soundscape have been unable to define a unique set of indicators. These indicators and related descriptors will be discussed more thoroughly in paragraph 2.5, whereas, the current paragraph analyses the methodology with which it is possible to investigate the soundscape.

There are many methods that investigate soundscape; by distinguishing a macro category it is possible to define a taxonomy of different methods used for the sound environment analysis. Every methodology can work together with others and can then be utilized for in situ analysis and/or laboratory research where it is necessary to reproduce the visual scenarios present during the on-site interviews.

The assessment of soundscape requires particular attention because it is not only an objective assessment based on acoustical parameters, measurable in situ but it is also a personal assessment of people who experience the analysed place and his sound environment. It is very important to define their perceptions and expectations. Undoubtedly, it is important to know the cultural and social background of the interviewed persons because of the influence it can have on their assessment of the soundscape. It is also fundamental to learn and try to understand how one's background could influence their assessment.

2.4.1 QUESTIONNAIRE

The first method used which allows the people's perceptions of the sound environment to be analysed is the questionnaire. With this method, the direct relationship between the interviewed people and the researcher is avoided because it could possibly influence the person's assessment.

In this way, the people experience the investigated place freely and without external influence; they are able to use the space in whatever way they want. The survey is based on a series of questions, opened or closed, but generally closed, that each person who participates in the experiment is required to respond to. The questions are always the same so that it is possible to compare the answers of each participant. The questionnaire can be structured in paragraph form giving the researchers the opportunity to investigate the different factors which influence the human perception of soundscape described in the previous chapter. At the end of the questionnaire, the privacy of the interviewed people is guaranteed, allowing for a more comfortable feel in answering any personal questions relating to the social and cultural data fundamentally necessary for defining the soundscape as previously explained.

2.4.2 INTERVIEW WITH GUIDELINE

The second method used is to interview with guidelines; in this case, there is a direct relationship between the researcher and the interviewee. Because the researcher orally interviews the participants there is a risk of influencing their assessment of the soundscape, but at the same time allows for a more detailed description of the sound environment because the participants are able to use personal ways and terms to describe it. The interview method guarantees also exploiting past experiences of the users interviewed in the investigated place, making it possible to collect data on the present soundscape, as well as data related to past soundscapes. Learning about past experiences also demonstrates how a sound environment can change over time.

2.4.3 BEHAVIOURAL OBSERVATIONS

The third method is to analyse the behaviour of the people who use the place of observation. The use of video and audio recorders allows data to be collected about human behavioural changes related to sound environment changes. In this way, the people can experience the investigated place in

total freedom without any influence from the researcher. It is important to note however that the quality of data collected has a tendency to be less specific compared to the previously mentioned methods and it is impossible to individually analyse the factors that influence the human perception of the sound environment.

2.4.4 PARTICIPANTS SELECTION

The participants of the questionnaire or of the interview with guidelines are selected in various ways from the researcher in order to get the best information from the experiment. If the researcher would like to gather data on the common users of a studied place the participants can be selected randomly and on-site. In this case, the researcher must find the same number of male and female participants across a wide age range.

2.4.5 SOUNDWALK

The second way to apply the questionnaire or interview is the Soundwalk. In this case, the participants are selected by the researcher, who will then bring the group of participants to the place of investigation where they walk around the given area. The participants must observe their surrounding environment during the walk, lending particular attention to the sound environment. At the end of the walk, a team of experts collects the perceptions or feelings of the group through a questionnaire or an interview with guidelines.

2.4.6 LABORATORY EXPERIMENTS

Lastly, in the case of laboratory analysis, the researcher can use the same parameters for participant selection as used in the previous method of Soundwalk. Those chosen to participate in the research will be submitted to audio and visual stimuli collected by the researcher on-site or that has been digitally reproduced. During laboratory analysis it is also possible to collect data from vital parameters of the interviewee; with this type of data it is possible to create a larger database of human response to audio stimuli and better define soundscape perception.

2.4.7 BINAURAL AUDIO RECORD

During the experiments, the acoustic data related to the sound environment perceived by the participants of the experiment must be collected through an audio recording. The most used system for this audio recording is the binaural measurement method, which utilizes an artificial head measurement system. In contrast to recordings based on a monaural microphone, the binaural acoustic measurements recorded sound is very similar to the original sound field, maintaining all spatial information.

It is important that during recording the position of the binaural measurement system is stationary and its orientation of the typical listener position remains the same. The height of the microphones of the artificial head measurement system should be chosen in accordance with the average height of the persons who generally use the investigated place, this height is generally 1,6 m +- 0,1 m, or if the listeners are sitting on a bench, the height of the microphones should be fixed at 1,2 m +- 0,1 m.

The duration of the audio recordings depends upon the features of the sound environment being analysed. A monotonous sound environment can be registered for just a short period; it is an area where no sound events emerge from the background sound. On the other hand, a sound environment with more variations should be registered for a longer duration.

Photos of the surrounding visual environment should be taken for each audio recording so that the data collected describing the soundscape and how the sound environment influences the human perception is complete.

2.5 SOUNDSCAPE DESCRIPTORS

The identification of descriptors which define a user's perception of a determined soundscape in a specific area is one of the most important

fields of study in today's research regarding soundscape and sound environment. The importance of defining descriptors in an easy and clear manner makes it possible to uniquely describe a specific soundscape. It is just as important that these descriptors are shared and recognized by the whole scientific community giving the possibility to establish what the indicators of soundscape should be: measurable and collectively recognized quantities that are able to forecast soundscapes. These indicators should become essential tools for the designer's work on the acoustic design of public and private open spaces. These indicators could possibly be used to define a unique European regulation regarding environmental noise and acoustic environments and also to define a new standard that ensures the comfort of its citizens and users; furthermore, they could be used to protect the historical soundscape of the city.

In the last few decades several research teams, working on soundscape and soundscape definition, have investigated plausible descriptors and have defined several indicators. These tools help define and describe different factors that compete in building the human perception of sound environment and soundscape. So far, every descriptor found has focused on a specific factor and therefore is unable to define the overall sound environment in a unique way; furthermore, not a single descriptor or its related indicator has been recognized by the scientific community as a whole.

The main descriptors found today are useful in describing a soundscape and the human perception of the given soundscape because they are complementary and are able to define the soundscape, even if it is not always possible to identify a single objective indicator of soundscape through these descriptors.

2.5.1 NOISE ANNOYANCE

The noise annoyance is a descriptor developed by Guski, Felsher-Suhr, and Schuemer in 1999, and in 2003, which was included in the International

Organization for Standardization (ISO).

In 2009, the research team composed of Fiebig, Guidati, and Goehrke tried to define noise annoyance as a combination of several psychoacoustic parameters: loudness, sharpness, roughness, and impulsiveness. This kind of indicator, relative to noise annoyance, can have values ranging from 1 to 9, and at the moment has always been used as an indicator of perceived noise from traffic or industrial noise, therefore the main problem of this indicator is that it has a particular purpose to define noise and unwanted sound. This characteristic is contrary to the soundscape policy that tries to consider the sound of cities not as a waste but as a resource.

2.5.2 PLEASANTNESS

Pleasantness is the descriptor that relates to the hedonic assessment of sound and defines the pleasantness perceived by the users related to their surrounding acoustic environment. This descriptor describes the soundscape as pleasant or unpleasant, therefore, the descriptor does not analyse the acoustic environment as an unwanted noise, or at least not only as an unwanted noise but introduces the concept of pleasantness in which sounds can increase the acoustic comfort of its users.

In 1981, the researchers, Terhodt and Stall, defined the descriptor of pleasantness as a relationship between several psychoacoustic parameters, in particular: roughness, sharpness, loudness, and tonality. However, they did not develop a real predictive model about the descriptor that could be used as a tool to previously define the pleasantness or unpleasantness of an analysed soundscape.

In 2006, Lavandier and Defreville analysed and defined the indicator of unpleasantness as a relationship between the Leq and the dominant sound source but their experiment could not uniquely define a level of pleasantness or unpleasantness of a soundscape.

2.5.3 QUIETNESS AND TRANQUILLITY

The European Environmental Noise Directive (END) introduced some directives and information related to "quiet areas"; for this reason, in 2005 and 2008, the researchers, Memoli and co-workers, defined an index called "slope", related to a historical database of sound levels of the analysed area, focusing on the presence of particular acoustic events and the frequency in with which they appear. Furthermore, they analysed how these acoustic events emerged from the background sound level.

The "slope" analysed with data collected from several questionnaires about perceived soundscape, with focus on "quiet areas", allowed for the development of the indicator TR, Tranquillity Rating, by the researcher Pheasant and co-workers in 2008-2009. Through the analysis of sound level and sound source, TR makes it possible to create a predictive model to define "quiet areas". Although this indicator does not allow for the definition of all kinds of soundscape because of its close relation to "quiet areas", it, in any case, is very important because it is the first indicator of soundscape added to a national regulation as a standard for the design of public quite areas. The TR has been used in UK regulations since 2014.

2.5.4 MUSIC LIKENESS

Music likeness is a descriptor based on Schafer's original study on soundscape. The team of researchers who worked on this descriptor was composed of Botteldooren, Coensel e De Meur. In 2006 the team analysed the acoustic environment by utilizing the same tools used for music studies; they analysed tempo, rhythm, and dynamics in terms of differences in statistical sound levels. From this study, they developed a fuzzy indicator called Music Likeness (ML), based on the spectrum of loudness fluctuation. When they tested this indicator in an infield experiment, the collected data demonstrated how difficult it is to define a relationship between the ML indicator and perceived music likeness; however, the experiment underlined that the soundscape was neither chaotic nor boring.

2.5.5 PERCEIVED AFFECTIVE QUALITY

In 2010, Axelsson, Nilsson, and Berglund developed a bi-dimensional model for the description of Soundscape Affective Quality, based on a bipolar factor, they found four positive and opposing factors: calm, pleasant, exciting, eventful, chaotic, annoying, monotonous and uneventful. Since 2013 and still today Axelsson, Nilson, and Lunden are looking to define a relationship between the human perception of soundscape and the description of soundscape through the above factors and acoustic signals.

In 2013, Cain, Jennings, and Poxon introduced a model similar to the Axelsson bidimensional model for the definition of perceived affective quality. They demonstrated that it was not possible to find a relationship between the Axelsson's factors and the sound level, as Axelsson had already done in 2010 when he highlighted that the dominant sound source and context influenced the human perception of soundscape more than the sound level.

At the end of 2013, Davies et Al proposed a new bi-dimensional model, inspired by the Axelsson model, where the dichotomous factors were the Cacophony-Hubbub axis, based on the relationship between the number of sound sources that collaborated to create a soundscape and the level of dissonance or discord perceived sound by an individual, and the Constant-Temporal axis, based on the relationship between the amount and frequency changes of a given soundscape.

2.5.6 RESTORATIVENESS

Restorativeness is a descriptor based on the Attention Restorative Theory of Kaplan and Kaplan (1989). In 2013, Payne resumed this theory to define the concept of Perceived Restorativeness Soundscape Scale (PRSS) where there is the possibility to define the soundscape as high restorativeness with the scale value being 1 and low restorativeness with the scale value being 7.

2.5.7 SOUNDSCAPE QUALITY

In 2015, the research team composed by Ricciardi, Delaitre, Lavandier, Torchia e Aumond developed a descriptor based on soundscape quality; they tried to identify the general features of soundscape as "good" or "bad". The experiment that they developed to promote their descriptor was a site investigation, taken place in the cities of Milan and Paris; they demonstrated that 52% of the responses from people about their perception of soundscape was not related to a measurable acoustic index but rather to context, dominant sound sources and other background conditions.

In 2012, Garcia Perez, Aspuru Soloaga, Herranz Pascual and Garcia Borroguiero proposed a descriptor related with the soundscape quality called Environmental Sound Experience Indicators (ESEI) with a numerical scale, ranging from 1, non-suitable soundscape, to 12, excellent soundscape. This indicator is based on the relationship between sound level, dominant sound sources, numbers and the energy of acoustical events.

2.5.8 APPROPRIATENESS

In 2011, the researcher Brown et Al. highlighted the importance of appropriateness between soundscape and context, because context today is recognized as an important factor that influences the user's perception of the soundscape. For this reason, in 2014, the research team composed of Daves and Murphy analysed and highlighted the importance of people's expectation of soundscape and context and their relation during an assessment of soundscape.

In 2015, Axelsson developed several experiments in various English cities and demonstrated how often the soundscape, although poor, is perceived from users better than a richer soundscape when the second one is considered less appropriate related with their context, these experiments highlighted the importance of appropriateness, and how what is appropriate is different from what is desired.

2.6 SOUNDSCAPE PREDICTIVE MODEL

The chief aim of the soundscape study and approach is to create a model that allows predicting the design and human perception of soundscape without direct measures or participant interviews. The creation of this model starts by identifying shared indicators that can help define soundscape quality through a numerical scale, allowing for the standardization of soundscape features and values.

As defined by the EN regulation, the first step that a country is required to do is to draw a map of the cities, identifying the noisy areas, the quiet areas, the different kinds of vegetation, the presence of rivers or lakes or artificial waters, the particular sound sources present in the cities and the residential or commercial areas. The researchers can draw several different cities maps and define the soundscape factors for each part of the city through the spatial interpolation analysis method in the GIS platform.

By analysing a great amount of data, it is possible to create models for the evaluation of perceived loudness or acoustic comfort of users from public spaces using the Artificial Neural Network (ANN). But these kinds of models have not been very useful in defining the complexity of physical and social environments that constitute the features of a soundscape.

The creation of soundscape is related to several features but the designers can mainly control only two factors: sound and space. The other features of a soundscape, like the people who use the designed area or the weather, are not configurable.

There are two different ways to analyse the sound of a specific area. The first is to analyse sound through the index of physics and the psychoacoustic index. These indices can define the physical parameters that describe sound, for example, sound level and frequency. The psychoacoustic index can describe how people perceive acoustic stimuli and how the human brain processes them. The second way to analyse

sound is by defining sound sources and how these sound sources influence the human perception of environmental sound; the presence of sound sources related to natural or human sounds usually allow for a higher quality of assessment of perceived soundscape quality, whereas the presence of sound sources such as noise from traffic or construction usually results in a lower assessment of soundscape quality.

Space also influences a person's assessment of soundscape quality; the presence of vegetation or water, such as rivers, lakes or fountains, can increase the quality of visual stimuli. Past studies on soundscape demonstrate how visual stimuli and context influence the assessment of soundscape quality. Another feature of space that it is very important to define the quality of soundscape is appropriateness, during the design of a projected area it is essential to ensure that the context is appropriate to the sound environment.

METHODOLOGY

This thesis is based on an experiment that investigates the human perception of soundscape and safety in a public space. The first data collected, by use of a questionnaire, are related to the assessment of soundscape quality. A questionnaire is a useful tool that investigates a person's assessment of soundscape and its factors while avoiding interference of the participants; this kind of investigation respects a person's experience of a studied environment.

The questionnaire is composed of six parts: sound sources, perceived affective quality, context, well-being, perceived safety, and personal data. Each part plays an essential role in defining the assessment of soundscape. Each questionnaire response is collected as an audio file, recorded by a binaural recording system. Also, with the use of an I-phone, eight photos are taken to represent the surrounding environment of the participant during the analysis through the questionnaire and the audio record.

Knowing the goals and objectives of the survey is necessary for choosing appropriate soundscape descriptors. The purpose of the following questionnaire is to identify general parameters that will allow designers and urban planners to properly plan their project's soundscape.

3.1 QUESTIONNAIRE

This questionnaire is based on the Draft Technical Specification 12913-2, with some additions regarding well-being from a WHO-5 protocol that allows for the self-evaluation of well-being and about perceived safety from several questionnaires used in the previous questionnaire for the

assessment of the relationship of soundscape and perceived safety.

Participants are randomly approached on site by a research student and are invited to take part in the survey. Participation is on a voluntary basis (unpaid). After reading the information sheet and provided informed consent, data collection begins. The research student hands over a tablet used by the participants to fill out the questionnaire. The questionnaire is completely anonymous and the data collection takes place during the daytime, both on weekdays and weekends.

When approached on site, participants are asked to take part in the soundscape study. If they verbally agree to do so, they will be asked to read the information sheet and consent form. Both these documents will be available on the tablet and associated to the questionnaire response (the app will generate a time-stamp and a participant ID). The informed consent will then be offered by participants by "clicking" the appropriate button on the tablet (instead of signing a document).

All data collected is safely stored on a personal computer, it is impossible to identify the profile of those who participate in the questionnaire with the type of data that is collected; the privacy of the participants is therefore protected.

The ethical implications of this field study are limited. Most of the questions relate to the perception of environmental factors/conditions and do not deal with personal matters. The few questions that do deal with more personal issues are related to perceived well-being and could possibly spark some negative feelings. However, these questions relate to a well-established WHO protocol which has been proven to be well-received in previous studies.

The benefit for participants of the experiment are not immediate; the perception of acoustic environments (and their quality) is often neglected in everyday life. Many of the questions urge the participants to "listen" to their surrounding sound environment. In a way, taking part in this study

could raise environmental awareness of sound domain.

The only foreseen risk of this study is that the participant becomes uncomfortable and/or bored during the process. If this is the case, the research student immediately stops the data collection and gives thanks to the participant for his/her effort.

3.1.1 INFORMATION SHEET

TITLE OF THE PROJECT: PERCEIVED SOUNDSCAPE

You are being invited to take part in a research project. Before you decide to participate, it is important for you to understand why the research is being done and what your participation will involve. Please take your time to read the following information carefully and discuss it with others, if you wish. Ask us if there is anything that is not clear or if you would like to have further information. Please take the necessary time to decide whether or not you wish to take part in this project. Thank you for reading this.

My name is Luca Molinero and I am a visiting student at the Bartlett School of Environment, Energy and Resources, University College London (UCL). I am working on a project about soundscapes. The aim of this questionnaire is to collect data about how people perceive urban acoustic environments, and what the relationships between acoustic environment, well-being, and perceived safety are. Results from this survey will help us gather further insight into these relationships and better inform urban sound planners.

Like you, other participants will be randomly approached on site and will be invited to take part in the survey. You can only participate if you are between the ages of eighteen and eighty. It is completely up to you to decide whether or not to participate. If you do choose to take part, you will be given this information sheet to keep. Please understand that participating in a scientific experiment is voluntary and you are free to withdraw at any time for, without explanation.

The questionnaire is designed to take approximately 10 minutes to complete. Its purpose is to allow you to evaluate the surrounding acoustic environment of the public area that you are currently in, in relation to your well-being and your perceived safety.

While there are no immediate benefits for those who decide to participate in the project, it is hoped that this work will raise environmental awareness for the soundscapes of our cities.

This study has been approved by the Ethics Review Procedure of the Bartlett School of Environment, Energy, and Resources. Any complaints can be addressed by contacting the head researcher of this project, Professor Jian Kang, by writing to kang@ucl.ac.uk or calling 020 3108 7338. If you feel your complaint has not been handled to your satisfaction, then you can contact the Chair of the UCL Research Ethics Committee (ethics@ucl.ac.uk).

Any information that we collect about you during the course of the research will be kept strictly confidential. You will not be able to be identified in any ensuing reports or publications. All the data collected will be stored on a personal computer with a password and at the end of the project, all data collected will be securely deleted.

This project is funded through the European Research Council (ERC) Advanced Grant (no. 740696) on "Soundscape Indices" (SSID) (Principal Investigator: Prof Jian Kang)

If you experience any problems or need further information, contact me by email:

molinero.luca93@gmail.com

Or by telephone:

+39 331 2730669

Thanks in advance,

Luca Molinero

3.1.2 PARTICIPANT CONSENT FORM

Title of Research Project: Perceived Soundscape

Name of Researcher: LUCA MOLINERO

By clicking this "confirm", I attest that:

1 I have read and I understand the information sheet explaining the experiment. I also have had the opportunity to ask questions regarding the project.

2. I understand that my participation is voluntary and I am free to withdraw at any time without reason or negative consequences. In addition, should I not wish to answer any particular question, I am free to decline.

3. I understand that my responses will be kept strictly confidential.

4. I give permission for members of the research team to have access to my anonymous responses. I understand that I will not be identifiable in reports that result from the research.

5. I agree to take part in the above-mentioned project.

6. I am over 18 years old and under 80 years old.

3.1.3 SOUND SOURCES

In the first section, there is a question about what the perceived dominant sound source in the analysed area is. The participants have to listen to their surrounding sound environment and distinguish what the dominant sound source is between noise (traffic, construction or industry), sound from human beings (conversation, laughter, footsteps, children at play) and natural sound (singing birds, flowing water, wind in vegetation). For each type of sound source, there is a scale from 1 to 5 that assesses how dominant each sound source is.

