Acoustic design artifacts and methods for urban soundscapes: a case study on the qualitative dimensions of sounds

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Noise is steadily on the rise in urban settings, creating a potential health hazard as well as being a nuisance. In major European cities, noise levels are so high that the majority of urban parks can no longer truly serve as recreational environments, a problem the WHO and the EU are attempting to address. This study explores various strategies that promote the sustainable development of urban soundscapes at locations meant for rest, recreation, and social interaction. How are people affected by the combined effects of traffic and nature sounds in urban parks? To this end, we adopted a new track – the use of interdisciplinary methodology – bringing together architectural analysis and artistic experiments, along with psychoacoustic methodology to evaluate aesthetic, emotional, perceptual, and spatial effects. A large-scale case study was conducted at a city park to explore if and how subjects are affected by purposely distributed sounds. The working hypothesis was that it is possible to cancel out traffic noise by affecting aural perceptions using a process known as informational masking. Our long-term objective is to create a scientific foundation for action plans, both pre-emptive and trouble-shooting, targeting parks and other similar public spaces that provide a relaxing environment.

1 INTRODUCTION

Due to urbanisation, economic growth, and motorised transport, noise is an ever-increasing problem in urban areas.\textsuperscript{1-2} It is a serious environmental health hazard that may reduce the restorative potential of public open spaces, such as city parks and green areas.\textsuperscript{3-4} The obvious solution to improve the acoustic environment is to make it quieter. This may be achieved by noise barriers, speed limits, or other noise mitigation methods. Such solutions cannot always be implemented, however, due to traffic safety concerns, the expense, or aesthetics.\textsuperscript{5} As a complement to conventional noise mitigation, the addition of desirable sounds — such as via sound-art installations — has been suggested as a method for improving low-quality acoustic environments.\textsuperscript{6} This loudspeaker distribution method may either mask unwanted sounds by being louder, \textit{Energetic masking}, or by attracting or deflecting the listener’s attention, \textit{Informational masking}.\textsuperscript{7}

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The installations referred to in this context are meant to be permanent features of the urban environment, and serve mainly as informational masking.

This study examines issues related to sound installations in public urban environments, particularly city parks and green areas. At present, we have very limited knowledge of the effects of sound installations on humans and the environment, so the thesis question in this study is: In what way can sound-art installations supplied via loudspeakers affect our perception of the audible environment in public spaces?

We would like to emphasize that the purpose of this project is not primarily to promote the use of sound systems and sound-art installations to improve urban soundscapes, as this cannot be regarded as a particularly feasible or sustainable solution. The main objective is to gather information about how people are affected by a combination of traffic and nature sounds when they spend time in open-air settings such as parks and squares. Today, the majority of these areas are impacted by the sounds of traffic, which is why this study explores the qualitative dimensions of sounds found in urban settings.

To best approach these issues, the study adopts an interdisciplinary point of departure. This is necessary not only to gain greater understanding of how sound affects us in different situations and settings, but also to expand and improve our knowledge of urban soundscape design. Our team consists of experts in the arts, urban planning, architecture, music, acoustics, and psychology. We conducted artistic experiments with an emphasis on site-specific questions. The focus was on sound as a conveyor of qualities, which could be aesthetic, social, spatial, or temporal in nature.

A major case study was conducted within the frame of our project. The location was Mariatorget, a popular square and city park in Stockholm. A permanent sound-art installation consisting of three separate units was put into place. The objective here was to develop a model for sustainable sound installations in noisy open-air urban spaces. Additional sounds were introduced by way of loudspeakers. This method has a dual function: to reinforce existing sounds, mainly from activities and nature; and to shift the listener's focus from traffic noise to the more desirable sounds. A further objective of the case study model is to generate qualitative questions about the relationships between sound and aesthetics, architecture, the environment, and sustainability.

2 BACKGROUND AND THEORIES

Like music, the sounds of the city are not easily captured by words. In addition to this, sounds are not isolated features; they interact with their surroundings and are affected by the location and the situation at hand, and they will be perceived in various ways by the listener, as well. It is in the very nature of sound to transcend borders. Activities and features that generate sound in public environments carry information that reflects aesthetic, cultural, social, spatial and temporal qualities. An underlying issue is how to address urban soundscapes and plan a sustainable aural environment that includes locations for rest and recreation. It is important to explore dimensions of sound that are more difficult to pinpoint, i.e. beyond mere quantities and levels.

