Aural Landscape: Composing an Urban Park

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

As a culture, the Western World has placed a negative stigma on noise, which has lead to the disregard of the urban soundscape. Researchers have been studying and theorizing ways of understanding the urban sound environment for many years, adding to the knowledge of listening. This thesis aims as a whole to act as a general tool to educate the public on the urban sound environment to aid in discriminate listening. Building on existing research, studies and theories on the urban sound environment it explores the cities inventory of sound possibilities from a psychological, sociological and architectural point of view and asks: what are the forms of constructed space that shape the sound opportunities of our urban environment?

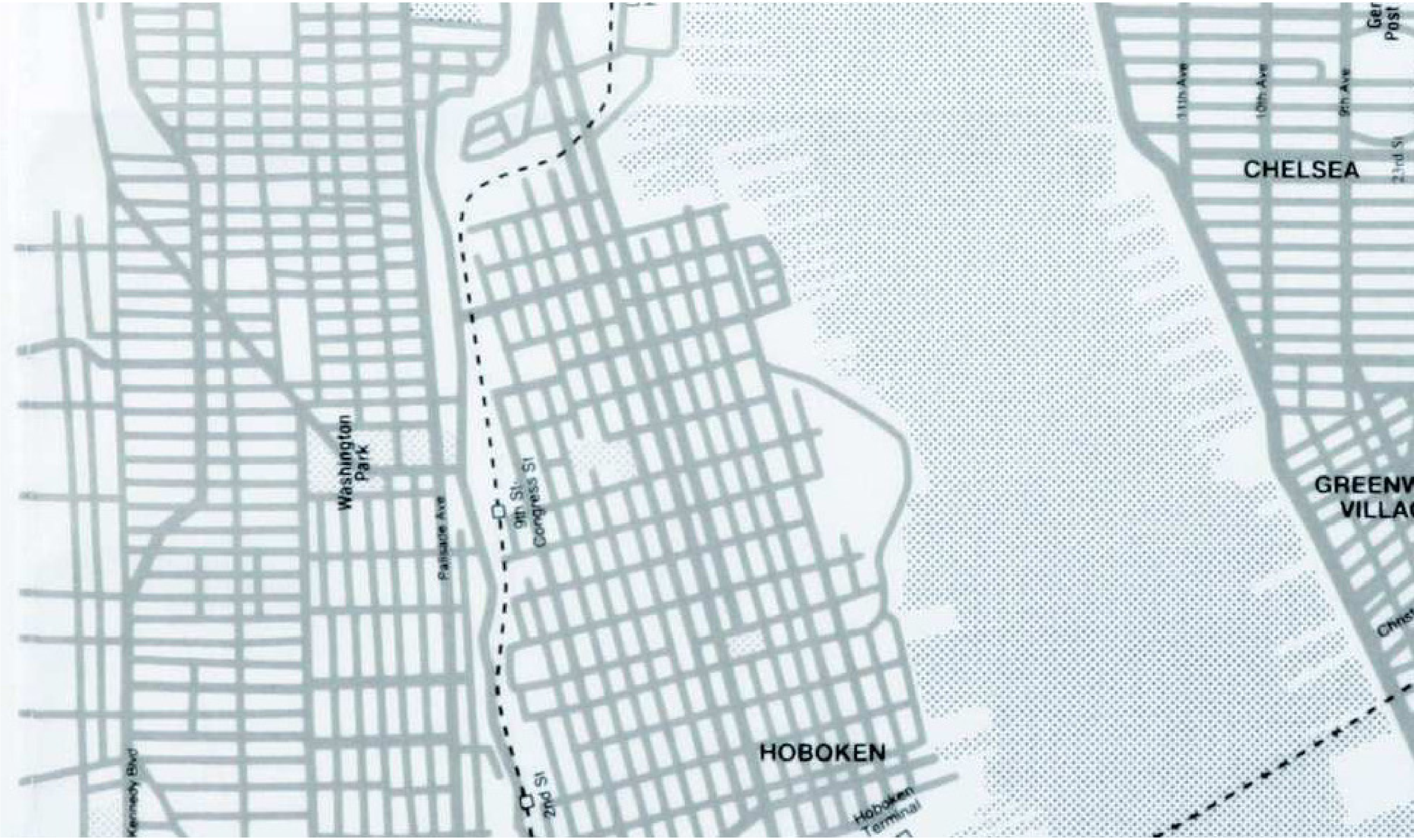
Based on a review of the literature of soundscapes, aural architecture and sound waves and the exploration of precedents that explore sound installations and transcoding, multidisciplinary experiments were conducted involving sound, using quantitative tools such as acoustical software, frequency spectrums, soundclips, physical models, listening exercises, cymatics and mathematics. Findings from the experiments demonstrated new relationships between the urban sound environment and musical composition techniques.

This resulted in a final design study of Washington Square Park using a stochastic methodology from both an architect's and composer's point of view, resulting in a synthesis of layering that demonstrates the cultivation of previous research adding to the body of knowledge of our urban sound environments. Further reflection is done in the form of an essay on how sound research impacted the author's psychological and sociological view not only as a designer but as a listener. This essay is a testimony to the significance of shifting our culture's aural behaviour and encouraging continued research into our urban soundscapes.