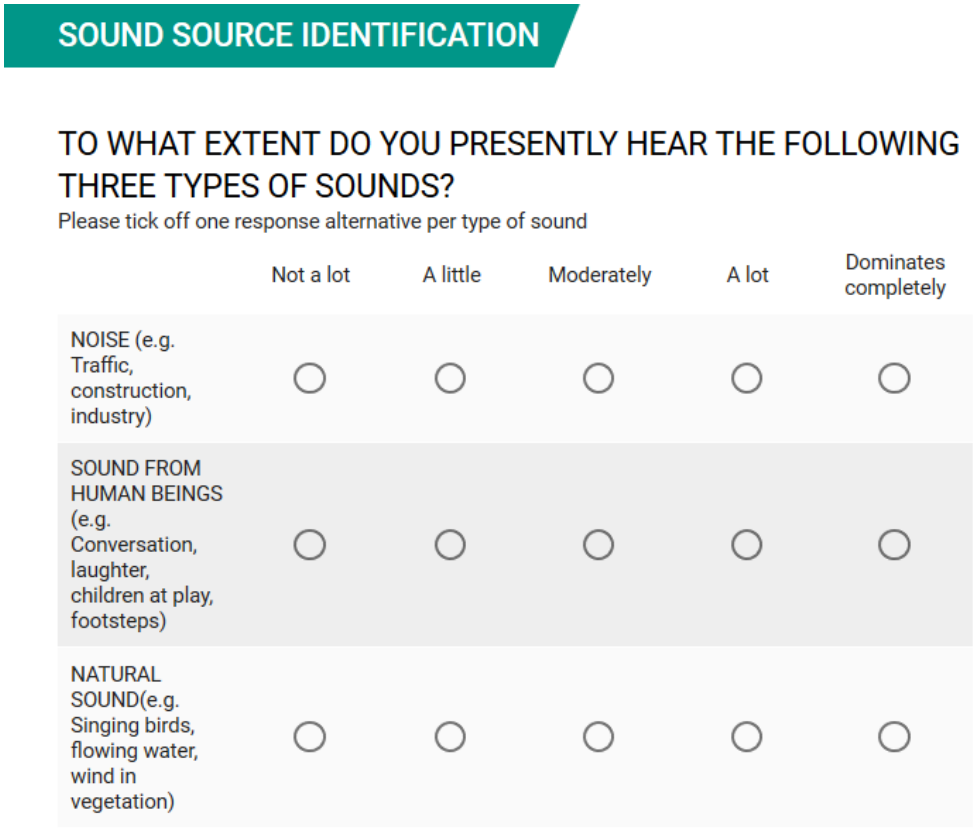
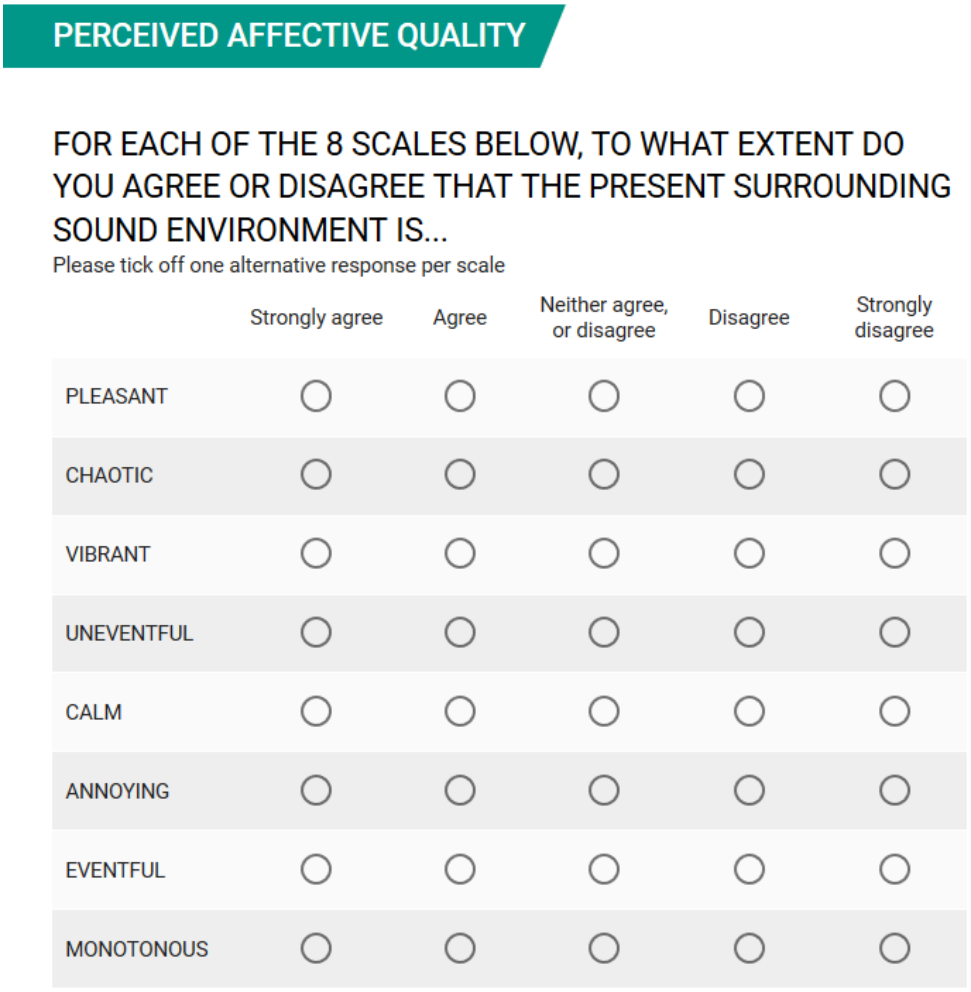


Fig.3.1 Questions about sound sources.

3.1.4 PERCEIVED AFFECTIVE QUALITY

In the second section, there are four groups of questions. The first group contains eight items and eight scales where participants can describe the sound of their surrounding environment. In the second group, there are two questions about the general assessment of surrounding soundscape quality and the perceived loudness of soundscape of the studied area. The third group is composed of two questions about the relationship between soundscape and the overall environment. The first asks about appropriateness; looking to define how much the soundscape is appropriate to the general environment. The second question defines how much the general environment influences the assessment of

soundscape. The last group is composed of a question about the general feeling of participants during the experiments. All the items are evaluated on a scale of 1 to 5.



PERCEIVED AFFECTIVE QUALITY

FOR EACH OF THE 8 SCALES BELOW, TO WHAT EXTENT DO YOU AGREE OR DISAGREE THAT THE PRESENT SURROUNDING SOUND ENVIRONMENT IS...

Please tick off one alternative response per scale

	Strongly agree	Agree	Neither agree, or disagree	Disagree	Strongly disagree
PLEASANT	○	○	○	○	○
CHAOTIC	○	○	○	○	○
VIBRANT	○	○	○	○	○
UNEVENTFUL	○	○	○	○	○
CALM	○	○	○	○	○
ANNOYING	○	○	○	○	○
EVENTFUL	○	○	○	○	○
MONOTONOUS	○	○	○	○	○

Fig.3.2 Questions about perceived affective quality.

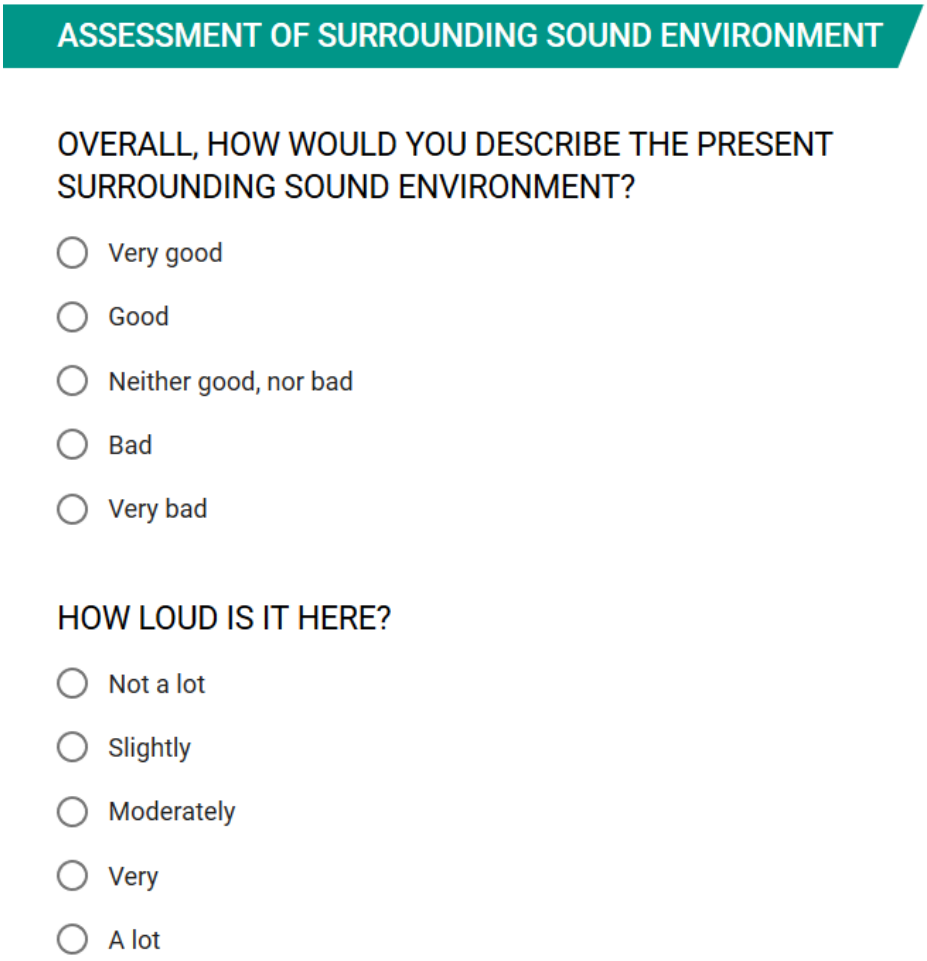


Fig.3.3 Questions about perceived soundscape quality.

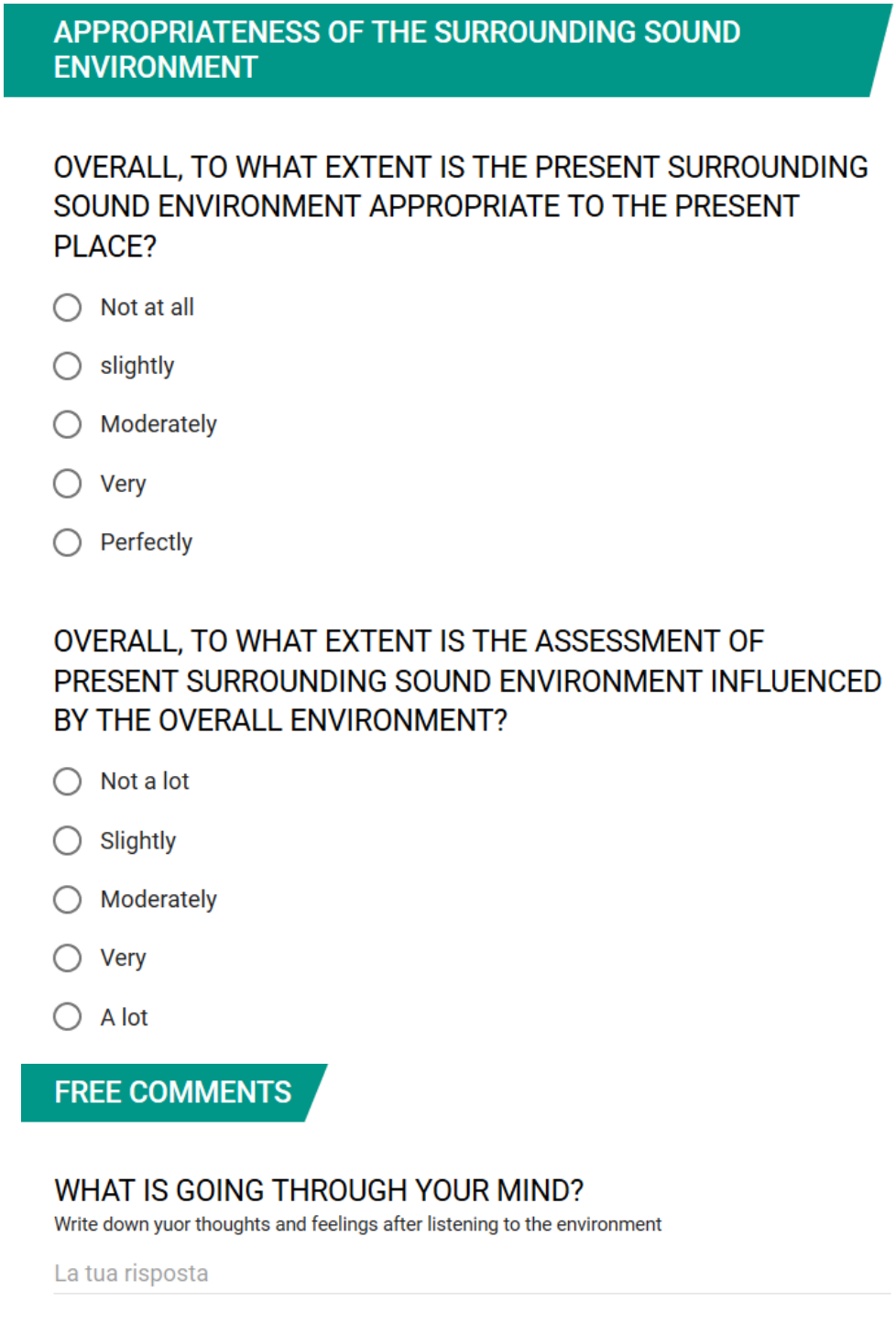


Fig.3.4 Questions about perceived appropriateness.

3.1.5 WELL BEING

The collection of data about the well-being of those who partake in the questionnaire is developed by a WHO-5 protocol; with the following items, it is possible to define the well-being of the participants. These five items are based on the respondent's feelings over the last two weeks before the survey. The Well-Being Index is calculated by taking the sum of the scores of each item, 0 to 5, and multiplying it by 4 to obtain indices ranging from 0 to 100.

Fig.3.5 Questions about well-being.

3.1.6 PERCEIVED SAFETY

The section on perceived safety is composed of two parts. The first part consists of five items, ranging from 1 to 5, regarding the participant's perceived safety. The second part is composed of two questions about the feeling of social presence, in this case, each question contains five items ranging from 1 to 5.

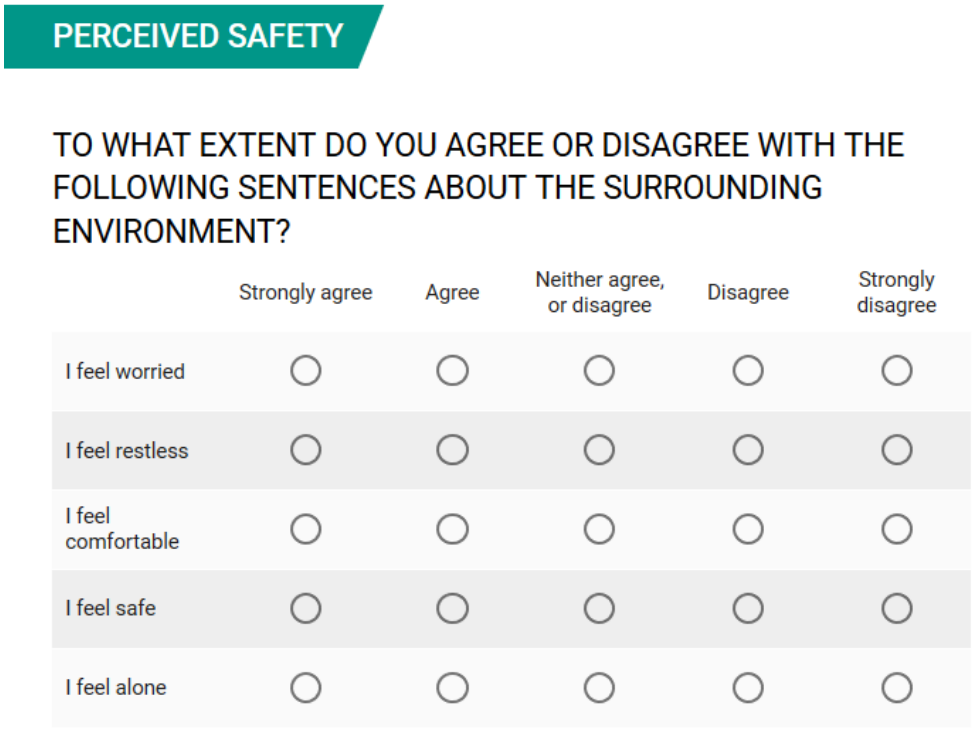


Fig.3.6 Questions about perceived safety.

FEELING OF SOCIAL PRESENCE

TO WHAT EXTENT DO YOU AGREE OR DISAGREE WITH THE FOLLOWING SENTENCES ABOUT THE SURROUNDING ENVIRONMENT?

	Strongly agree	Agree	Neither agree, or disagree	Disagree	Strongly disagree
I would walk alone along this place	○	○	○	○	○
I would extend my route to avoid walking in this place	○	○	○	○	○
I am feeling uncomfortable along this route	○	○	○	○	○
I would quickly cross this place to get away from here	○	○	○	○	○
I have an unpleasant feeling in this place	○	○	○	○	○

Fig.3.7 Questions about feeling of social presence.

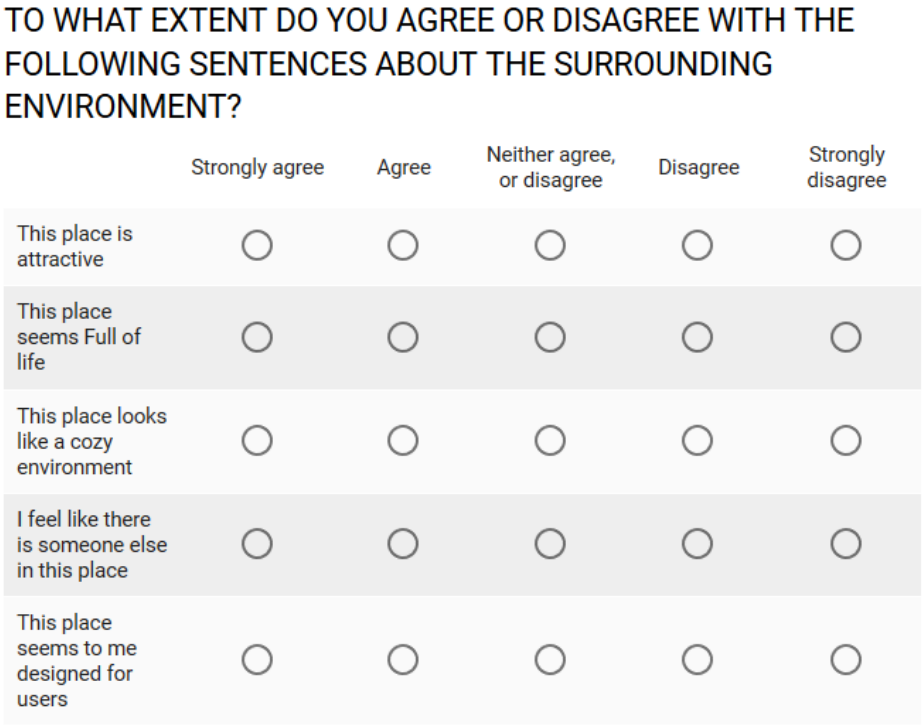


Fig.3.8 Questions about feeling of social presence.

3.1.7 CONTEXT

This section of the questionnaire deals with the investigation of how people evaluate the architectural context that surrounds them. Again, the responses range from 1 to 5 and look to understand what state the maintenance of public spaces and private buildings are in and the cleanliness of these public spaces.

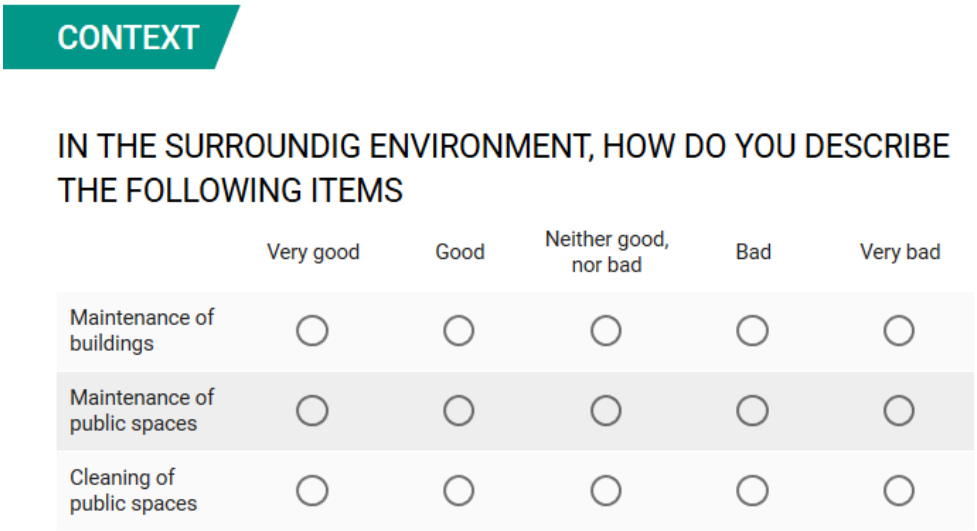


Fig.3.9 Questions about context.

3.1.8 PERSONAL DATA

The final section of the questionnaire is based on personal data and the frequency of visits to the analysed area; the scope of this data is to see how it is linked to the perception of soundscape and security.

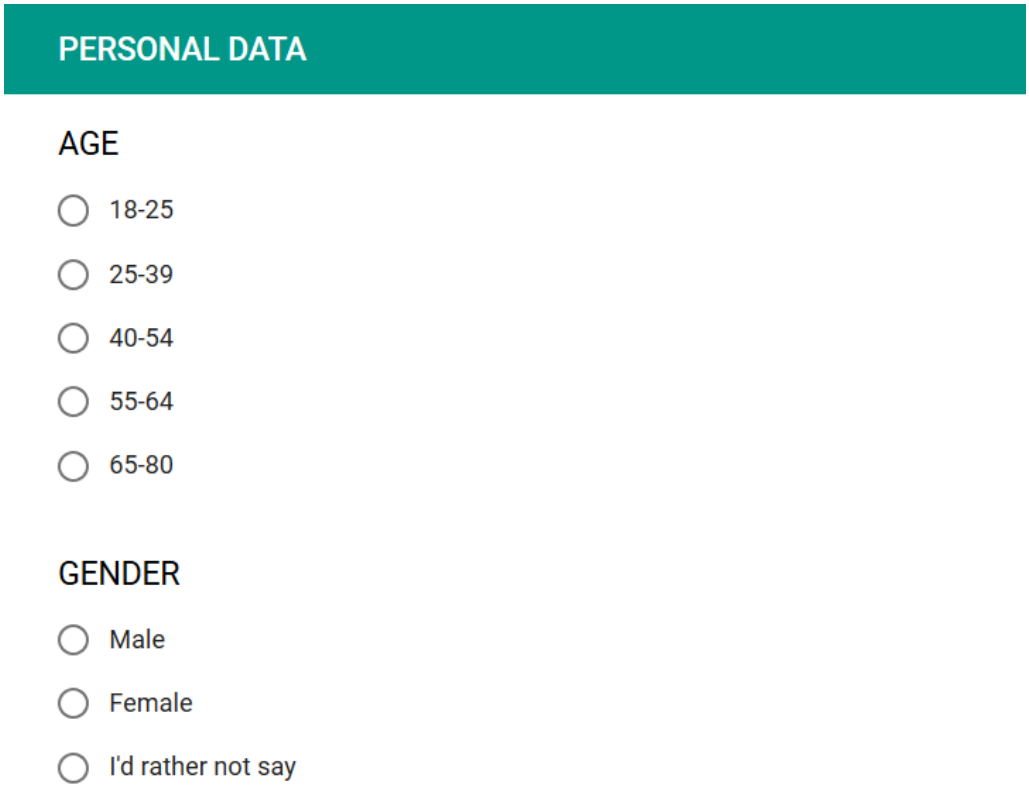


Fig.3.9 Questions about personal data.