Our study employs an interdisciplinary approach: In what way can sound-art installations supplied via loudspeakers affect our perception of the audible environment in public spaces? Here are a few important concepts and theories:
2.1 Sound Perception

A concept that deals with issues of sound distributed by way of loudspeakers is acousmatics. Often, the ever-increasing amount of sound distributed by loudspeakers in public settings creates problems, but this process can also be a resource. A good place to start is by establishing how to create sustainable site-specific sound installations that take the existing soundscape into account. Acousmatics comes into play when you hear a sound without any visual contact with the source. This happens all the time and it affects our behaviour, particularly when we are on the go in a city. It is also possible to link acousmatics to cultural, spatial and social connotations; such as in everyday activities, where you are unable to verify the source of a sound visually and automatically associate the sound in question with previous experiences.

Most of us picture listening as a straightforward “on or off” process - either you’re listening, or you’re not – while in fact, the process is highly sophisticated and complex. The French composer, theoretician and pioneer of electroacoustic music, Pierre Schaeffer, developed the theoretical underpinnings of the aesthetic known as Concrete music (Musique concrète). Schaeffer separated sound perception into four modes: Listening (Ecouter), Hearing (Ouïr), Attending (Entendre), and Comprehending (Comprendre):

* **Listening** is about information gathering; directing our aural attention to someone or something, aiming to identify the event, such as a scream, and its source, the person screaming;
* **Hearing** is the most elementary or crudest level of perception. We passively take in sounds that we are not trying to listen to or understand;
* **Attending** involves selectively processing the sounds, to select what interests us and effect a qualification. It involves responding to intrinsic properties of the sound;
* **Comprehending** involves semantics. The sound is treated like a sign or code, as a representation of content or meaning;

Schaeffer devised a diagram demonstrating the relationships between these listening modes that also ties in the contrasting aspects abstract/concrete and objective/subjective. Abstract refers to the quality of a sound at a perceptive and semantic level, i.e. the intent to comprehend a message. Concrete refers to the causal references, the intent to comprehend the causal connection and context. Objective refers to a state where you are confronted with the sound, while subjective would be when you are confronting the activity related to the sound experienced:

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<th>3 ATTENDING</th>
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<td>- inside level : perceptual qualification</td>
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<td>1 &amp; 4 : objective</td>
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<td>- outside level : sound quality</td>
<td>- outside level : inarticulate about information of sound</td>
<td>1 &amp; 2 : concrete</td>
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<td>Selection of certain aspects of sound</td>
<td>Reception of sound</td>
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**Fig 1. – Diagram of listening modes, as per P. Schaeffer**
2.2 Sonic Environmental Characteristics

The Swiss-French architect and geographer Pascal Amphoux has outlined a model consisting of the three categories *sonic signals*, *sonic background*, and *sonic ambience* as conceptual tools to distinguish certain sonic environmental characteristics in urban space. The three categories correspond to listening behaviour as well as to spatial and temporal aspects within the environment. Amphoux employs Pierre Schaeffer’s listening modes.

The first category, *sonic signals*, concerns the emission of sounds envisaged from an acoustic viewpoint, such as difference in intensity; a statistic viewpoint, such as an aleatorical event; a psycho-sociological or a semantic viewpoint, such as an unusual or unexpected sound. This category of sonic signals corresponds to the mode *Listening*. The sonic signal literally grabs our attention. From a temporal viewpoint, the signal is always a *discontinuity*; it is a *sonic event* that makes us listen.

The second category, *sonic background*, refers to passive reception. The sonic background correlates to the mode *Hearing*. From a temporal perspective, sonic background can be outlined in terms of *continuity* or *duration*, i.e. it is an ongoing stream – a continuum – of sounds.

The third category, *sonic ambience*, Amphoux defines as the composition of existing sounds within a sonic environment: The sound that lends a location its distinctive character, a sonic code. Moreover, sonic ambience corresponds to *Attending* (or *paying attention*). From a temporal viewpoint, sonic ambience can be characterised through its *dynamics*: The mobility, movement, rhythm, and alteration of the sonic units of a cohesive ensemble constitutes the *sonic ambience* of a place.