WHAT IS THE HIGHEST LEVEL OF EDUCATION YOU HAVE COMPLETED?

- ○ No formal education
- ○ Primary (or elementary) education (Year 1-6)
- ○ Secondary education (Year 7-12)
- ○ College/Sixth form education (Year 12-13)
- ○ Higher education (University) less than 3 years
- ○ Higher education (University) 3 years or more

WHAT IS YOUR CURRENT MAIN OCCUPATION?

- ○ Employed
- ○ Self-employed
- ○ Student
- ○ Retired (old.age, disability or early retirement)
- ○ Long-term sick (more than 3 months)
- ○ Leave of absence or parental leave
- ○ Unemployed or in labour market policy measures
- ○ House wife/husband, manages the household
- ○ Other

Fig.3.10 Questions about personal data.

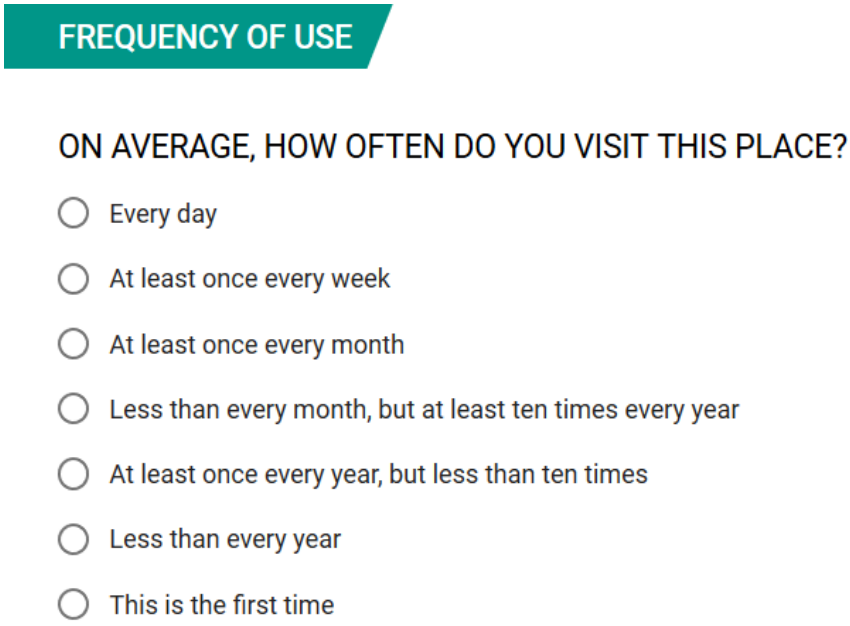


Fig.3.11 Questions about frequency of use.

3.2 AUDIO RECORDINGS

Audio tracks of the people who were in the square and participated in the survey were recorded during the data collection of soundscape perception. An audio recording of each participant was taken while they filled out the questionnaire. For those who fully completed carried the survey, an audio file with extension .wav lasting one minute was created making it possible to analyse the objective physics levels that describe the square's soundscape.

The measurement was performed using a binaural recording system, composed of an audio recorder EDIROL by ROLAND and a 4 channel portable recorder R-44, 24 bit 192 Hz DIGITAL, to which were connected to two microphones DPA MICROPHONE NEUTRIK, mc-mmx, DAD6001 P48 (12V-48V) with windshield; the microphones were placed at ear level, one to the left and the other to the right of the operator performing the measurements, in order to simulate in the most coherent way possible, the means in which the participant perceived the surrounding sound environment.

All the measurements were directly saved onto a micro SD memory card in the audio recorder itself, they were then moved onto a personal computer protected by a password where the measurements are analysed. Every morning, before starting the registration campaign, microphone calibrations were performed, thus ensuring the best possible reliability of the measurements. The calibrator used is a sound calibrator type 4231, by Bruel & Kjaer, with a sound pressure level of 94 dB, and a frequency of 1000 Hz; reference conditions were: temperature 23°C, pressure 101.325 Pa, humidity 50% RH, load 0,25 cm3.

The audio files collected are analysed through the LMS TestLab, a Siemens software for audio file analysis. Acoustic levels taken from this analysis are the equivalent sound level A-weighted and the psychoacoustic level of loudness ISO 532.

3.3 PHOTOS

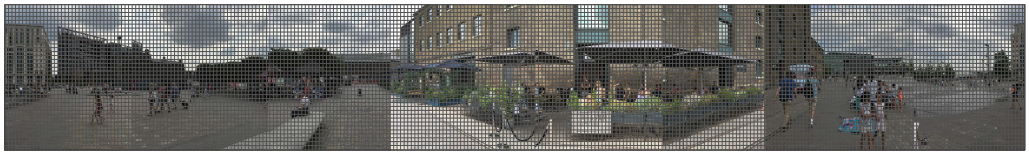
Moreover, for every audio recording made, eight photos were taken from the position of each participant during the questionnaire. The first photo was taken from the participant's point of view; the remaining seven were taken from the same position but rotating around itself in order to have a panoramic view of the architectural environment surrounding the participant.

The photos were taken with an I-phone SE; during the shoot, the smartphone was held in a vertical position at a height of 1,60 m, the flash and exposure were set in automatic mode, and between each shot, the photographer, himself, performed a 45-degree rotation.

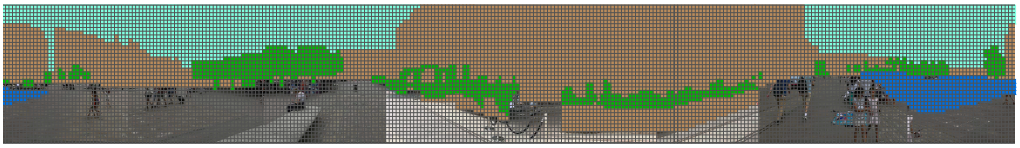
The analysis of the photos has been carried out in five stages:

1)The first part of the analysis consists in the reconstruction of the eight photos into a single panoramic photo.

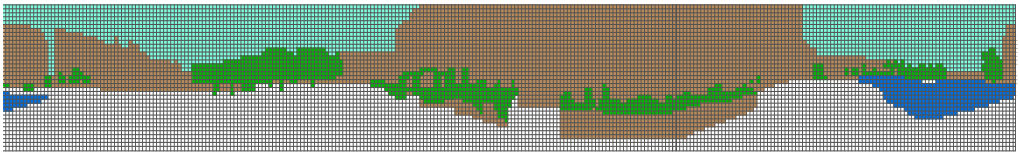
2) The second stage divides the panoramic photo into squares that have all the same dimension.



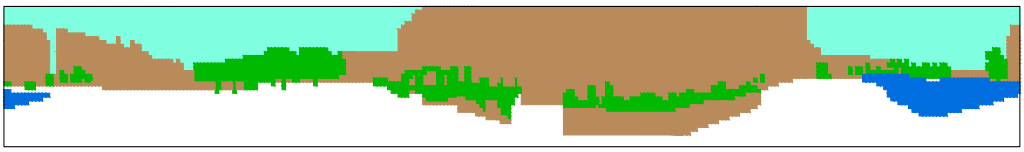
3) The third phase is characterized by coloring each part of the photograph with different colors depending on the different factors: vegetation (green), fountains or water in general (blue), buildings (orange), sky (light blue) and stoned pavement (not colored).



4) The fourth phase looks to define the total area of the photo and its surfaces (buildings, vegetation, water, sky, and pavement). In this way, it is possible to calculate the percentage with which each factor listed above makes up the surrounding environment of the participants. Each group of analyzed photographs helps describe one of the areas that will be analyzed later.



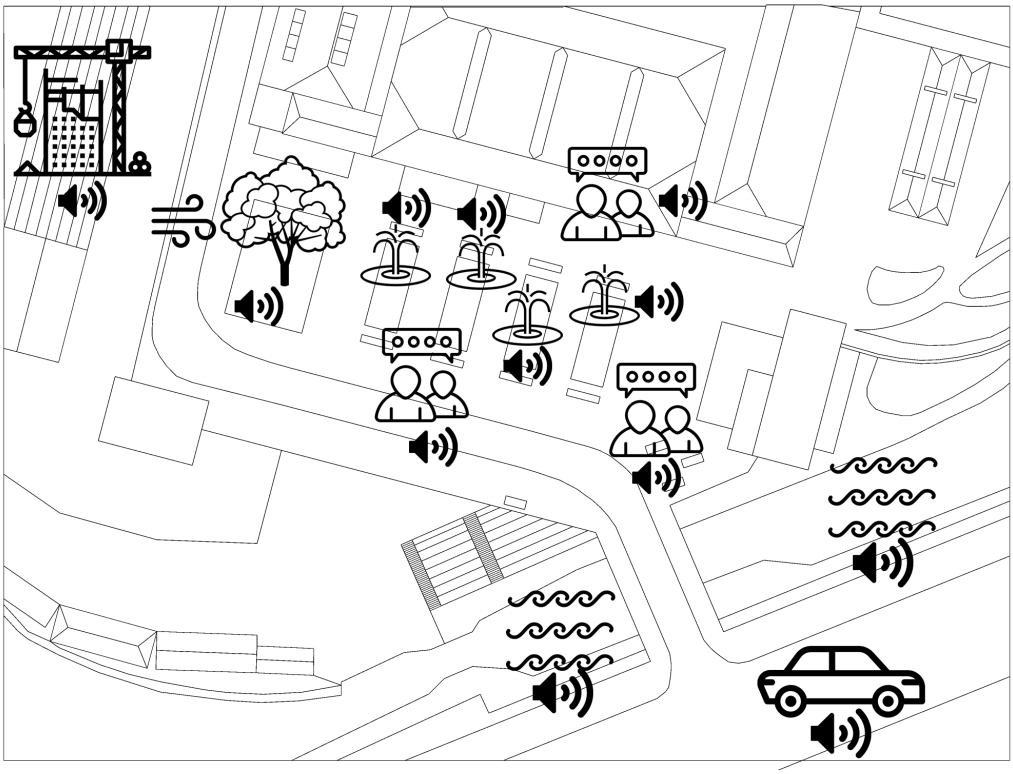
5) Finally, the last phase allows for a first visualization of how the surrounding environment of the participants is composed. Using the data percentage calculated through this analysis, it will be possible to understand the relationship between the factors that make up the architectural environment perceived by the participants and the perceived sound environment.



ANALYSIS

4.1 AREA

GANARY SQUARE



4.2 LOCATION

The study case is a square at the north of the station of King Cross St. Pancras. The square is 50 meters wide and 120 meters long, and its area is 6.000 square Meters. In this place there are a buildings on the north side and east side, where there are restaurants, caffè and pubs, the south side is bordered by the Regent's canal, and in the west side there is a building site.

The square is crossed by a small road, furthermore in the south side of the Regent's canal there is a wide street.

In the middle of the square there are a fountains and on the west side of the fountains there are some vegetation. The rooftop of the square is stone.

4.3 SOUND SOURCES

In the study case there are nature sounds from the Canal and the fountains, but there also some vegetation that can become sound source during the windy days. There are also sounds from human being because the square is always very busy and there are a lot of children who play in the fountains. At the end there is also noise from traffic road and the constructions site near the study case.

4.4 PEOPLE

there are several commercial activity, and a lot of space for recreational activity for adult and children in the square. Then the range of people who use the square is varied and wide.

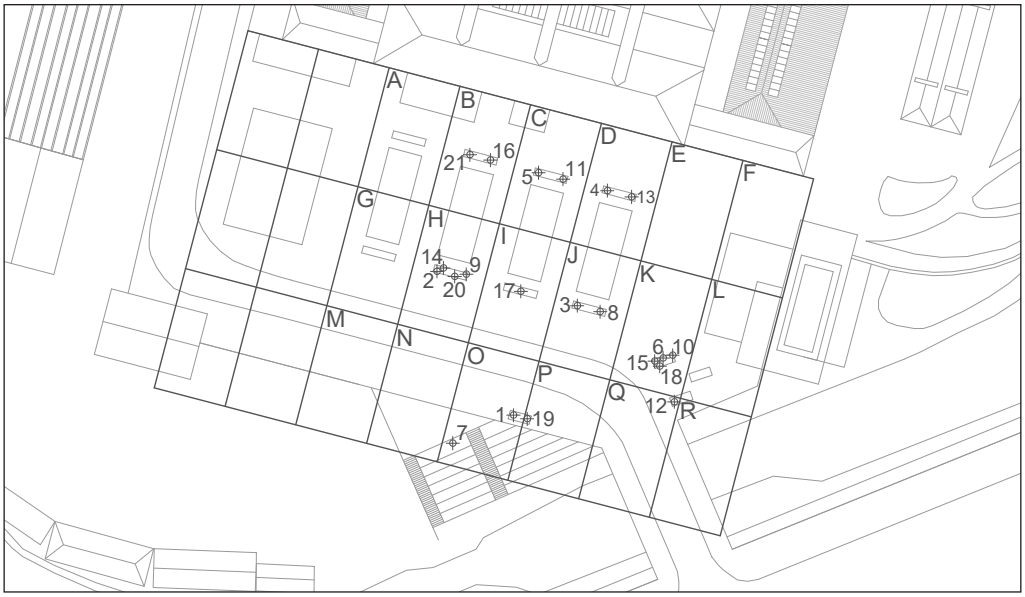


4.5 MAPS POSITIONS

The data collection campaign inside the square was held in 5 days, which were on 18-19-23-24-25 July 2018, during the daytime hours between 10.00am and 6.00pm.

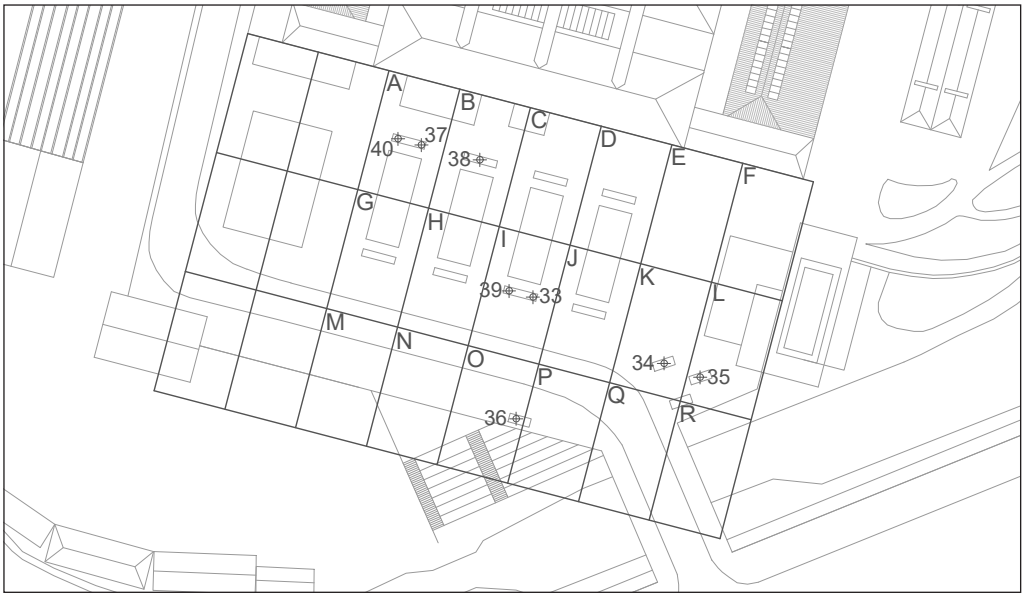
The following maps show the positions in which the various questionnaires have been completed, which are the same positions where the audio recordings and photographs were taken.

DAY 1_18.07.2018



DAY 2_19.07.2018

DAY 3_23.07.2018



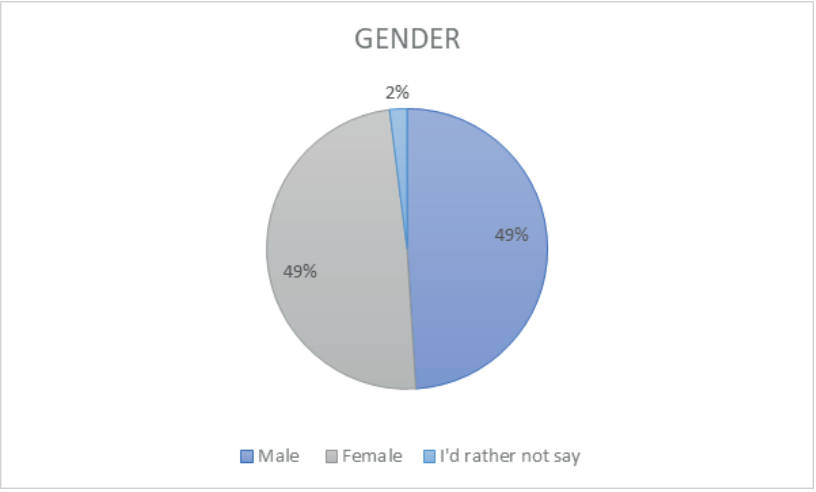
DAY 4_24.07.2018

DAY 5_25.07.2018

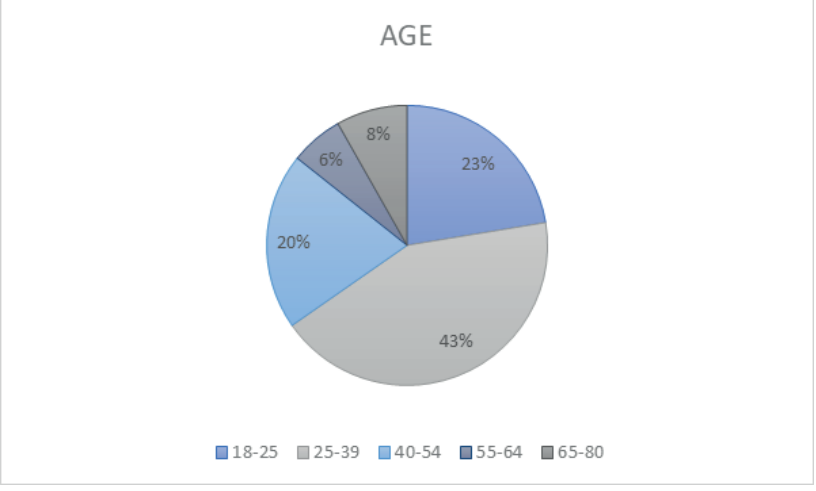
4.6 PARTICIPANTS

The number of people who took part in the experiment is 50 units.

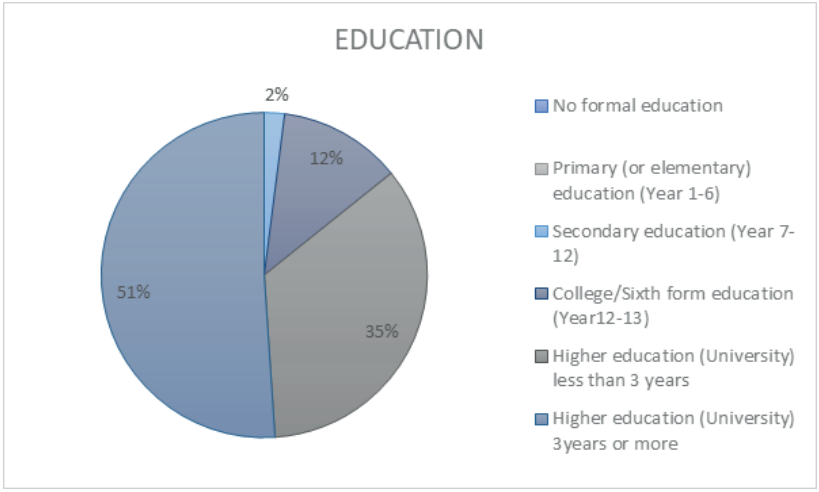
And the people was 49% male and 49% female, the 2% of participants did not indicate their gender.



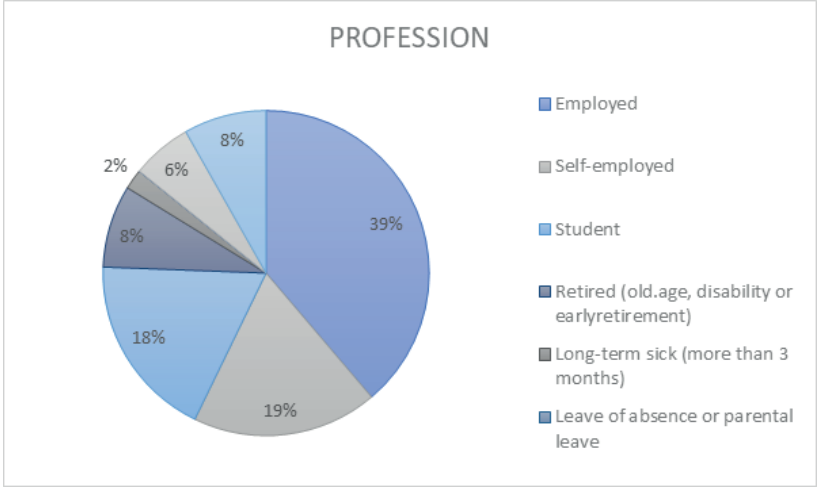
The group of participants are composed by people with wide range of age, but the most populous group is made up by people between 25 and 39 years old.



More than half of the people who participated in the test attended the university for more than three years, while the remaining sample the most of the people attended the university for less than 3 years.



The Group of participants is made up largely by employed or self employed and students.



4.7 STATISTICAL ANALYSIS

In order to analyse the data collected, the IBM Statistical Package for Social Sciences (SPSS) for Windows, is used. All the variables asked to people in the questionnaire are analysed using spearman test, in order to define several possible correlations between the variables. The results contain the correlations considered statistically significant with a P-value lower than 0,01, or correlations with a P-value lower than 0,05 significant for the aims of the research.

RESULTS

5.1 PERCEIVED QUALITY OF SURROUNDING SOUND ENVIRONMENT

The mean value of perceived quality of surrounding sound environment is **3.72/5** and the standard deviation is **0.72**, then the perceveid quality is generally good. There are not values far from the mean value.

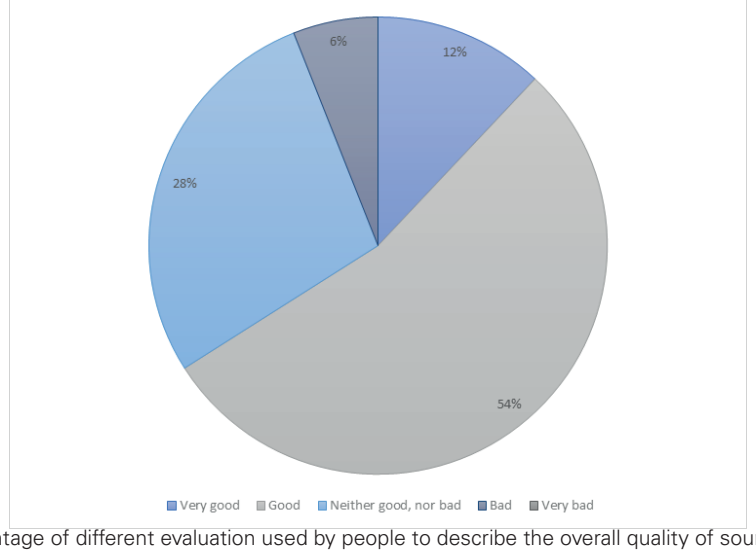


Fig.5.1.1 Percentage of different evaluation used by people to describe the overall quality of soundscape.

The perceived affective quality of soundscape by people Highlight that the quality of soundscape is very high. From these data it is possible to confirm that the quality of surrounding sound environment is good even if it is generally full of sounds and chaotic.

Tab.5.1.2 mean value (mean) and standard deviation (SD) of attributes related with the perceived affective quality.

	EVENTFUL	VIBRANT	PLEASANT	CALM	UNEVENTFUL	MONOTONOUS	ANNOYING	CHAOTIC
mean	3.64	3.64	3.60	2.56	2.38	2.44	2.36	3.24
sd	0.53	0.88	0.81	1.09	0.95	0.86	0.83	1.00

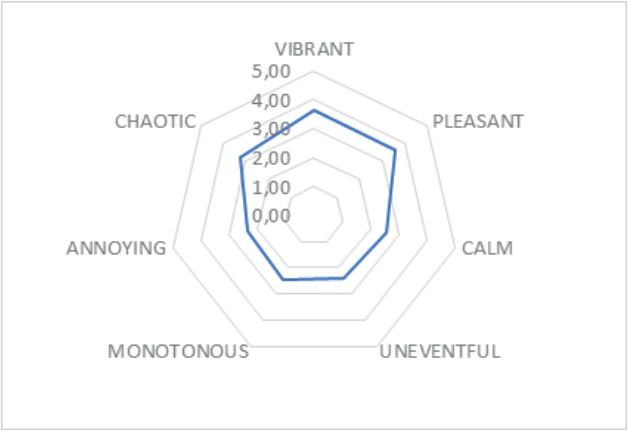


Fig.5.1.3 Graphic that represent the mean value of perceived affective quality.

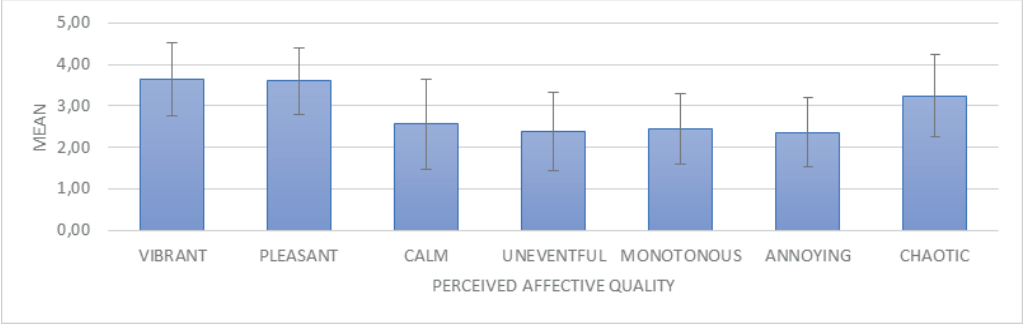


Fig.5.1.4 mean value (mean) and standard deviation (SD) of attributes related with the perceived affective quality.

Tab.5.1.5 Mean value(mean) and Standard deviation(sd) of the pleasantness related with the values of the quality of surrounding soundscape.

		QUALITY SURROUNDING SOUND ENVIRONMENT						
		Very bad	Bad	Neither good.nor bad	Good	Very good	spearman's rho	two-tailed value of P
PLEASANTNESS	mean	0.00	2.67	3.07	3.78	4.50	**0.599**	**0.000**
	sd	0.00	1.15	0.62	0.64	0.55		

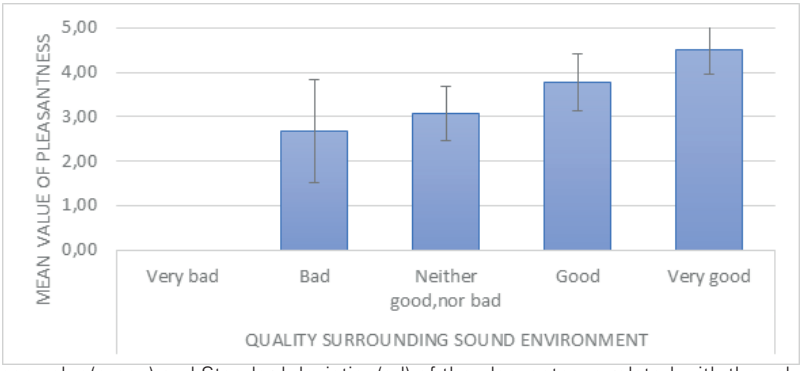


Fig.5.1.6 Mean value(mean) and Standard deviation(sd) of the pleasantness related with the values of the quality of surrounding soundscape.

Tab.5.1.7 Mean value(mean) and Standard deviation(sd) of the calmness related with the values of the quality of surrounding soundscape.

		QUALITY SURROUNDING SOUND ENVIRONMENT						
		Very bad	Bad	Neither good.nor bad	Good	Very good	spearman's rho	two-tailed value of P
CALM	mean	0.00	1.67	2.00	2.63	4.00	**0.521**	**0.000**
	sd	0.00	0.58	0.55	1.04	1.10		

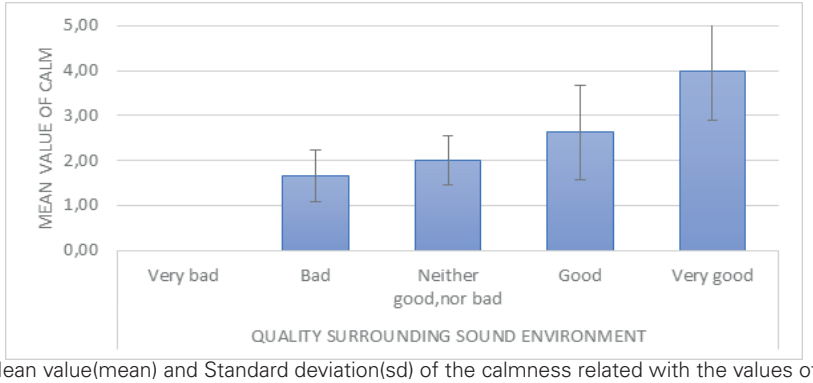


Fig.5.1.8 Mean value(mean) and Standard deviation(sd) of the calmness related with the values of the quality of surrounding soundscape.

The mean value of perceived loudness is **2.98/5** and the standard deviation is **0.71**, then people perceive the sound environment of the square as moderately loudness. There are only three values far from the mean value.

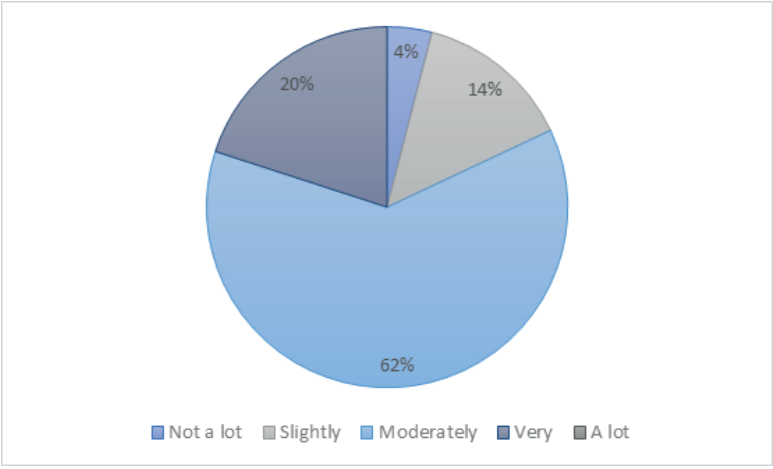


Fig.5.1.9 Percentage of different evaluation used by people to describe the perceived loudness.

Tab.5.1.10 Mean value(mean) and Standard deviation(sd) of the perceived loudness related with the values of the quality of surrounding soundscape.

		QUALITY SURROUNDING SOUND ENVIRONMENT						
		Very bad	Bad	Neither good.nor bad	Good	Very good	spearman's rho	two-tailed value of P
P. LOUDNESS	mean	0.00	4.00	3.07	2.96	2.33	**-0.349**	**0.013**
	sd	0.00	0.00	0.47	0.59	1.21		

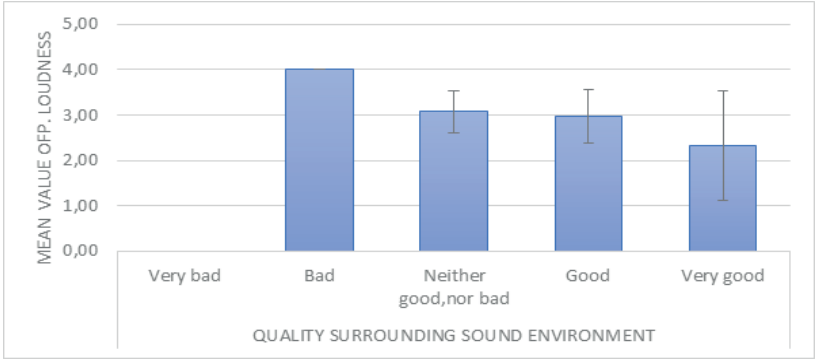


Fig.5.1.11 Mean value(mean) and Standard deviation(sd) of the perceived loudness related with the values of the quality of surrounding soundscape.

5. 2 SOUND SOURCES

Interviewed people have defined the Sound from Human Being as a dominant sound source in the square. this sound sources was the dominant for the 42% of people who answered to questionnaire. the second sound source that had been perceived as dominant is the Noise, 20% of participants chose this answer. the Natural sound had been perceived as dominant only by the 4% of participants. The remaining 34% of people did not define a unique dominant sound sources.

Tab.5.2.1 mean value of perceived dominant sound sources.

	NOISE FROM TRAFFIC AND CONSTRUCTIONS	SOUND FROM HUMAN BEINGS	NATURAL SOUND
mean	3.12	3.74	2.64
sd	1.02	0.72	1.17

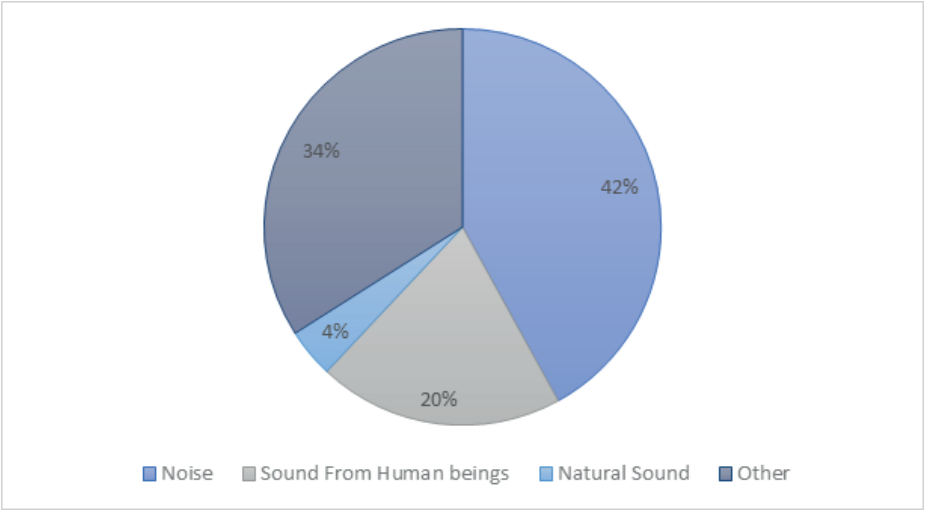


Fig.5.2.2 mean value of perceived dominant sound sources.

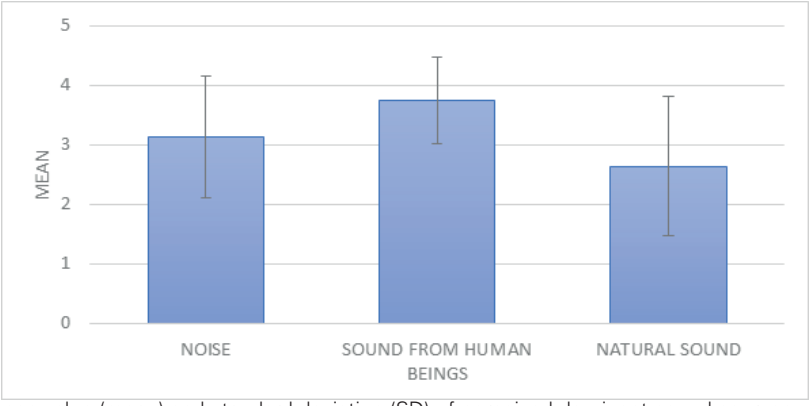


Fig.5.2.3 mean value (mean) and standard deviation (SD) of perceived dominant sound sources.

Tab.5.2.4 mean value and standard deviation (sd) of perceived Noise related to perceived pleasantness.

		NOISE (e.g. Traffic. construction. industry)						
		Not a lot	A little	Moderately	A lot	Dominates completely	Spearman's RHO	P-value
PLEASANTNESS	mean	4.00	3.50	3.79	3.32	3.50	**-0.282**	**0.047**
	sd	0.63	0.58	0.63	1.00	0.71		

Fig.5.2.5 mean value and standard deviation (sd) of perceived Noise related to perceived pleasantness.

Tab.5.2.6 mean value and standard deviation (sd) of perceived Noise related to perceived eventfulness.

		NOISE (e.g. Traffic. construction. industry)						
		Not a lot	A little	Moderately	A lot	Dominates completely	Spearman's RHO	P-value
EVENTFULNESS	mean	3.33	3.50	3.63	3.74	4.00	**0.303**	**0.032**
	sd	0.52	0.58	0.50	0.56	0.00		

Fig.5.2.7 mean value and standard deviation (sd) of perceived Noise related to perceived eventfulness.

Tab.5.2.8 mean value and standard deviation (sd) of perceived Noise related to perceived annoyance.

		NOISE (e.g. Traffic. construction. industry)						
		Not a lot	A little	Moderately	A lot	Dominates completely	Spearman's RHO	P-value
ANNOYANCE	mean	2.17	1.75	2.21	2.63	3.00	**0.333**	**0.018**
	sd	0.75	0.50	0.79	0.90	0.00		

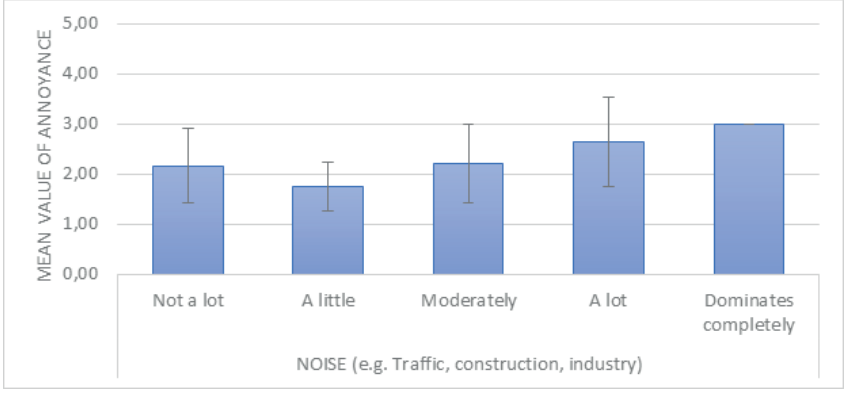
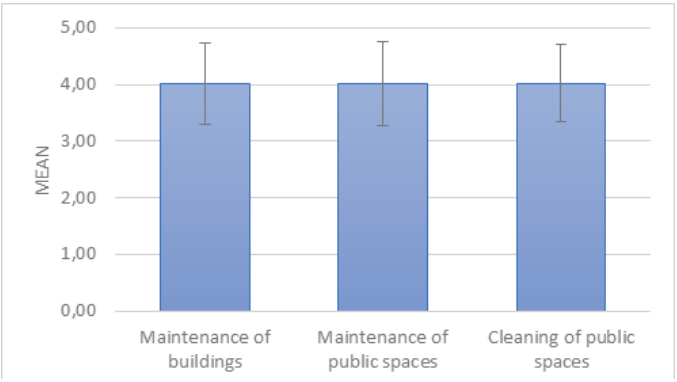


Fig.5.2.9 mean value and standard deviation (sd) of perceived Noise related to perceived annoyance.

5.3 CONTEXT

Tab.5.3.1 Mean value(mean) and Standard deviation(sd) of the maintenance of buldings and public spaces and cleaning of public spaces

	Maintenance of buildings	Maintenance of public spaces	Cleaning of public spaces
mean	4.02	4.02	4.02
sd	0.71	0.74	0.68



Fog.5.3.2 Mean value(mean) and Standard deviation(sd) of the maintenance of buldings and public spaces and cleaning of public spaces

The Appropriateness has been defined as "Moderately" by 42% of participants. "Very" by 36% of participants and "Perfectly" by 8%. and only the 14% of participants have chosen "Slightly". Than the Appropriateness of environment and soundscape is very high, on average the value of Appropriateness is **3.38/5** and the standard deviation is **0.83**.

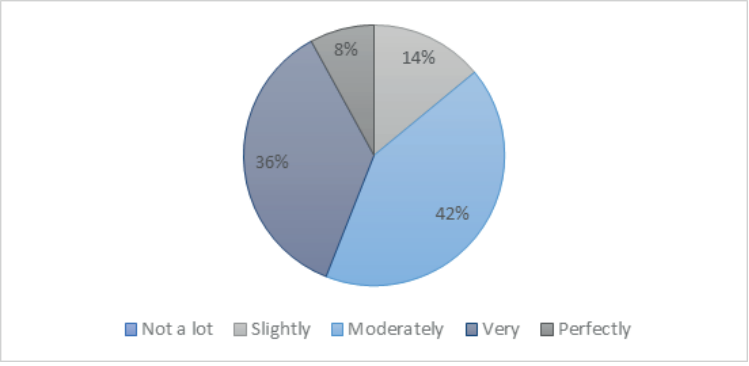


Fig.5.3.3 Percentage of different evaluation used by people to describe the appropriateness of soundscape to the general environment.

The mean value of appropriateness is directly related with the assessment of the surrounding sound environment quality, when the perceived quality grows up also the appropriateness increases. By normal standards, the association between the two variables would be considered statistically significant.

Tab.5.3.4 Mean value(mean) and Standard deviation(sd) of the appropriateness related with the values of the quality of surrounding soundscape.

		QUALITY SURROUNDING SOUND ENVIRONMENT						
		Very bad	Bad	Neither good.nor bad	Good	Very good	spearman's rho	two-tailed value of P
APPROPRIATENSS	mean	0.00	2.33	3.29	3.37	4.17	**0.362**	**0.010**
	sd	0.00	0.58	0.83	0.74	0.75		

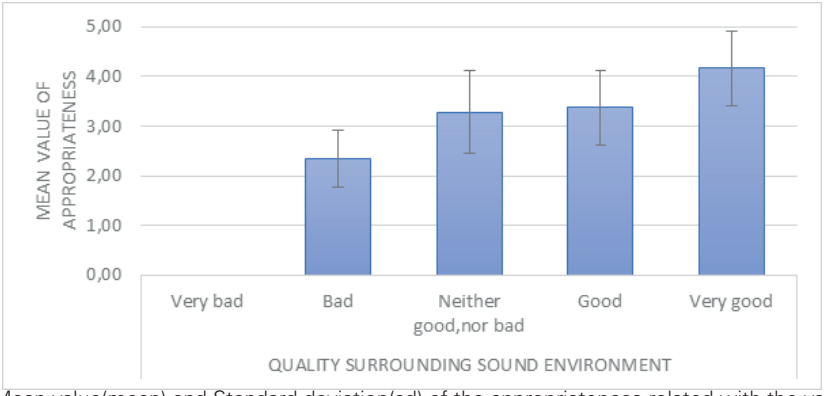


Fig.5.3.5 Mean value(mean) and Standard deviation(sd) of the appropriateness related with the values of the quality of surrounding soundscape.