Summing up, Amphoux’s model of sonic environmental characteristics in urban space could be divided into *signal* / *background* / *ambience*, which expresses the three temporalities *event* / *duration* / *dynamics*, and the three perceptual modes *listening* / *hearing* / *attending*.

2.3 Space and Time

Acousmatics is a cornerstone concept that deals with the relationship between auditory and visual configurations. However, in order to gain an appropriate overview, affiliated concepts dealing with *temporal* and *spatial dimensions* should also be included.

Music is an art form that has many ties to the temporal dimension. A narrative content is presented over time and it possesses temporally regulated features. In the latter half of the 20th century, John Cage outlined a principle for *Indeterminacy* which, expressed in brief terms, was about experimenting with musical structures. The result is music that appears to be free of the constraints of time. Cage opened the door to a mode of listening concentrated on the qualities and nature of sounds, creating pieces that also include everyday sounds. Thus Cage expanded our perception of the musical process to include an aesthetic perception of the sounds surrounding us, where the listener is the starting point for the process itself.

A central concept in this study is *l’effet métabole*, or *metabolic environment*, as defined by the French research institute Cresson, in Grenoble. A metabolic environment is a structural and perceptual concept. To explain it in simple terms: it involves a sound environment that is stable over time, while the individual sounds creating this environment are perceived as being in constant flux. Thus, there is a paradox in that the sound environment is perceived as being homogeneous, while the individual sound objects (such as voices, footsteps, vehicles) are difficult to perceive over time. Spaces with a long reverberation time such as terminals, railway stations and shopping malls are typical examples of metabolic environments, where the ability to perceive individual sound sources is reduced.
Another central concept is atmosphere. The concept is, perhaps, most commonly associated with the German philosopher Gernot Böhme. According to Böhme, atmosphere has evolved into a scientific concept. Since it deals with phenomena that operate on several levels, it is not easy to pin down. Böhme states that the aesthetics of an atmosphere reflects the objects that produce it. This, however, is not from an ontological viewpoint, arising from the nature of the objects, it involves the qualities that radiate into the room through the objects. In other words, urban sounds are not interpreted as if they were independent of the acoustic space, they are connected to the listener, the location and the situation.\textsuperscript{15}

Acousmatics, indeterminacy, metabolic environment, and atmosphere are thus combined to conduct investigations of urban soundscapes based on aesthetic, social, spatial, and temporal criteria.

3 METHODOLOGY

An extensive case study was a part of this project. The location was Mariatorget, a popular city park in central Stockholm, Sweden.

3.1 Mariatorget

In 2010, the City of Stockholm decided to install a permanent sound-art installation in a city park located at Mariatorget. The park is rectangular in shape (130 × 60 m) and is surrounded by streets lined with moderately high, 5 to 7 storey, buildings. Traffic flows mainly along the shorter sides of this rectangular park. Hornsgatan, on the northern side of Mariatorget, is one of the major traffic arteries of Stockholm. Hornsgatan sees a heavy flow of traffic, approximately 22,000 vehicles every 24 hours. St Paulsgatan, located at the southern border of Mariatorget, is mostly used by residents, taxis, and delivery services: Some 3,000 to 3,500 vehicles every 24 hours. Two perpendicular footpaths running through the middle of the park divide Mariatorget into four rectangular grass areas. A fountain is located at the intersection of these footpaths. Close to St Paulsgatan, there is a small playground popular with families.

The equivalent sound level at Mariatorget exceeded the recommended level of 55 dB(A). This recommendation is for traffic noise only. Very few parks and squares in central Stockholm have, in fact, a sound level below 55 dB(A). This goes for most major European cities as well, making it difficult to find urban green areas that provide an environment truly conducive to recreation. Nowadays, it is a well-known fact that levels exceeding 55 dB(A) are not compatible with good sound comfort, and the majority of people exposed to them will perceive the environment as uncomfortably noisy.\textsuperscript{16} Recent findings indicate that long-term exposure may lead to ill health, such as an increased risk for heart disease.\textsuperscript{17}

The sound-art installation, known as “Sonic Space”, was played at three locations at Mariatorget. The sounds were distributed in a stereo format, by way of loudspeakers (2 x 3 speakers) mounted on nearby lampposts. The purpose of the present study was to evaluate “Sonic Space” and to investigate how people experience this sound-art installation.
Fig. 2 – Noise map of Mariatorget

Fig. 3 – Locations of the sound-art installation “Sonic Space”, see no. 1.

Fig. 4ab – Views of Mariatorget

Fig. 5 – 3D-model

Fig. 6 – Sound Design Lab, Univ. College of Arts, Crafts and Design, Stockholm
3.2 Inventory, Simulation, Composition, and Installation

The first step in this case study was to conduct an inventory of the following criteria at Mariatorget, with regard to sound-generating events and features:

* **Spatial qualities**, demarcated spaces, such as those created by the fountain and the street Hornsgatan;
* **Orientation**, finding your way based on sounds at various spots;
* **Dynamics**, spatially stationary sources of sound that change over time, moving sources of sound, the general sound environment and how it changes over time;
* **Artifacts**, sound-generating features and fixtures;
* **Activities**, social activities, playgrounds, trade, etc;
* **Infrastructure**, pedestrians, cyclists, automotive traffic;
* **Sound atmosphere**, the aesthetic features of the soundscape.

Alongside this analysis, features, events, and spaces were assessed with regard to visual criteria. Recordings in situ were also performed at Mariatorget using ambisonics technology (a type of surround recording); and binaural technology (artificial head).

The next phase of the case study involved a laboratory simulation that could be described in brief as experiments with various sounds and how they interact with the existing sounds at the location. These experiments were conducted using Pro Tools. A virtual model of Mariatorget was generated with Sketch Up software.

The next phase involved the composition of the sound-art installation “Sonic Space” at Mariatorget. The piece is strongly rooted in the theories previously presented in this paper: acousmatics, indeterminacy, metabolic environment, and atmosphere. No single sound objects are in the forefront in the piece, all the objects meld into a uniform background. The main reason a metabolic environment was chosen as a structure was to integrate the installation into the existing soundscape at Mariatorget, thereby creating a sustainable solution.

**Sound masking** is an important concept to define. Our project did not employ energetic masking, a process that takes place in the inner ear, where the sound level of the piece would have to be loud enough to cancel out the noise from the busy thoroughfare, Hornsgatan. In principle, such a process is possible, but the loudness entailed makes it infeasible, since the results would be perceived as intrusive and disturbing. The type of masking used in our study corresponds to the concept of informational masking,18-19 where sounds are used to deflect or distract the attention of the listener. The hypothesis is that the perceptual focus will be shifted away from traffic noise, and the focus will be on processing the sounds of the installation instead.

The work on the actual composition for “Sonic Space” started out with in situ experiments to determine a range of sound elements that harmonized with the existing soundscape at Mariatorget. Some fifty recordings were made to obtain material for “Sonic Space”. These recordings could not, however, be made at Mariatorget, since it was necessary to isolate individual sound sources and record them separately. The recordings were made at a nature preserve located on an island in the southern portion of the archipelago in the Baltic Sea. The following sounds were recorded: Aspen in the wind (at close enough range to hear single leaves, and at a distance); wind sounds in general; barbecue coals and pine burning; the sea (close range and at a distance); birds (at a distance).

Once the sound palette was finished, it was time to compose the piece. Something like a dozen versions of “Sonic Space” were produced and tested in situ. The differences consisted of tiny shifts in the composition, such as where the aspen was in the forefront, and dynamic variations. The team decided which version they felt worked the best in situ. The piece has a duration of 20 minutes, and it is played as a continuous loop.
3.3 Psychoacoustic Evaluation

A psychoacoustic study was also a part of the project and are described only briefly below. Twenty-one respondents were polled on their reactions to the sound-art installation “Sonic Space”. This study, performed as a laboratory experiment, concentrated on the installation at the north-eastern corner of the park, near the busy street known as Hornsgatan. It was a two-part experiment.

Part 1. Investigating which of the two conditions — sound installation on or off — the participants preferred

Part 2. Investigating whether or not the participants would use the sound installation as a cue in sorting the experimental sounds into two groups.