5.4 PERCEIVED SAFETY

Tab.5.4.1 mean value (mean) and standard deviation (SD) of perceived safety by people in the square during the experiment.

	mean	sd
I feel worried	2.12	0.96
I feel restless	2.22	0.86
I feel alone	2.38	1.03
	mean	sd
I feel comfortable	3.62	0.90
I feel safe	3.60	1.01

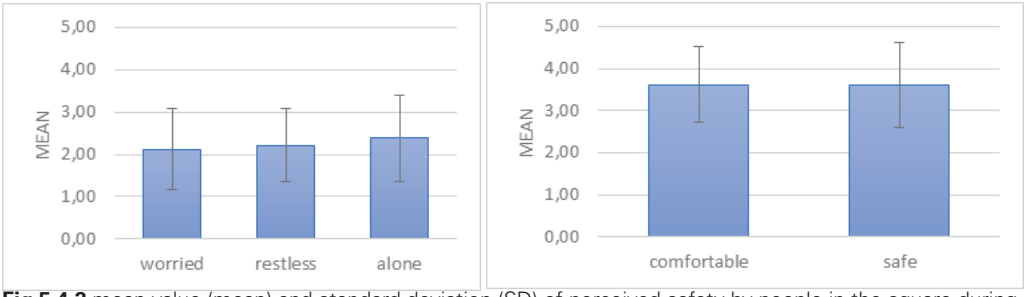


Fig.5.4.2 mean value (mean) and standard deviation (SD) of perceived safety by people in the square during the experiment.

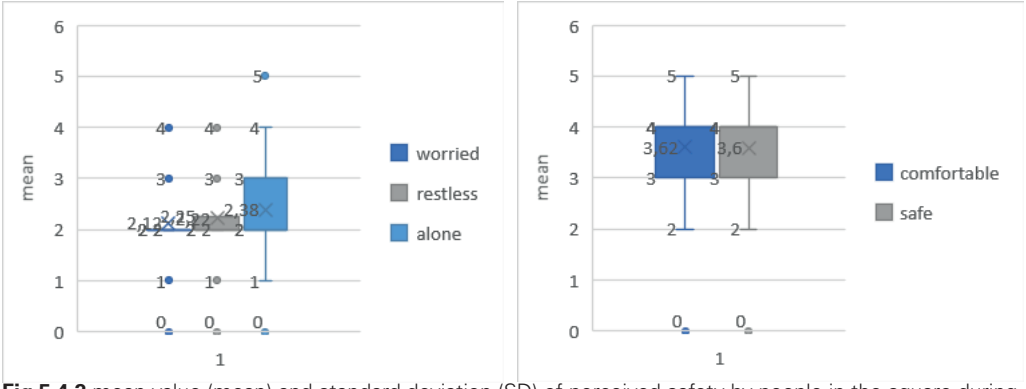


Fig.5.4.3 mean value (mean) and standard deviation (SD) of perceived safety by people in the square during the experiment.

Tab.5.4.4 mean value (mean) and standard deviation (SD)) of feeling of social presence by people in the square during the experiment.

	mean	sd
I would not walk alone along this place	2.06	0.74
I would extend my route to avoid walking in this place	2.38	0.99
I am feeling uncomfortable along this route	2.04	0.81
I would quickly cross this place to get away from here	2.26	1.05
I have an unpleasant feeling in this place	1.90	0.81

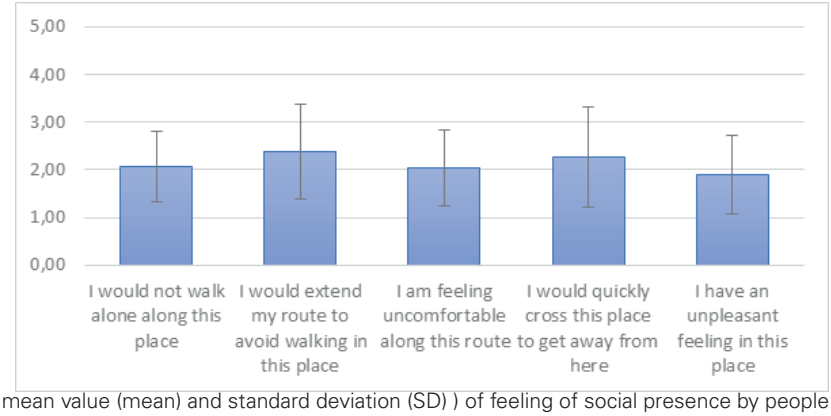


Fig.5.4.5 mean value (mean) and standard deviation (SD)) of feeling of social presence by people in the square during the experiment.

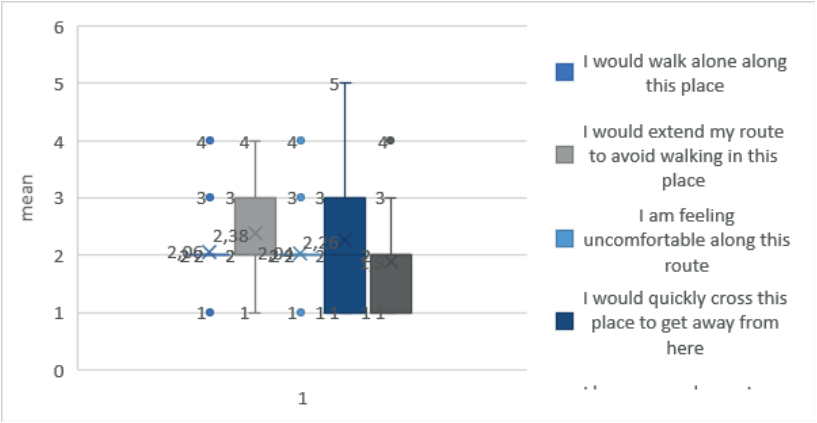


Fig.5.4.6 mean value (mean) and standard deviation (SD)) of feeling of social presence by people in the square during the experiment.

Tab.5.4.7 mean value (mean) and standard deviation (SD)) of feeling of social presence by people in the square during the experiment.

	mean	sd
This place is attractive	3.90	0.61
This place seems Full of life	4.12	0.56
This place looks like a cozy environment	3.12	0.75
I feel like there is someone else in this place	3.68	0.89
This place seems to me designed for users	3.68	0.91

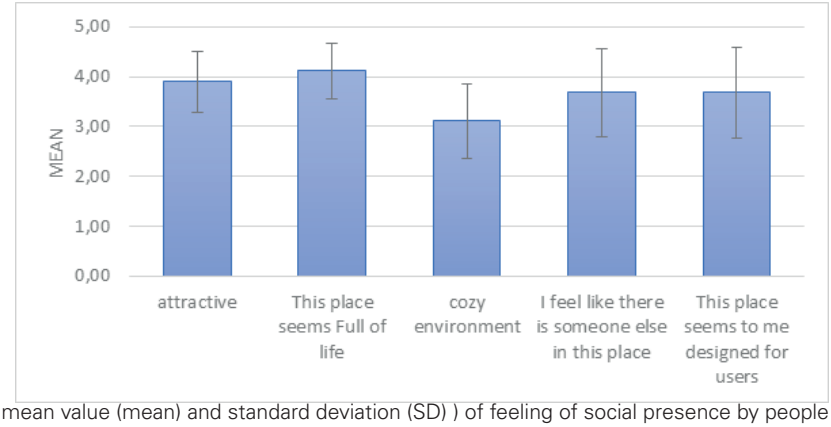


Fig.5.4.8 mean value (mean) and standard deviation (SD)) of feeling of social presence by people in the square during the experiment.

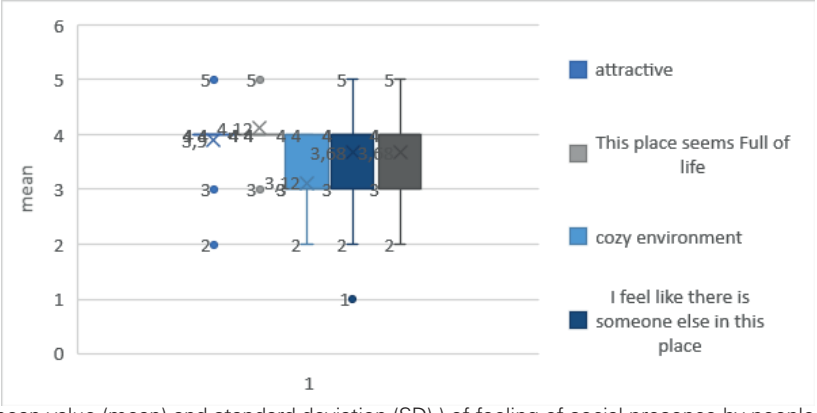


Fig.5.4.9 mean value (mean) and standard deviation (SD)) of feeling of social presence by people in the square during the experiment.

5.4.1 PERCEIVED SAFETY RELATED TO SOUND SOURCES

Tab.5.4.10 mean value (mean) and standard deviation (SD)) of perceived cosiness of environment related to the perceived level of noise from traffic and constructions.

		NOISE (e.g. Traffic. construction. industry)						
		Not a lot	A little	Moderately	A lot	Dominates completely	Spearman's RHO	P-value
THIS PLACE LOOKS LIKE A COZY ENVIRONMENT	mean	3.67	3.50	3.11	2.90	3.00	**-0.321**	**0.023**
	sd	0.52	0.58	0.74	0.79	0.00		

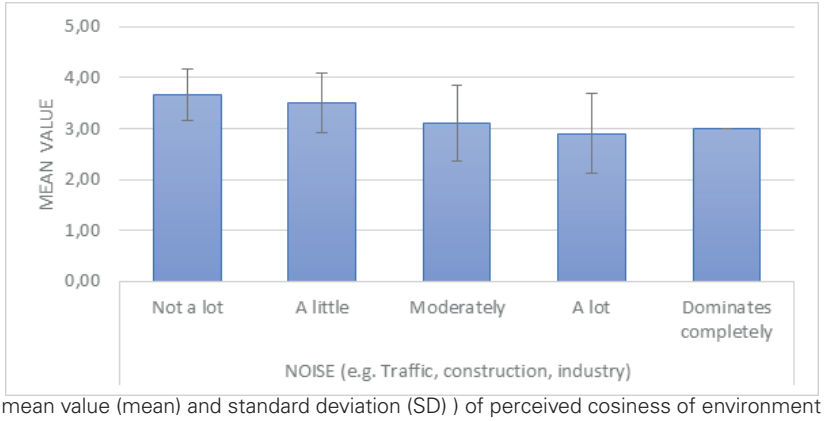


Fig.5.4.11 mean value (mean) and standard deviation (SD)) of perceived cosiness of environment related to the perceived level of noise from traffic and constructions.

5.4.2 PERCEIVED SAFETY RELATED TO THE AFFECTIVE QUALITY OF SOUNDSCAPE

Tab.5.4.12 mean value (mean) and standard deviation (SD)) of feeling of worried and restless related to the level of annoyance.

		ANNOYANCE						
		Strongly disagree	Disagree	Neither agree. or disagree	Agree	Strongly agree	Spearman's RHO	P-value
I FEEL WORRIED	mean	1.14	2.09	2.29	3.25	0.00	**0.440**	**0.001**
	sd	0.69	0.75	0.85	1.50	0.00		
I FEEL RESTLESS	mean	1.43	2.14	2.35	3.50	0.00	**0.500**	**0.000**
	sd	0.79	0.71	0.79	0.58	0.00		

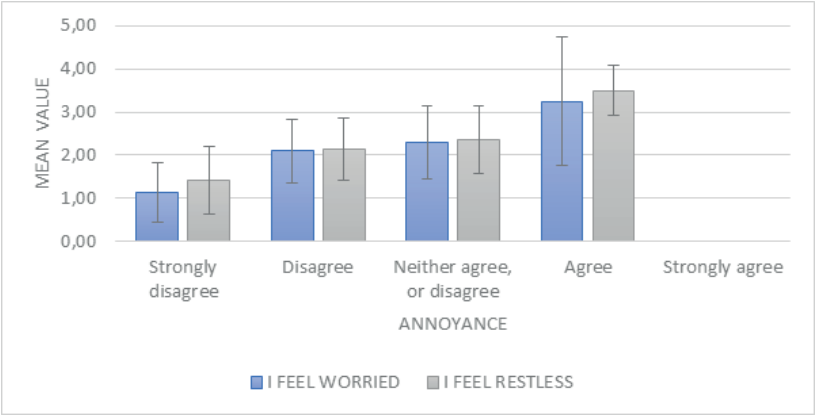


Fig.5.4.13 mean value (mean) and standard deviation (SD)) of feeling of worried and restless related to the level of annoyance.

Tab.5.4.14 mean value (mean) and standard deviation (SD)) of feeling of worried and restless related to the level of perceived loudness.

		PERCEIVED LOUDNESS						
		Not a lot	Slightly	Moderately	Very	A lot	Spearman's RHO	P-value
I FEEL WORRIED	mean	2.00	1.57	2.13	2.70	0.00	**0.365**	**0.009**
	sd	0.00	0.53	0.81	1.25	0.00		
I FEEL RESTLESS	mean	2.00	1.86	2.16	2.90	0.00	**0.415**	**0.003**
	sd	0.00	0.69	0.69	0.99	0.00		

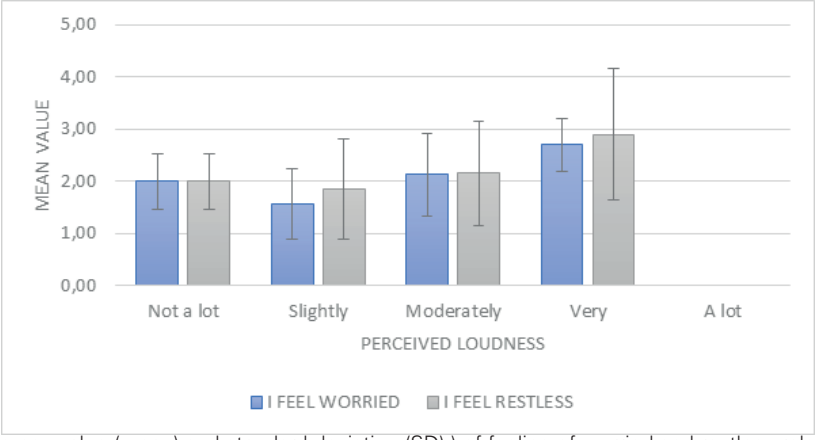


Fig.5.4.15 mean value (mean) and standard deviation (SD)) of feeling of worried and restless related to the level of perceived loudness.

Tab.5.4.16 mean value (mean) and standard deviation (SD)) of feeling of comfortable related to the level of perceived chaos.

		CHAOTIC						
		Strongly disagree	Disagree	Neither agree. or disagree	Agree	Strongly agree	Spearman's RHO	P-value
I FEEL COMFORTABLE	mean	4.00	3.92	3.62	3.63	2.50	**-0.301**	**0.034**
	sd	0.00	0.76	0.77	0.76	2.08		

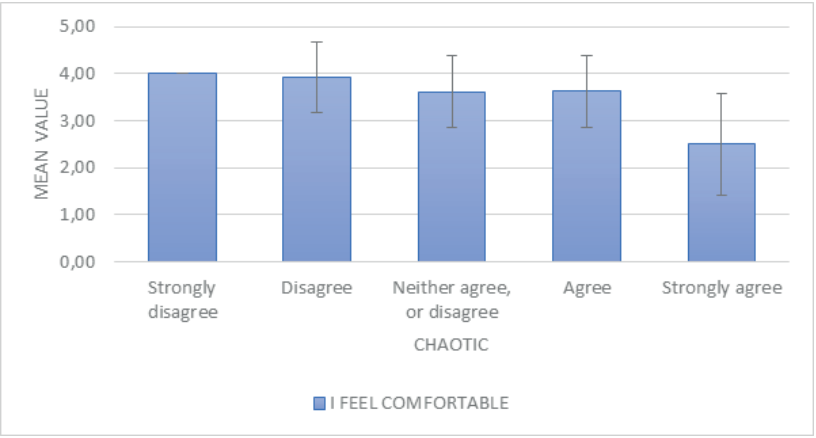


Fig.5.4.17 mean value (mean) and standard deviation (SD)) of feeling of comfortable related to the level of perceived chaos.

Tab.5.4.18 mean value (mean) and standard deviation (SD)) of feeling of social presence related to the level of annoyance.

		ANNOYANCE						
		Strongly disagree	Disagree	Neither agree. or disagree	Agree	Strongly agree	Spearman's RHO	P-value
I WOULD WALK ALONE ALONG THIS ROUTE	mean	4.43	4.09	3.59	3.75	0.00	**-0.416**	**0.003**
	sd	0.53	0.68	0.80	0.50	0.00		
I WOULD EXTENT MY ROUTE TO AVOID WALKING IN THIS PLACE	mean	1.57	2.36	2.65	2.75	0.00	**0.332**	**0.019**
	sd	0.53	0.95	1.00	1.26	0.00		

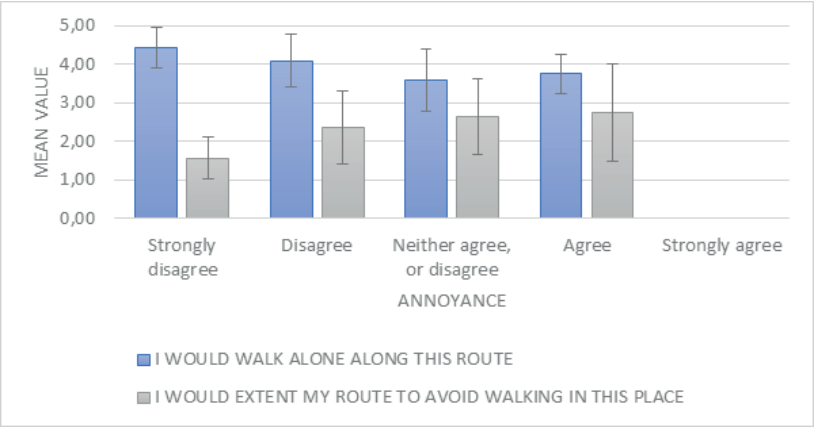


Fig.5.4.19 mean value (mean) and standard deviation (SD)) of feeling of social presence related to the level of annoyance.

Tab.5.4.20 mean value (mean) and standard deviation (SD)) of feeling of social presence related to the level of vibrancy.

		VIBRANCY						
		Strongly disagree	Disagree	Neither agree. or disagree	Agree	Strongly agree	Spearman's RHO	P-value
I WOULD WALK ALONE ALONG THIS ROUTE	mean	0.00	4.00	3.73	4.00	4.40	**0.308**	**0.030**
	sd	0.00	0.00	0.80	0.73	0.55		
I WOULD EXTENT MY ROUTE TO AVOID WALKING IN THIS PLACE	mean	0.00	3.50	2.73	2.11	2.00	**-0.409**	**0.003**
	sd	0.00	0.71	0.96	0.93	0.71		
I WOULD QUICKLY CROSS THIS PLACE TO GET AWAY FROM HERE	mean	0.00	4.50	2.40	1.93	2.40	**-0.291**	**0.040**
	sd	0.00	0.71	0.91	0.96	0.55		
IHAVE AN UNPLEASANT FEELING IN THIS PLACE	mean	0.00	1.50	2.20	1.78	1.60	**-0.282**	**0.047**
	sd	0.00	0.71	0.68	0.89	0.55		

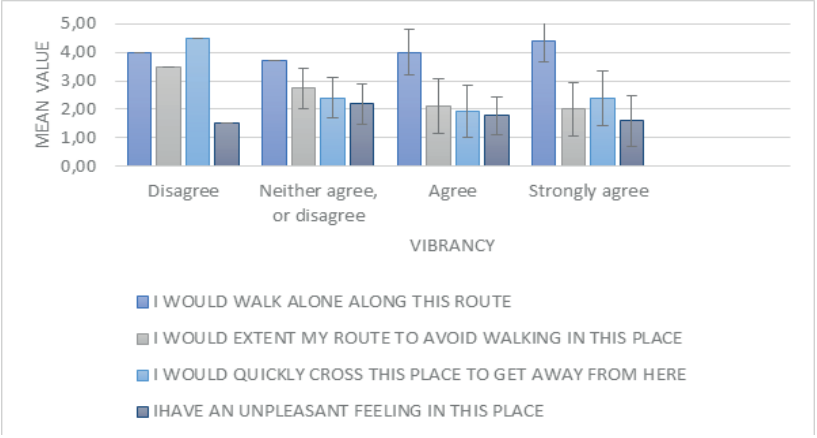


Fig.5.4.21 mean value (mean) and standard deviation (SD)) of feeling of social presence related to the level of vibrancy.

Tab.5.4.22 mean value (mean) and standard deviation (SD)) of feeling of social presence related to the level of appropriateness.

		APPROPRIATENESS						
		Not a lot	Slightly	Moderately	Very	Perfectly	Spearman's RHO	P-value
I WOULD WALK ALONE ALONG THIS ROUTE	mean	0.00	3.86	3.67	4.22	4.25	**0.337**	**0.017**
	sd	0.00	0.69	0.73	0.73	0.50		

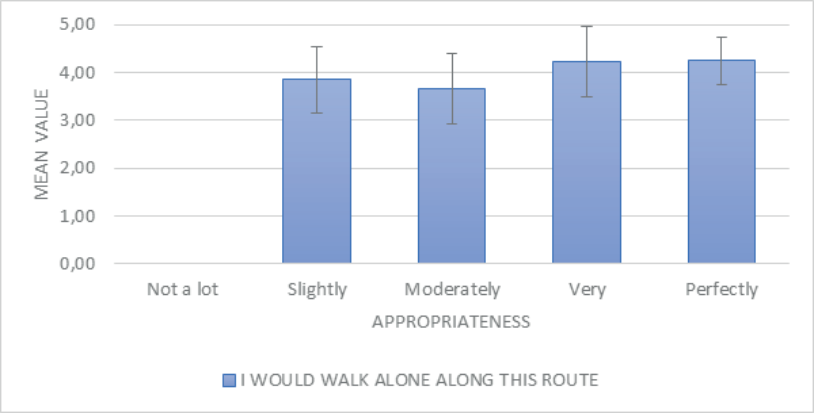


Fig.5.4.23 mean value (mean) and standard deviation (SD)) of feeling of social presence related to the level of appropriateness.

Tab.5.4.24 mean value (mean) and standard deviation (SD)) of feeling of social presence related to the level of eventfulness.

		UNEVENTFUL						
		Not a lot	Slightly	Moderately	Very	Perfectly	Spearman's RHO	P-value
I WOULD EXTENT MY ROUTE TO AVOID WALKING IN THIS PLACE	mean	1.67	2.13	2.46	3.43	0.00	**0.372**	**0.008**
	sd	0.82	0.76	1.05	0.79	0.00		

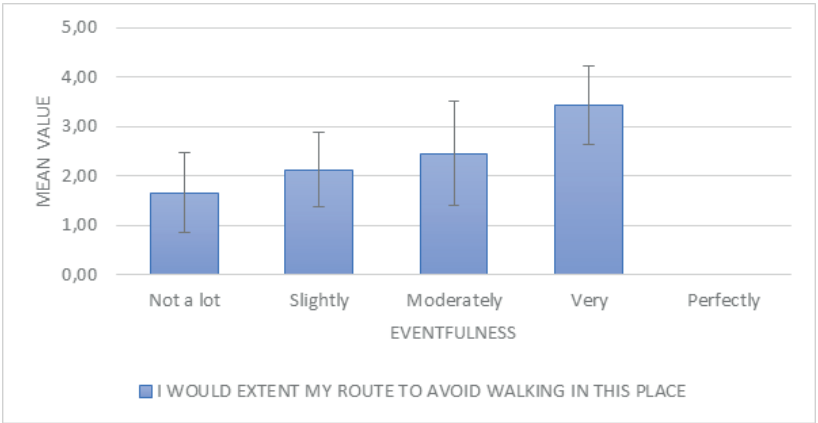


Fig.5.4.25 mean value (mean) and standard deviation (SD)) of feeling of social presence related to the level of eventfulness.

Tab.5.4.26 mean value (mean) and standard deviation (SD)) of feeling of cosiness related to the level of appropriateness.

		APPROPRIATENESS						
		Not a lot	Slightly	Moderately	Very	Perfectly	Spearman's RHO	P-value
THIS PLACE LOOKS LIKE A COZY ENVIRONMENT	mean	0.00	2.57	3.10	3.22	3.75	**0.332**	**0.019**
	sd	0.00	0.79	0.70	0.73	0.50		

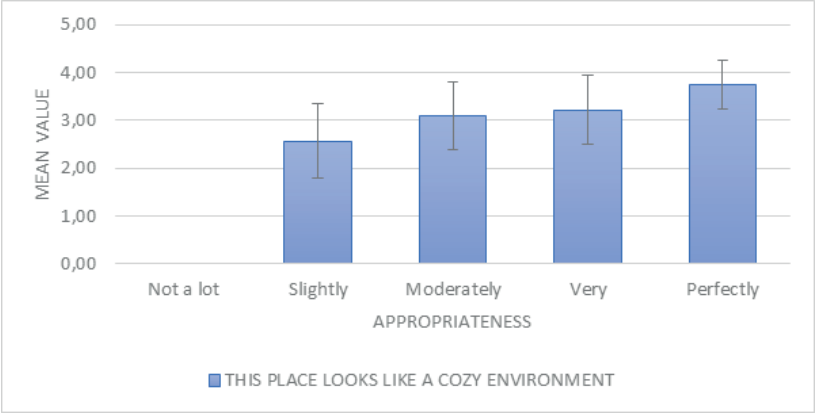


Fig.5.4.27 mean value (mean) and standard deviation (SD)) of feeling of cosiness related to the level of appropriateness.

Tab.5.4.28 mean value (mean) and standard deviation (SD)) of feeling of social presence related to the level of vibrancy.

		VIBRANCY						
		Strongly disagree	Disagree	Neither agree. or disagree	Agree	Strongly agree	Spearman's RHO	P-value
THIS PLACE SEEMS TO ME DESIGNED FOR USERS	mean	0.00	3.50	3.27	3.85	4.40	**0.443**	**0.001**
	sd	0.00	0.71	0.59	0.99	0.55		

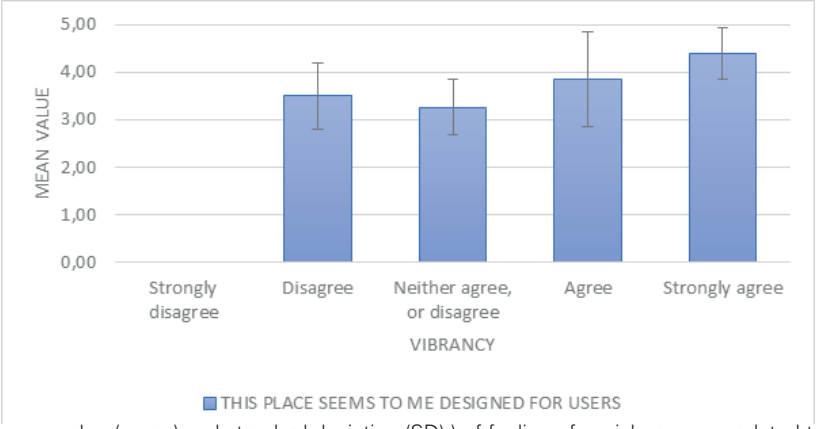


Fig.5.4.29 mean value (mean) and standard deviation (SD)) of feeling of social presence related to the level of vibrancy.

5.5 WELL-BEING

The mean value of Well-being Index is **55.28** and the standard deviation is **18.15**, the mean value of Well-being in the UK is 63, then the Well-being of people who answered to the questionnaire is low, depsite this,the perception of soundscape quality is high.

5.5.1 WELL-BEING INDEX RELATED TO CONTEXT'S MAINTENANCE AND CLEANING

Tab.5.5.1 mean value (mean) and standard deviation (SD)) of well-being's level related to the perceived level of buildings' maintenance

		MAINTENACE OF BUILDINGS						
		Very bad	Bad	Neither good. nor bad	Good	Very good	spearmen's RHO	P-value
WELL-BEING	mean	0.00	48.00	46.22	53.86	66.00	**0.399**	**0.004**
	sd	0.00	0.00	15.89	15.57	22.07		

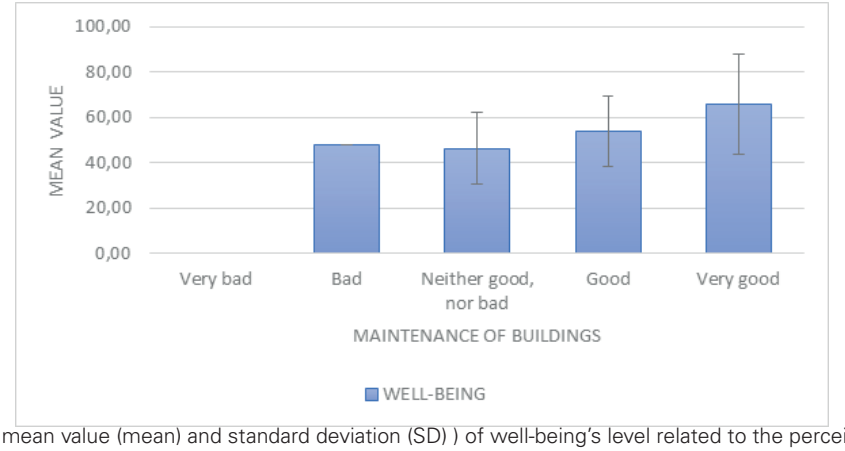


Fig.5.5.2 mean value (mean) and standard deviation (SD)) of well-being's level related to the perceived level of buildings' maintenance

Tab.5.5.3 mean value (mean) and standard deviation (SD)) of well-being's level related to the perceived level of public spaces' maintenance

		MAINTENACE OF PUBLIC SPACES						
		Very bad	Bad	Neither good, nor bad	Good	Very good	spearmen's RHO	P-value
WELL-BEING	mean	0.00	56.00	47.20	52.77	66.46	**0.383**	**0.006**
	sd	0.00	0.00	12.19	16.71	21.20		

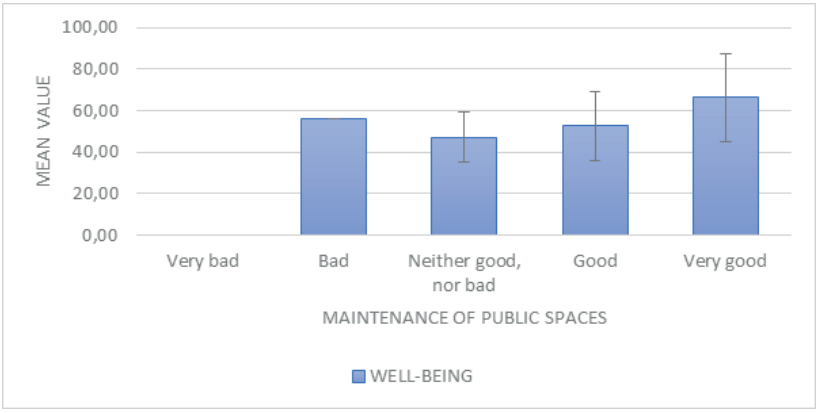


Fig.5.5.4 mean value (mean) and standard deviation (SD)) of well-being's level related to the perceived level of public spaces' maintenance

Tab.5.5.5 mean value (mean) and standard deviation (SD)) of well-being's level related to the perceived level of public spaces' cleaning.

		CLEANING OF PUBLIC SPACES						
		Very bad	Bad	Neither good, nor bad	Good	Very good	spearmen's RHO	P-value
WELL-BEING	mean	0.00	0.00	51.64	51.85	66.33	**0.301**	**0.034**
	sd	0.00	0.00	15.64	16.81	20.07		

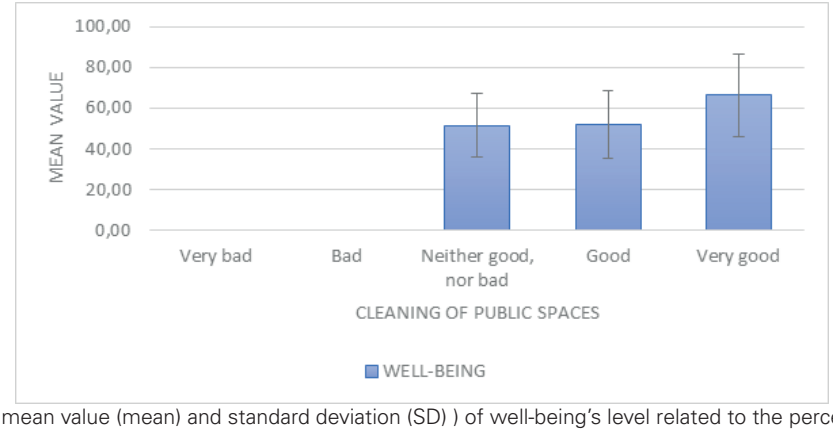


Fig.5.5.6 mean value (mean) and standard deviation (SD)) of well-being's level related to the perceived level of public spaces' cleaning.

5.6 EQUIVALENT SOUND LEVEL A-WEIGHTED

This map represents the Leq A for each zone, this map demonstrates that the Leq A is quiet high compared to the level recommended by the world health organization (WHO). In the area around the fountains in the centre of the square the equivalent sound level is higher than the other zones. and this high level is related with the presence of a lot of people and fountains. Moreover, in the Zones A H the sound level is influenced by the presence of the constructions site. In the zones A B C and D the sound level is high also because in this area there are several restaurants 'and coffee bar's dehors.

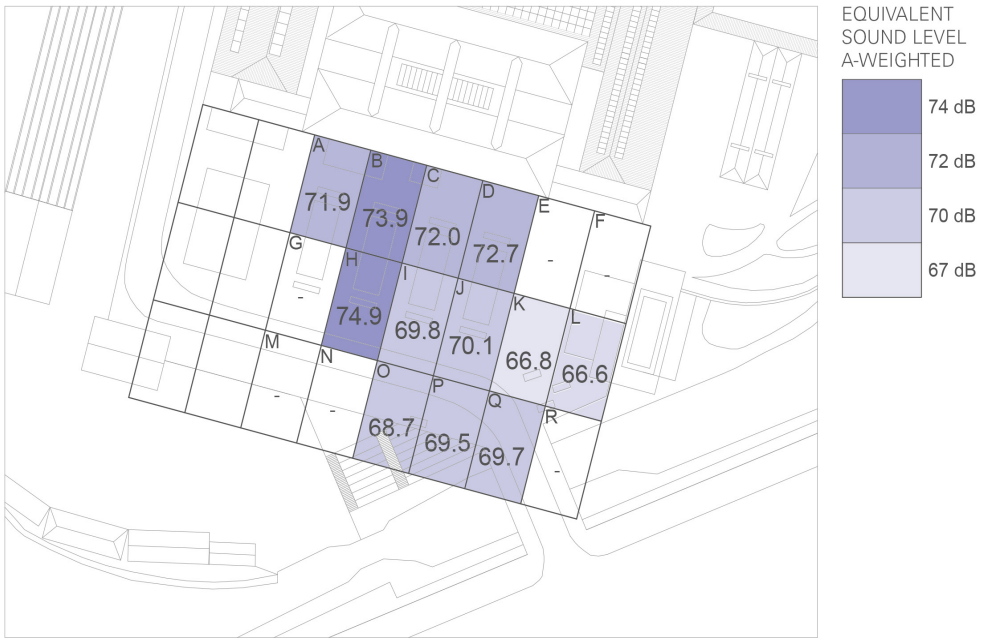


Fig.5.6.1 LeqA (dB) of sound environment per zone.

5.6.1 EQUIVALENT SOUND LEVEL A-WEIGHTED/PERCEIVED LOUDNESS

The zones have been classified in four areas. the difference between the areas is based on a sound level with a just notifiable difference (JND) of 2 dB. Trought this analisys is possible to highligth that the level of perceived loudness increases when the Leq-A grows up, generally the level of perceived loudness grows up near to the constructions site and bar's dehors like the Leq-A.

Fig.5.6.2 Level of perceived loudness per zone.

5.7 MEASURED LOUDNESS

This map represents the measured loudness level for each zone. the zones with an higher level of loudness are related with the map about equivalent sound level. Indeed. the zones with an high level of loudnes are in the centre of square where there are the fountains. Moreover. also in this case it is possible to recognize that the zones near to the restaurant or to the constructions site have an high level of measured loudness.

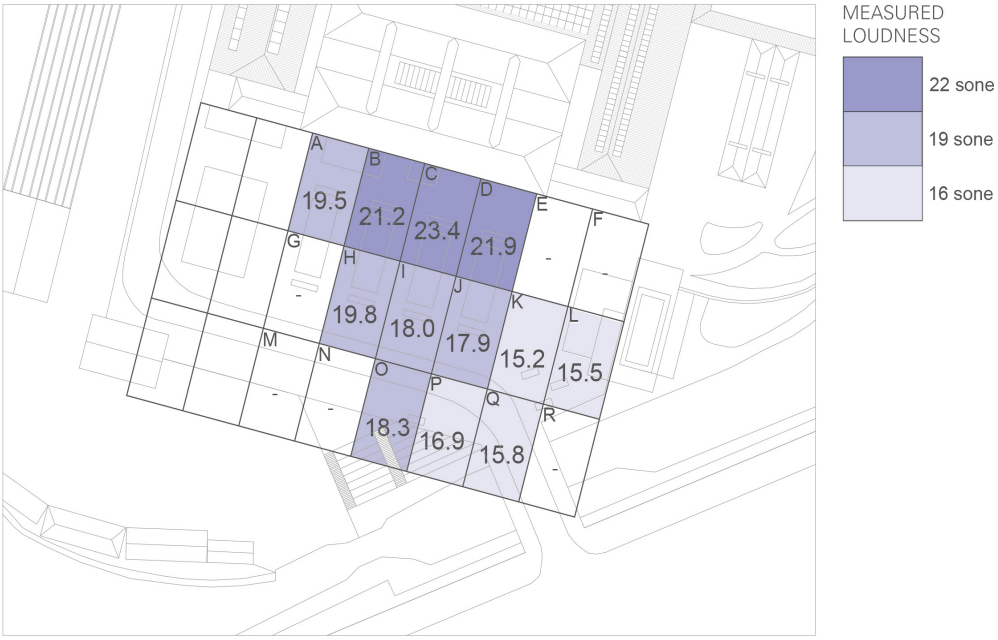


Fig.5.7.1 Level of measured loudness (sone) of sound environment per zone.

5.7.1 MEASURED LOUDNESS/PERCEIVED LOUDNESS

This map represents the relationship between the level of measured loudness and the mean value of perceived loudness. The cluster of the map is based on the measured loudness with a just notifiable difference (JND) of 3 sone. In the map it is possible to understand how the measured loudness and perceived loudness are directly related, moreover, it is possible to understand that the zones B C and D have the higher level of perceived loudness and in the south of the square the level of perceived loudness is the lower.

Fig.5.7.2 Level of perceived loudness per zone.

5.8 PERCENTAGE OF VEGETATION AND WATER SEEN PER ZONE

This map represents the percentage of vegetation and fountanins and river seen by the participants in each zone. Across the square the percentage of natural factors changes its value. in the north of the square there is a lower percentage of vegetation and water then the other part of the square. In the zones J K L and O the percentage is higher then in the other zones because in this areas it is possible to see the river and the vegetation on the sounth side of the river.

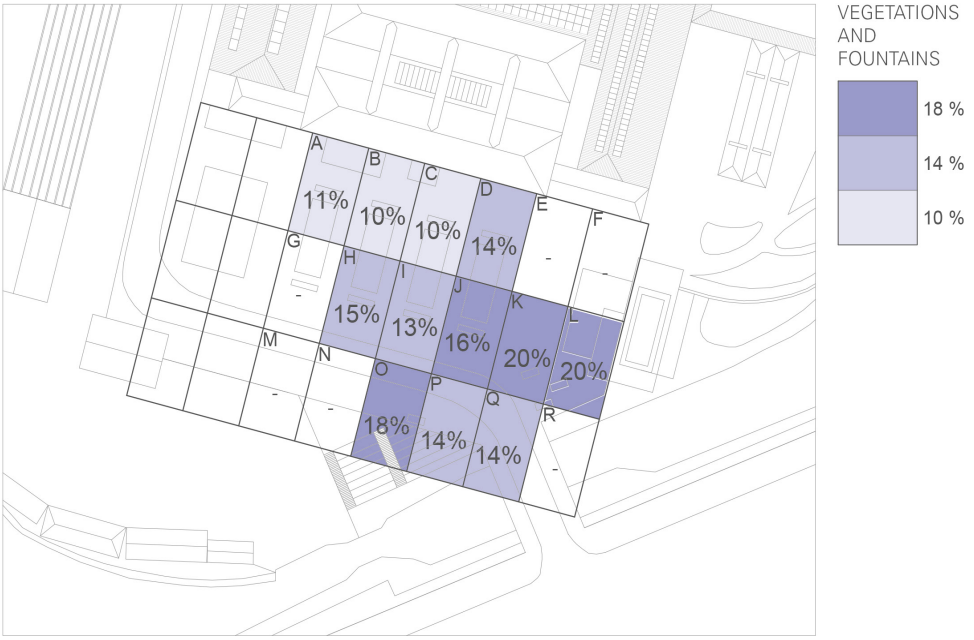


Fig.5.8.1 Percentage of vegetation and fountains and river seen per zone

5.8.1 PERCENTAGE OF VEGETATION AND WATER SEEN PER ZONE / PERCEIVED LOUDNESS

This map highlights the relationship between the percentage of vegetation and water per zone and the assessment loudness by participants. in the areas A B and C where the percentage of vegetation is low the level of perceived loudness increases, instead, in the zones J K L and O, where there is an high percentage of vegetation, the mean value of perceived loudness decreases.

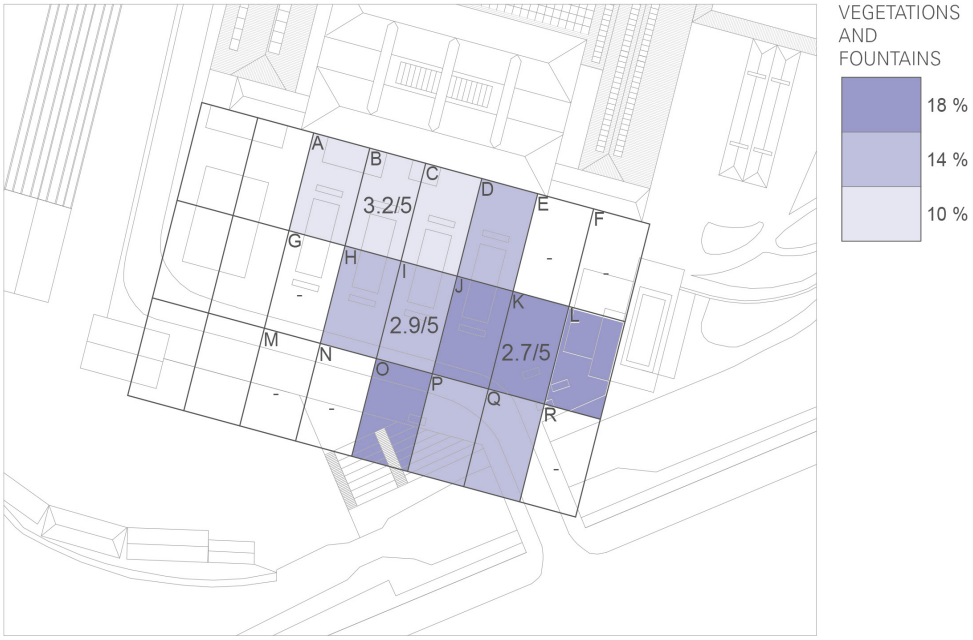


Fig.5.8.2 Level of perceived loudness per zone.

5.9 PERCENTAGE OF BUILDINGS SEEN PER ZONE

This map represents the percentage of buildings seen by the participants in each zone. In the zones A B C the percentage of buldings seen is very high, besause these positions are the closer to the high buildings in the north of the sqaure. In the rest of the square the value of percentage of buildings seen is not very high beacause the square is very wide and the buildings are far quite far from the square, near to river, the percentage of buildings further decreases.