Based on the results of these two investigations, preference to the sound installation “Sonic Space” is a personal matter. Our respondents were no more likely to prefer the sound installation than not. Another conclusion was that the respondents were not immediately aware of the sound installation at all. Thus, the sound installation may not contribute directly to the acoustic environment of Mariatorget, as it is very subtle, but it is certainly not disruptive or disturbing. The majority of the 21 respondents was either positive or indifferent to the sound installation.

In conclusion, the main objective of this sound-art installation was to distribute a selection of sounds via loudspeakers and create a soundscape that would enhance the existing sounds at Mariatorget. No actual traffic sounds were used, simply sounds with similar frequency patterns. The results of the controlled laboratory experiment, the fact that it was difficult to distinguish the added sounds from the naturally occurring ones, are therefore to be regarded as positive.

4 RESULTS AND DISCUSSION

A focal point of this project was how the installation was perceived in situ with regard to site-specific issues dealing with the existing soundscape at Mariatorget and the sound-art installation “Sonic Space”. The installation had a dual purpose, to enhance the existing sounds at the site emanating from various events and activities, and to shift the aural focus away from the traffic noise of Hornsgatan. The results are presented in the following paragraphs and then rounded off with a discussion of future objectives.
4.1 Listening – In Situ

One of the expected outcomes was that the majority of the people present at Mariatorget would not actively be aware of the sound-art installation “Sonic Space” at all. In other words, the experience would involve passive listening. The corresponding Schaeffer listening mode is *Hearing* (ouïr): The passive reception of sounds.

Previous projects of a similar nature demonstrate this phenomenon. The Urban Sound Institute, USIT (www.usit.nu), is a group of architects, acousticians, composers, sound artists and sound designers that works with sound art, acoustic design and the sound design of public and commercial spaces. In 2006, USIT installed a sound-art installation at a shopping mall in downtown Stockholm. It consisted of four benches placed under a large chandelier. It was constructed in the same manner as the installation at Mariatorget. The study of the mall project indicated that about 70 percent of the passers by were not consciously aware of the installation, though their behaviour was more relaxed and they chose the spot to breastfeed their baby, read a paper, or sit down and rest. No psychoacoustic study was performed, this information is based on unstructured interviews and in situ observations.

4.2 Listening – Laboratory Experiment

The results of the psychoacoustic laboratory experiment indicates that the respondents found it difficult to differentiate between recordings of the existing soundscapes at Mariatorget as compared to the ones that included the installation “Sonic Space”. Obviously, the conditions for the controlled environment of the experiment differ a great deal from the natural listening mode of anyone visiting Mariatorget. The main difference is that the respondents in the experiment were asked to listen in an active manner, while people at the square would listen in a passive manner.

The dominant conscious/active listening mode in the lab experiment is, as per Schaeffer, *Listening* (écouter). This involves an active attempt to tie a sound to a source; trying to understand who or what created a sound. See “concrete” and “objective” in the diagram (see Schaeffer, Figure 1).

The lab experiment indicates that problems arise when people attempt to listen to the recordings from Mariatorget in an active manner. This is due to two factors: The piece, “Sonic Space”, is very similar to the sounds occurring naturally at Mariatorget; particularly with regard to the sounds of the fountain and the hum of traffic from Hornsgatan, with an auditory texture much like that of the sound-art installation. The other factor is the spatial configuration of the installation, which can be compared to a *metabolic environment*. One very obvious effect of active listening is that the focus shifts to the sounds of the location, since it is not possible to follow individual sounds over time. The installation lacks a narrative that follows a linear timeline. The fleeting nature of a metabolic environment makes it difficult to focus on the sounds presented in “Sonic Space”.

The results of the lab experiment support the basic tenet of “Sonic Space”: The piece reflects the sounds of the location, which means it enhances the existing sounds at the site (employing sounds with a similar frequency range as the hum of traffic), making it difficult to distinguish the added sounds from the actual sounds present at Mariatorget.
4.3 Listening – Informational Masking

A concept the laboratory experiment did not deal with was informational masking, i.e. that the auditory focus of people present at Mariatorget would unconsciously shift away from the noise of traffic to the sounds presented by “Sonic Space”.