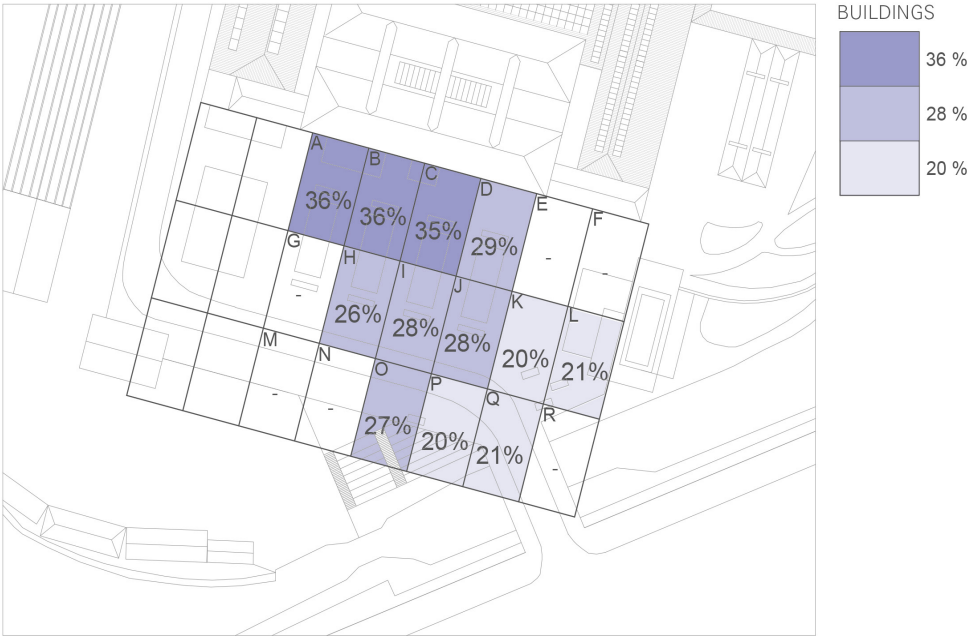


Fig.5.9.1 Percentage of buildings seen per zone.

5.9.1 PERCENTAGE OF BUILDINGS SEEN PER ZONE/PERCEIVED LOUDNESS

This map represents the relationship between the percentage of buildings seen per zone and the mean value of perceived loudness. The square has been divided in three zones and the map highlights that, when the percentage of buildings grows up, the mean value of perceived loudness increases. Than the higher value of loudness has been perceived in the zones A B and C and the lower value of loudness has been perceinved in the zones K L P and Q.

Fig.5.9.2 Level of perceived loudness per zone.

5.10 PERCENTAGE OF SKY SEEN PER ZONE

This map represents the percentage of sky seen by the participants in each zone. The highest value of percentage of sky seen is in the zones in the south of the square, this level of sky seen is related the percentage of buildings seen. In the south of square, where the value of percentage of buildings seen is lower, the percentage of sky seen grows up.

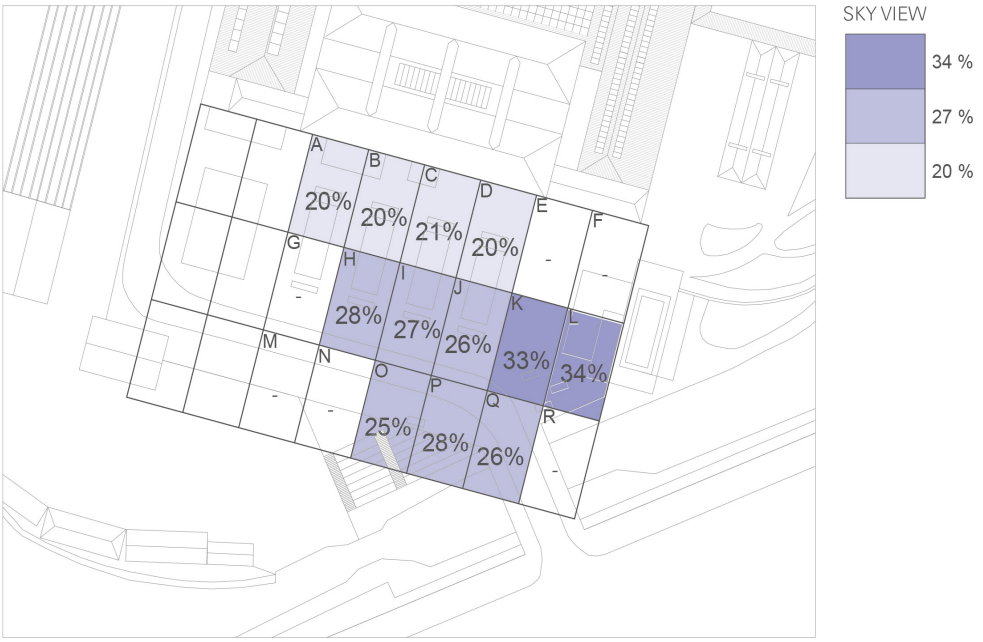


Fig.5.10.1 Percentage of sky seen per zone.

5.10.1 PERCENTAGE OF SKY SEEN PER ZONE/ PERCEIVED LOUDNESS

This map represents the relationship between the percentage of sky seen per zone and the level of perceived loudness. The analysis demonstrates that an high percentage of sky view can decrease the mean value of perceived loudness.

Fig.5.10.2 Level of perceived loudness per zone.

5.11 LEVEL OF PERCEIVED NOISE FROM TRAFFIC AND CONSTRUCTIONS

In this map is represented the mean value of perceived noise for each zone that composes the square. As is foreseeable the highest level of noise is registered in the zones A-H-O, the nearest zones to the constructions site, in the rest of the square the mean valeu of perceived noise it is not high.

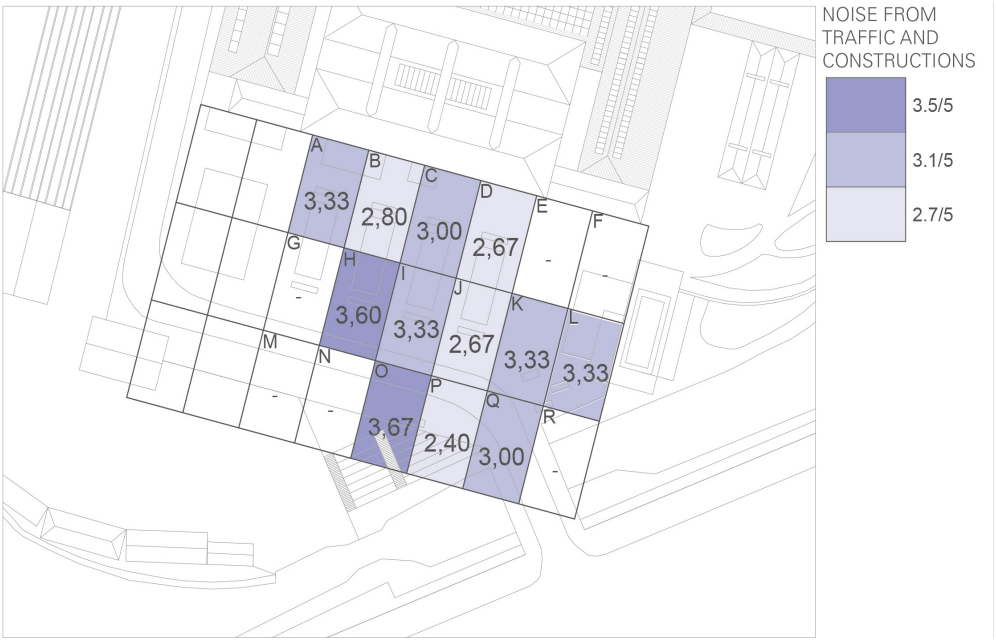


Fig.5.11.1 Level of perceived noise per zone

5.11.1 LEVEL OF PERCEIVED NOISE FROM TRAFFIC AND CONSTRUCTIONS/PLEASANTNESS

This map represents the relationship between the level of perceived noise from traffic and constructions per zone and the level of perceived pleasantness. The analysis demonstrates that an high level of perceived noise can decrease the mean value of pleasantness.

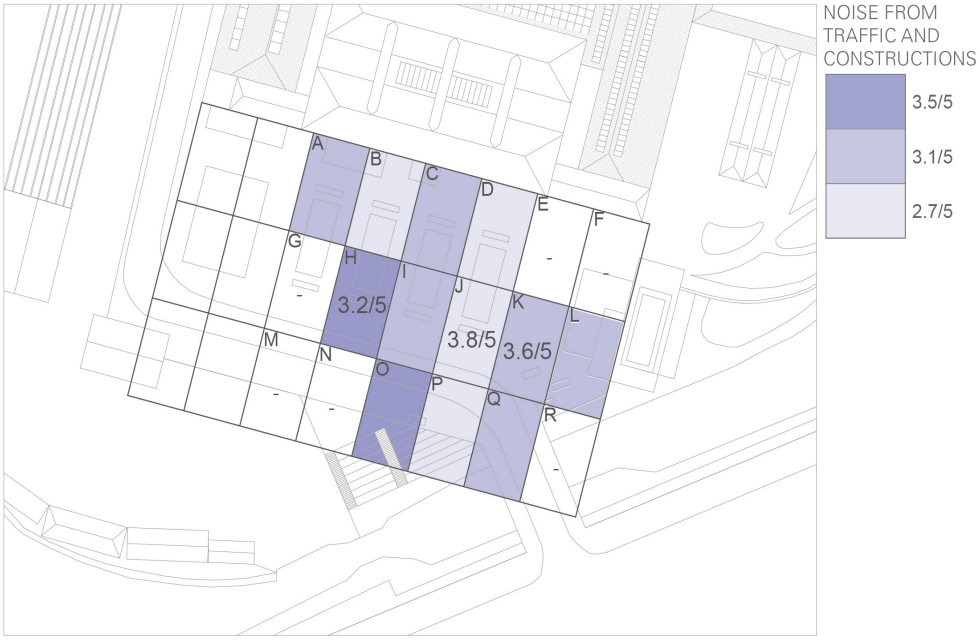


Fig.5.11.2 Level of perceived pleasantness per zone.

5.12 LEVEL OF PERCEIVED NATURAL SOUND

In this map is represented the mean value of perceived natural sound for each zone that composes the square. The highest level of natural sound is registered in the zones A-H-O, the nearest zones to the constructions site.

Fig.5.12.1 Level of perceived natural sound per zone

5.12 LEVEL OF PERCEIVED NATURAL SOUND/PLEASANTNESS

This map represents the relationship between the level of perceived natural sound per zone and the level of perceived pleasantness. The analysis demonstrates that an high level of perceived noise can increase the mean value of pleasantness.

Fig.5.12.2 Level of perceived pleasantness per zone.

GUIDELINES FOR NEW PROJECTS

6.1 PREDICTIVE MODEL FOR SOUNDSCAPE

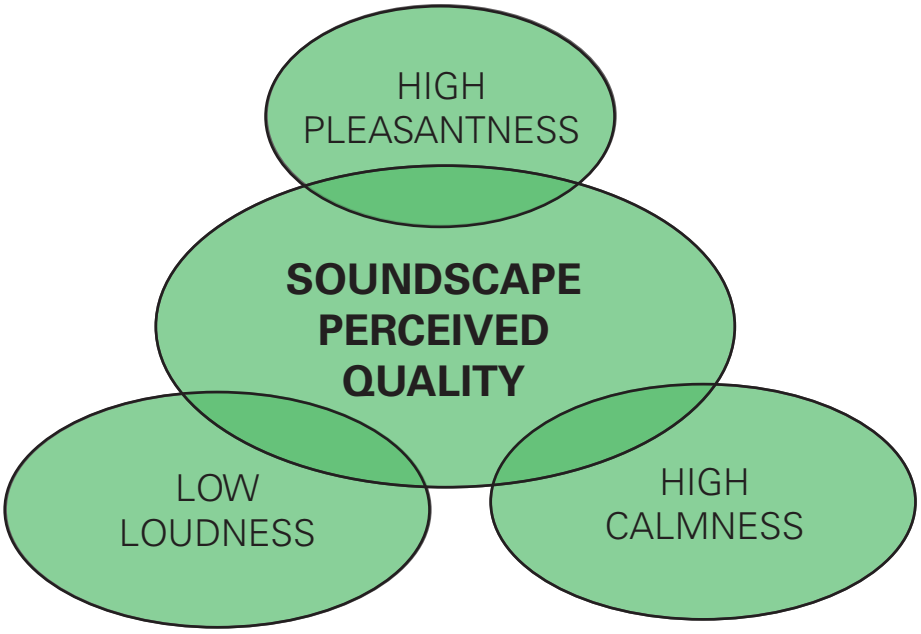


Fig.6.1 Relationship between soundscape quality and perceived affective quality

At the end of the analysis it is possible to define several aspects of environment that could influence the human perception of sound environment, and these results are very useful to create a predictive model of soundscape for the designer and planner.

First of all, the quality of soundscape is closely related to the perceived pleasantness and calmness of sound environment, and these two descriptors highlight the importance of this study to increase the quality of urban outdoor spaces, in particular for the recreational and quiet areas, like park or square.

Instead, the level of perceived loudness decreases the assessment of soundscape quality, and it is very useful to find new tools for planner for the control of this factor, and the soundscape approach could be one of this tool.

The classical instrument of architecture to improve the acoustic environment in outdoor spaces, where the dimensions of the free area are very wide, is to reduce the sound level. But, it is not always possible decrease the sound level of a square, where there are many sound sources, moreover, to reduce the sound from human being there are only one way, reduce the number of people in the square, and it is not possible for a good public spaces policy.

However, through the soundscape approach it is possible to manipulate the human perception of sound environment, without reducing the sound level. In this case the focus of the designer must be the sound sources and architectural context.

6.2 PREDICTIVE MODEL USING THE SOUND SOURCES

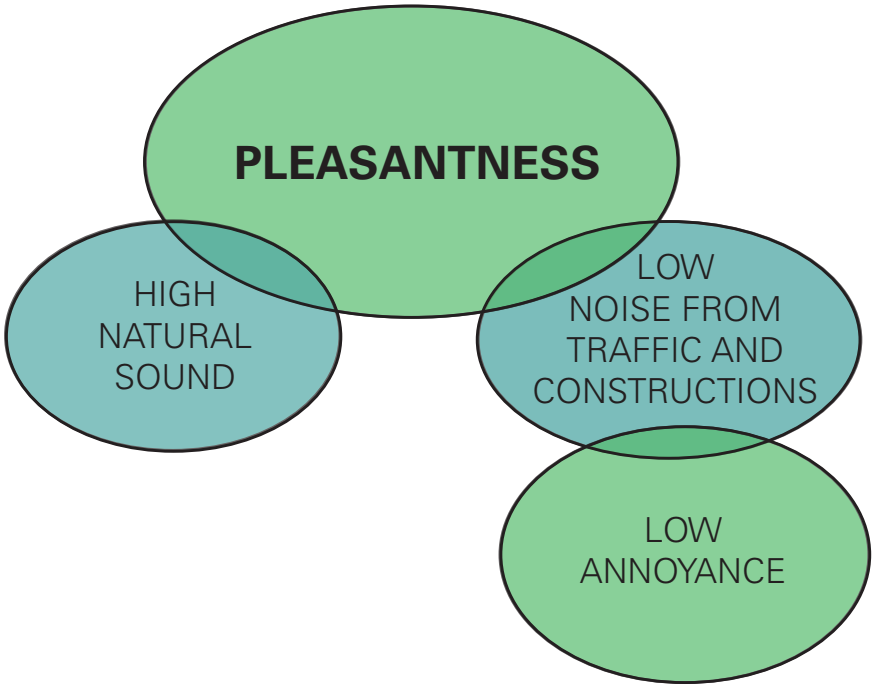


Fig.6.2 Relationship between perceived affective quality of soundscape and sound sources

The analysis of collected data highlights that the perceived soundscape quality is influenced by the sound sources, the enhance of natural sound can increase the level of perceived pleasantness. At the same time, the decrease of noise from traffic and constructions improves the level of pleasantness and decreases the level of annoyance.

6.2.1 NATURAL SOUND

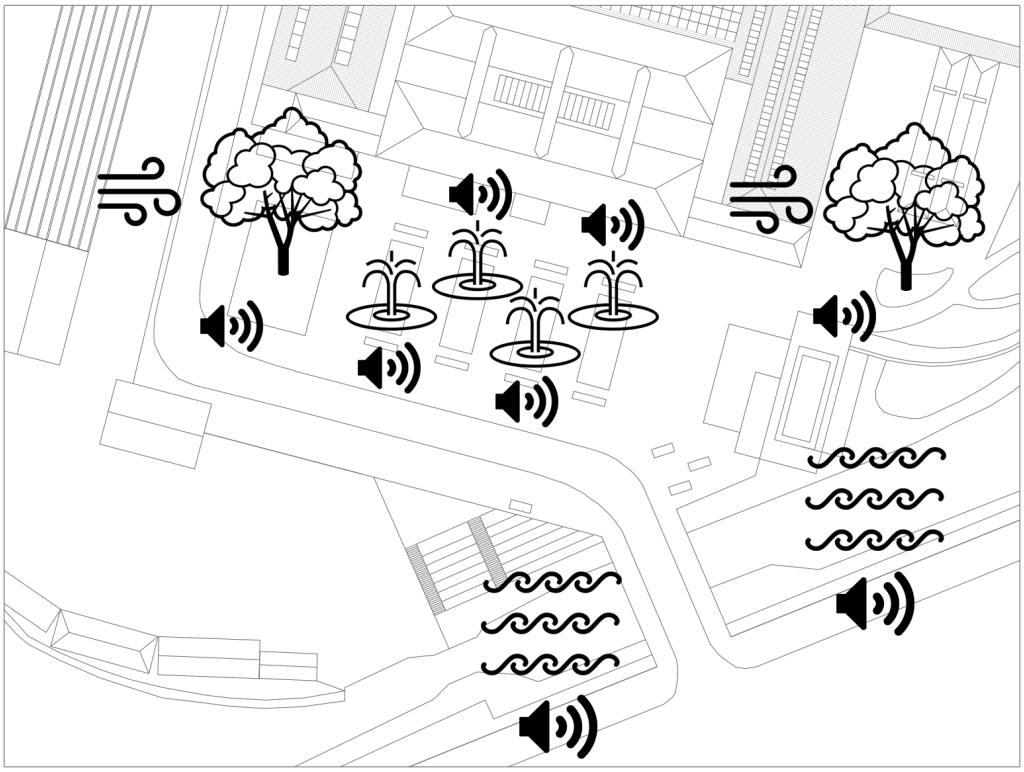


Fig.6.3 maps with sound sources

The level of perceived soundscape quality in the square is generally high, In the maps (Fig. 6.3) it is possible to see several natural sound sources, located in different part of the square, in the east side and west side of the square there are the trees, the wind through the vegetations could make a sound, in the south of the square there is a river, where the flowing water make another natural sound, but the most important natural sound sources in the square are the fountains, they are in the centre of the square, where usually there are more people, and this natural sound can influence the soundscape quality decreasing the perceived level of sound from other sources like car or constructions.

Fig.6.4 maps of level of pleasantness related to the level of natural sound perceived per zone

Using the natural sound as a tool to increase the pleasantness in the square it is possible also to reduce the perceived loudness of sound environment, indeed with the equality of sound level the natural sound sources are less loudness than sound sources related to traffic or constructions. Decreasing the level of perceived loudness it is possible to increase the perceived soundscape quality.

Fig.6.5 pic of fountains in Granary square

In Granary square the most important natural sound sources are the fountains, there are several projects that use the fountains as a sound sources, and they could be a useful tool for the designers to improve the quality of soundscape, moreover the fountains could be useful for the climatic control of the outdoor space and for the phytoremediation of sanitary waters.

Fig.6.6 pic of fountains in Pancras square

6.2.2 NOISE FROM TRAFFIC AND CONSTRUCTIONS

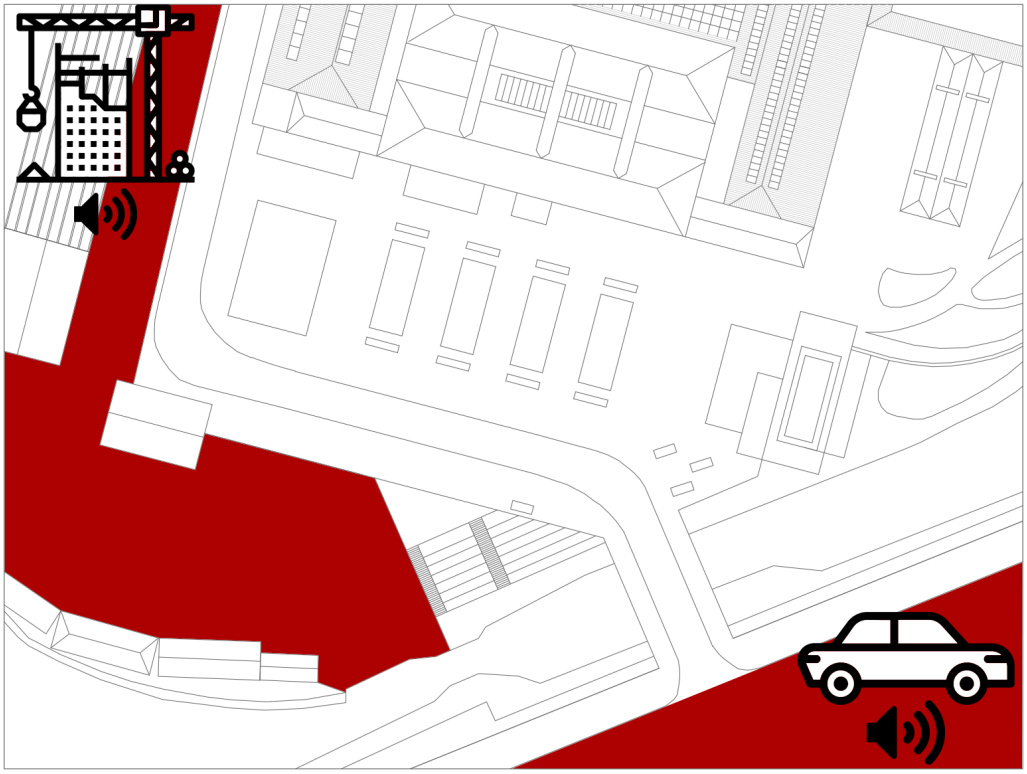


Fig.6.7 map of noise from traffic and constructions

Another tool that could be useful for the increase of the perceived level of pleasantness and the decrease of the perceived level of annoyance is the reduction of the noise from traffic and constructions. On the west side of the square there is a constructions site, that it make a lot of noise, but it is a temporary noise sources. In the south of the square there is a street, and the cars on this street are another noise sources, but in the square the street is quiet far from the area used by people, then the level of noise from traffic is low.

Fig.6.8 map of pleasantness perceived related to the noise from traffic and constructions

Reducing the noise from traffic and constructions it is possible to decrease the perceived loudness in the square and consequently increase the soundscape quality. The use of natural sound sources and the reduction of noise from traffic for to increase the soundscape quality are tools that it is possible to use contemporary.

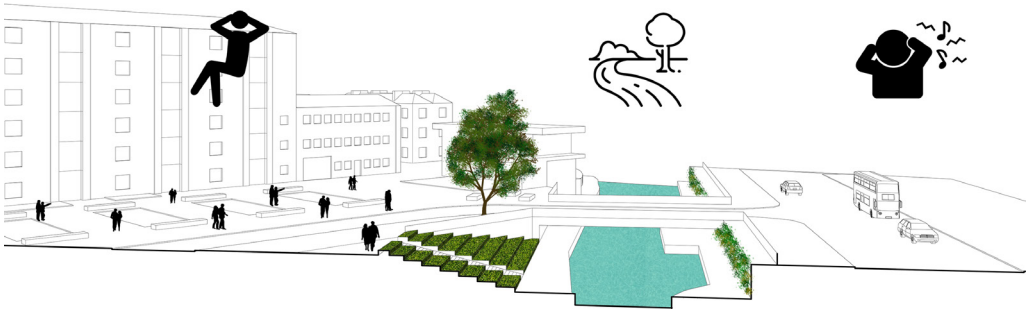


Fig.6.9 prospective section with the division noise and relaxing area.

In the Granary square, the river is in the middle of the square with people and the street with cars, through this design of the square it is possible to reduce the noise from traffic using the natural sound produced by the flowing water of the river and stave off the noise from the people's ears.

6.3 PREDICTIVE MODEL USING THE URBAN CONTEXT

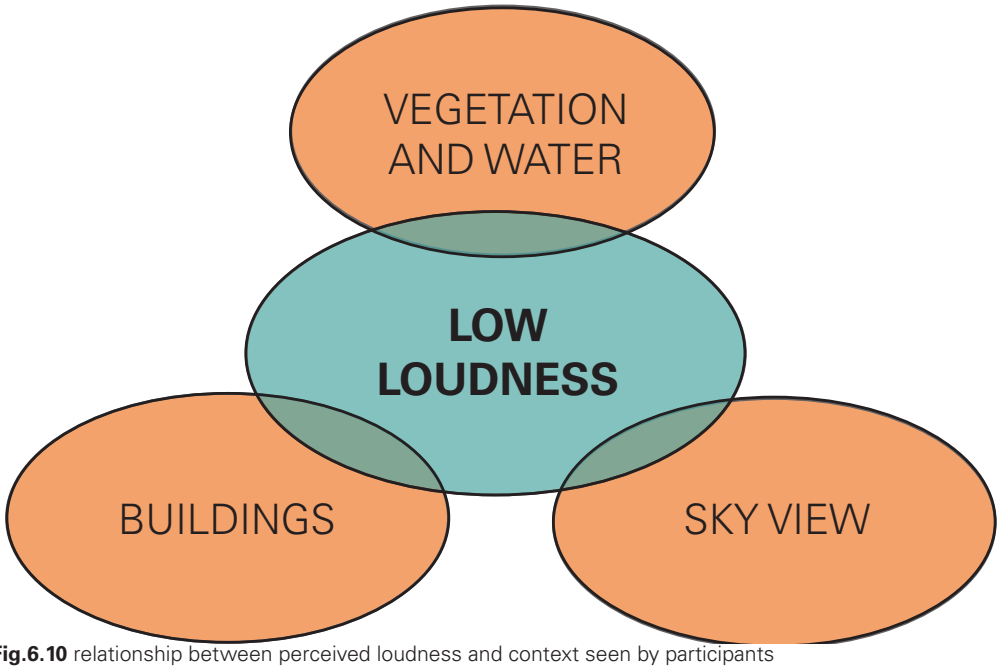


Fig.6.10 relationship between perceived loudness and context seen by participants

In order to decrease the perceived loudness, it is possible to increase the vegetations and fountains and generally the natural factors of the square. Contrariwise, the high buildings all around the square increase the human perception of loudness.

6.3.1 BUILDINGS AND SKY SEEN

Fig.6.11 map of perceived loudness related to the building seen by people

Through these maps, it is possible to highlight that the percentage of buildings seen by people in the square and the percentage of sky seen are related. Therefore, these two data allow to influence the quality of soundscape, reducing the perceived loudness.

Fig.6.12 map of perceived loudness related to the sky seen by people

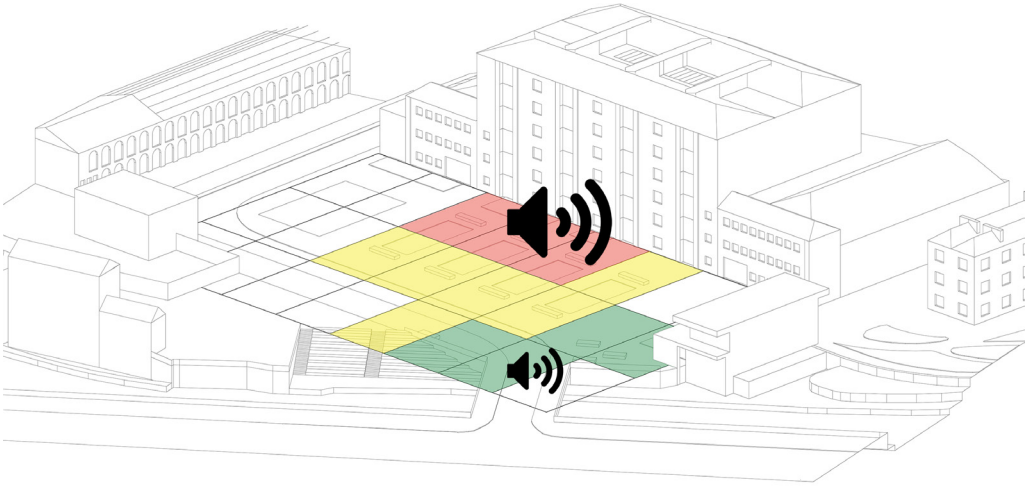


Fig.6.13 3-D of perceived loudness related to the sky seen by people

This 3-D highlights that in the areas in the north of the square, near to the high buildings, the level of perceived loudness is higher than the rest of the square. In the south of the square, the buildings are far from the square and there is a broader horizon and the level of perceived loudness is lower then in the north of the square.

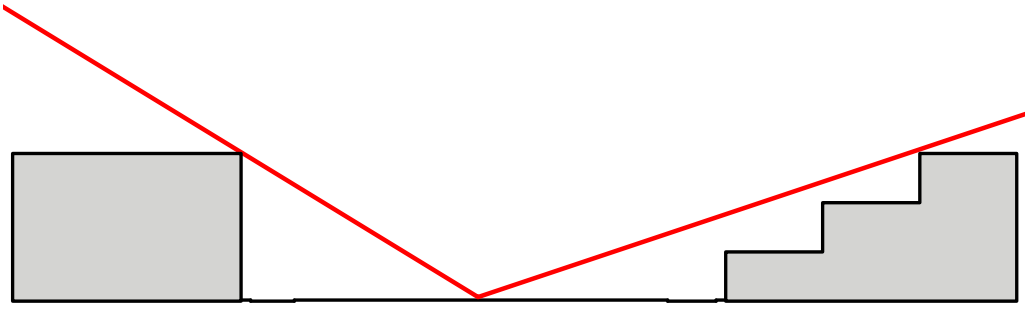


Fig.6.14 section of buildings profile to increase the soundscape quality

Therefore, during the design of outdoor space, it is possible to control the level of perceived loudness using the buildings profile. This section represents the difference between two possible profile of building, and the second one can decrease the perceived loudness.

6.3.2 VEGETATION AND WATER SEEN

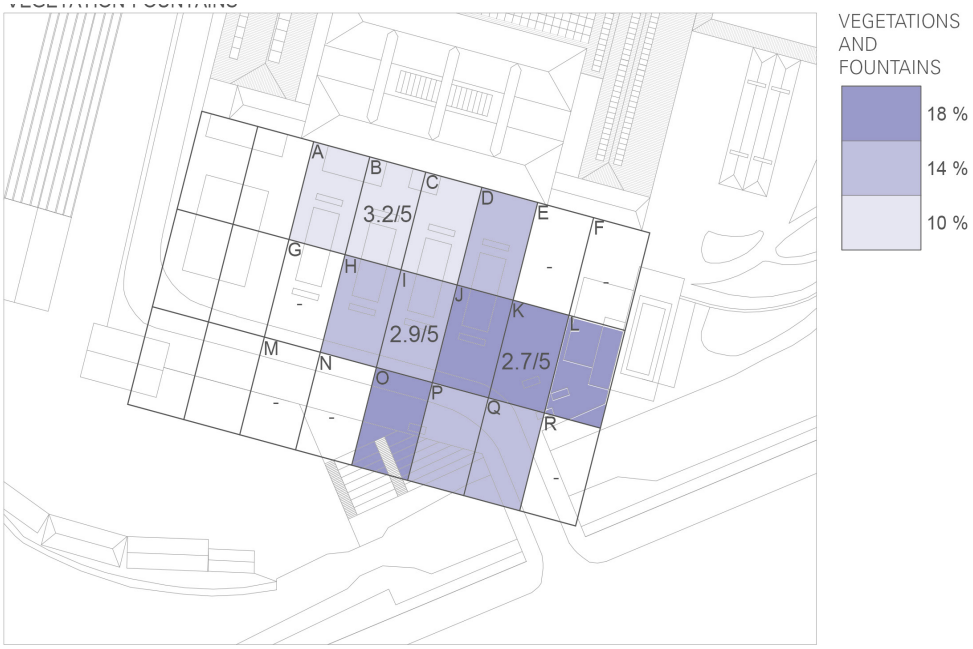


Fig.6.15 map of perceived loudness related to the vegetation seen by people

Another tool to decrease the level of perceived loudness is the vegetation, but also the fountains and natural factors. In Granary square the areas near to the vegetation or the river are the areas with a lower level of perceived loudness.

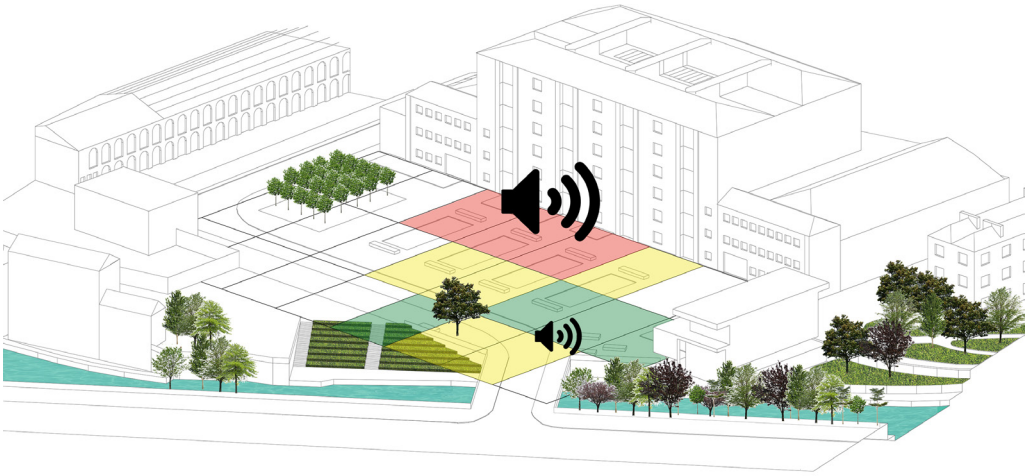


Fig.6.16 3-D of perceived loudness related to the vegetation seen by people

In the south of the square, where the height of buildings is lower and there is a river with a lot of vegetation the level of perceived loudness decreases. Than, the vegetation allows to increase the quality of soundscape and it is useful tool for the planners and designer for their urban project.

Fig.6.17 pic of vegetated wall

In order to increase the quality of soundscape of ex-novo square or outdoor space, the vegetated wall could be a optimal solution, because it increases the percentage of vegetation seen by users and decreases the percentage of buildings seen, both this factors allow to reduce the level of perceived loundness.

6.4 PREDICTIVE MODEL USING THE APPROPRIATENESS

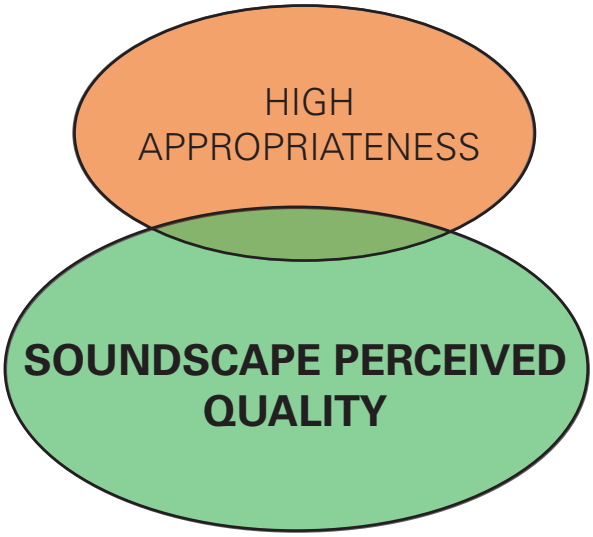


Fig.6.18 relationship between soudnscape quality and appropriateness

An important result obtained during the analysis is that, the appropriateness is closely related to perceived soundscape quality. Through this relationship, it is possible to understand that the use of vegetation to decrease the perceived loudness and also with the same aim the natural sound sources, it is possible to increase the appropriateness of the soundscape with the urban environment, and the appropriateness itself increases the perceived quality of soundscape.

6.5 WELL-BEING AND CONTEXT

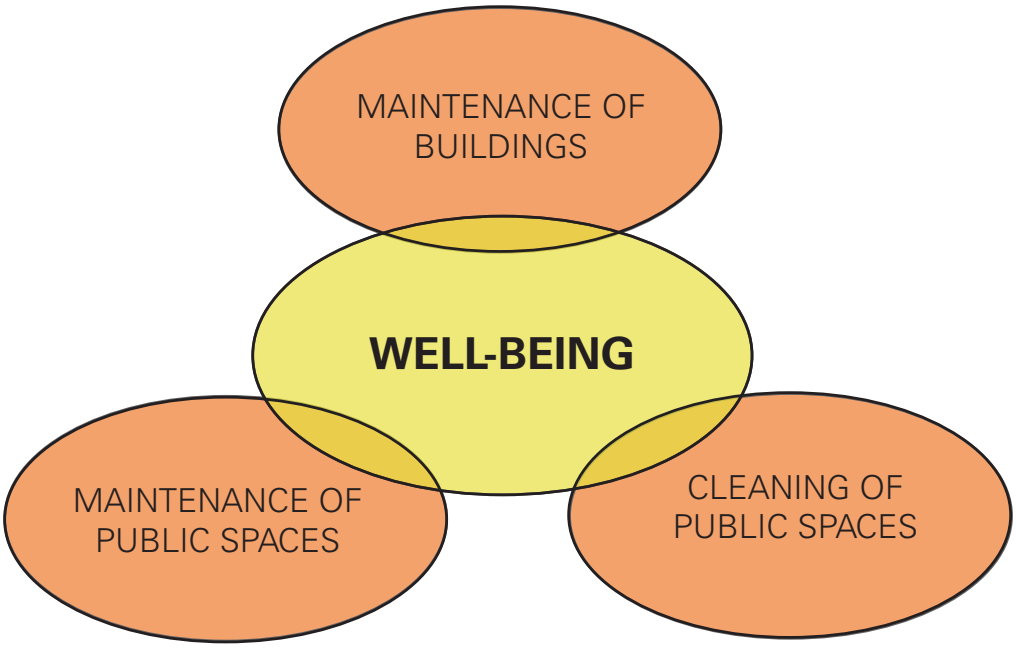


Fig.6.19 relationship between well-being and context

Following the results of the experiment, the level of the participants' Well-being is not related to sound environment and how they perceived the soundscape quality, but this result could be influenced by the little number of participants. Instead, the level of Well-being is related to the perceived level of maintenance and cleaning of buildings and public spaces, and this result is very important for the future analysis of soundscape and how people perceive the urban context.

This results could highlight a useful tool to increase the mean value of the citizens well-being, for this aim the urban policy have to take under control the maintenance and the cleaning o the city.

6.6 SOUNDSCAPE AND PERCEIVED SAFETY

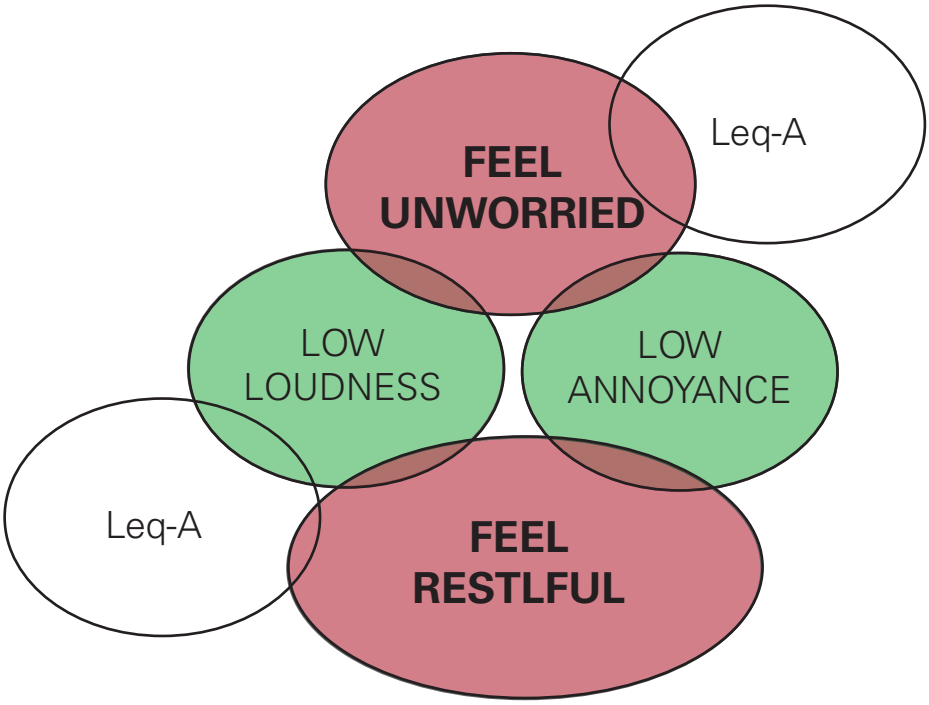


Fig.6.20 relationship between soundscape and perceived safety.

The analysis of perceived safety in the square highlights that, on average the perceived safety is high, but it is possible to define a relationship between the level of perceived loudness and the level of annoyance with the feeling of worried and restless. Then, the previous tools for planners and designers, that they allow to reduce the perceived loudness and annoyance, also allow to increase the feeling of safety.

6.7 WELL-BEING AND PERCEIVED SAFETY

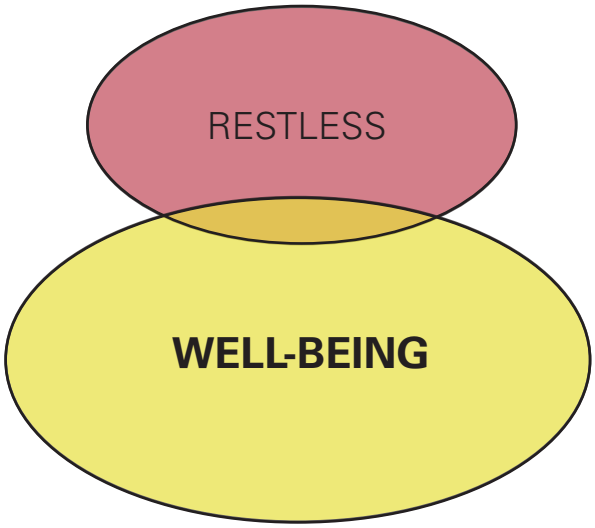


Fig.6.20 relationship between well-being and perceived safety.

Finally, the analysis of collected data point out that the level of well-being and the perceived safety are related. Then, a urban policy about maintence and cleaning of public spaces can increase also the perceived safety, and a decrease of the level of perceived loudness could also increase the well-being of citizens.

CONCLUSIONS

At the end of this thesis, it is possible to highlights the several results obtained during the research and what could be study in deep in the next research.

•The experiment developed in Granary square confirms that, the acoustic soundscape is influenced by several factors and it is possible to manipulate it using urban factors

•The best tools for planners and designers to improve the soundscape quality are the sound sources and the context

•Through the sound sources is possible to increase the perceived pleasantness of sound environment and through the urban context and the natural factors it is possible to reduce the perceived loudness

•These results are very important for the architects because they demonstrate that the acoustic comfort in the cities is in their hands during the project, and it is possible to control this comfort

•In the last year, the cities are perceived as dangerous places, the soundscape could be useful to improve the perceived safety related with other aspects of the cities like lightscape.

•The relationship between context's maintenance and cleaning and the level of people's well-being is an inedited result, and it is possible to use this relationship to improve the citizens well-being using the architecture. However, this relationship has to deeply studied in future research, in order to confirm the obtained results.

•Unfortunately, the experiment does not highlight a relationship between soundscape and well-being, but it is possible to define a relationship between soundscape and safety and well-being and safety. Then, probably the next research could analyse the relationship between soundscape and well-being using more data, and the relationship could be defined.

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