The previously discussed listening modes, as delineated by Schaeffer, are Listening and Hearing. Yet another mode should be tied in with the experiment at Mariatorget with Ljudrum, and that is Attending. This particular mode does not attempt to locate the source or cause of a sound, but instead focuses on the characteristics and qualities of sounds.

Amphoux, like Schaeffer, attributes the listening mode Attending to the sonic environmental characteristics sonic ambience, which could be described as the sonic character of a certain location. Thus the sounds themselves are in focus, and not their physical context. According to Amphoux, active listening is not even required in order to perceive sonic ambience. Sonic ambience is also equivalent to Böhme’s concept of atmosphere (defined previously in this paper).

The anticipated informational masking process at Mariatorget is rooted in the concept of atmosphere. The pivotal concept of this project is to influence the atmosphere of the location by distributing site-specific sounds via loudspeakers. Any investigations into this type of sound masking need to be conducted in situ, since it is impossible to simulate an atmosphere correctly in a laboratory environment. No such study, however, has been possible within the framework of this project.

In the future, studies that focus on the interaction between people, the sonic atmosphere, and the listening mode at the location would be highly interesting and enriching. The hypothesis to explore is whether it is possible to “make” a sound no longer perceptible, or less audible, by redirecting the attention of the listener. This would take place at Mariatorget, as a continuation of our previous study, as an investigation into informational masking. The projected outcome is that the listener’s focus is shifted (unconsciously) from the hum of traffic along Hornsgatan to the sounds emitted from the loudspeakers. The study will include qualitative analyses and the collection of data. This will entail interviews (structured and unstructured); questionnaires; observations (systematic and non-systematic); measurement tools (film and sound recordings, dB(A) readings); and experiments (including variations of loudspeaker volume).

5 CONCLUSIONS AND IMPLICATIONS

An important aspect of this project was to develop a methodology for the architectural, artistic and psychoacoustic processes. In accord with concepts pertaining to environment, atmosphere, and perception, and in relation to indeterminacy, metabolic environment, and acousmatics, urban sounds can be scrutinized from an architectural and artistic point of view. In this light, the blend of sounds from Mariatorget and the sound-art installation “Sonic Space” should be viewed as a composition, based on qualitative and aesthetic criteria.

The psychoacoustic process, on the other hand, aims to determine how “Sonic Space” affects the perceived soundscape with regard to environmental health hazards. In the long term, a psychoacoustic evaluation is an important factor in creating a scientific foundation for action plans pertaining to city parks and other similar areas, solutions aiming to create urban landscapes that offer recreational qualities.

The scientific method goes beyond the prevalent application of individual, quantitative, noise level measurements such as dB(A), Lden, and Lnight. Instead, the objective is to develop new acoustic indicators with ties to qualitative environment and health criteria.
Within the framework of this project, the sound-art installation is an experimental as well as a tentative model that the psychologists can use to gain knowledge of the effect of soundscapes on comfort and well-being. Thus, these experiments are a first step towards interdisciplinary knowledge and methodology development. And in the future, these acoustic indicators, or acoustic aids, could be integrated in action plans for sustainable urban soundscapes.

As previously mentioned, our project does not focus on improving urban soundscapes by using sound systems to mask noise. Installing sound systems in city parks is not a sustainable strategy. The ultimate purpose is to explore how we are affected by the combination of traffic noise and natural sounds found in outdoor urban locations such as parks and squares. Nowadays, there is a great deal of information to be had with regard to the effects of traffic and nature: Traffic is perceived as noise, and affects stress-induced hormones and blood pressure in an adverse manner, while the sounds of nature have positive health benefits. However, conventional research generally pits traffic noise and nature sounds against each other, instead of studying the interaction between the two. Most urban landscapes today display a blend of nature and traffic sounds, which is a reality we must deal with and even embrace. More knowledge is required to create a truly viable and sustainable soundscape. These are the issues our project addresses.

The departure point when creating urban outdoor spaces in the future should be identifying the diverse configurations created by sound sources, artifacts and structures, events, social activities, and sensory experiences. In the forefront, you will find concepts such as atmosphere, identity, comfort, and aesthetics, along with social and ecological sustainability – features by which you can gain a deeper understanding for the qualitative dimensions of urban sounds.

6 REFERENCES