Acknowledgements

Thank you to my committee, family and friends for your constant support and tolerance. This would not have been possible without you.

Special thanks goes ot my fiancee, Lauren, for her continuous support and positivity through this entire process.


CHELSEA
11th Ave
10th Ave
9th Ave
21st St
Washington Park
Palisade Ave
9th St-Congress St
2nd St
Kennedy Blvd
HOBOKEN
Hoboken Terminal

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Introduction

In the Western world, we as a culture teach that noise is a disturbance, something to ignore or mitigate. The Oxford dictionary defines noise as: a sound, series or combination of sounds especially one that is loud or unpleasant or that causes a disturbance.[1] Music, by contrast, means the way sounds are composed, with a single universally appreciated connotation. In the Western world music is typically defined as vocal or instrumental sounds combined in such a way as to produce beauty of form, harmony, and expression of emotion.[2] Our cities and metropolitan areas are noisy environments due to the interwoven presence and the solidity and nature of the complex overlap of sounds found within those environments. Human-made machine sounds of that urban world are typically dominant, chaotic, strident, and irritating.

Most municipalities have written by-laws to mitigate such noise. These commonly contain prohibitions as well as temporal and spatial limitations on noise of power equipment, construction-excavation, loud yelling, amplified sound, vehicle warning devices and attracting

1 Noise definition. Accessed August 22, 2019. www.oxforddictionaries.com.

2 Music definition. Accessed August 22, 2019. www.oxforddictionaries.com.

Introduction

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Most municipalities have written by-laws to mitigate such noise. These commonly contain prohibitions as well as temporal and spatial limitations on noise of power equipment, construction-excavation, loud yelling, amplified sound, vehicle warning devices and attracting attention to performances, among other things. Noise by-laws result in complaints and then also in a word of warning by police and other authorities or in fines. Such by-laws reinforce our aural cultural behaviour to focus on limiting or shaping the presence of sounds that are merely disturbances. A result is that people also tune out familiar everyday sounds.

This thesis is an attempt to disengage the stereotypes of listening in our culture and to qualitatively understand the broader sound environment by examining the instrumentation of the urban environment from a psychological and sociological position. Such an instrumentation hopes to create new concepts associated with the examination and reflection of the sonic effects of the overlooked or mitigated urban sound environment, by developing and applying a methodology of composition as an architect, and as a composer. The first step is a design study of Washington Square Park considering the sonic effects from an architectural and urban perspective and then giving them an architectural form. By engaging the expanded discourse of significant researchers and artists in sound environment research, the thesis searches for broad incidental instruments that are available to architects and designers in the urban fabric and the compositional studies of sonic effects, *Aural Landscape:Composing an Urban Park* sheds radiance on the possibilities of unrealised sounds and the possible form and context where they can be appreciated.

Through the eye of multidisciplinary research teams such as The World Soundscape Project, and The Centre de Recherche sur L'espace Sonore et L'environment Urbain (CRESSON), and leaders in the sound environment like R.Murray Schafer, Barry Blesser, Iannis Xenakis, Jean Francois Augoyard and Henry Torgue, concepts are explored such as noise, the soundscape, aural architecture, composition and sonic effect. During the early stages of the thesis research the theories of Canadian composer, R. Murray Schafer, pioneer of The World Soundscape Project, were analysed. Schafer classified a soundscape by a selection of the three key elements he believed every soundscape has: keynote sounds, soundmarks, and signals. Several additional researchers have also influenced the thesis work. Jean Francois Augoyard, a philosopher, urban planner, musicologist and founder of CRESSON, and Henry Torgue, a sociologist, urban planner and composer, jointly invented and wrote a book titled, *Sonic Experience, A Guide to Everyday Sounds*. The book is a guide of defined sonic effects from a musical, psychological, acoustical and architectural and urban design viewpoint. The composition methods of Iannis Xenakis, an architect and composer, are explored to understand his stochastic and mathematical approach to design. His piece titled *Achorippsis* uses Poisson's Formula of distribution as a compositional methodology. A similar tactic is used to compose the final two compositions of the thesis. Schafer's three fundamentals of a soundscape, the guide of sonic effects and the compositional technique of Xenakis plays a critical role in the final thesis studies. The research focused on the evolving sound environment through the 1960s to the 1980s generated a strong set of concepts and questions regarding the tools and instruments accessible to architects, researchers, designers and composers to explore the abundant array and form of sound possibilities of the urban environment.

There exist many examples relevant to this thesis work of precedents and built projects using acoustics, listening and built landscape forms to attain desired sonic environments — projects such as the Philips Pavilion, Pavilion 21, *Public Acoustic Shells*, *Le Cylindre Sonore*, *Aeolus*, *Cells of Life* and *Orpheu*s. The Philips Pavilion from 1958 touches on the aspect of architecture as a composition of music. Pavilion 21 and Public Acoustic Shells from 2010 investigate the effects built form can have on the sound environment. A case study on Pavilion 21 attempts to reverse engineer the facade using a reconstructed virtual three-dimensional model as a deconstructed geometry by principles of soundwaves. In *Le Cylindre Sonore* from 1987 a sound installation that used loudspeakers coupled with microphones and amplifiers to generate an enhanced listening experience of the natural environment. This thesis case study looks at the acoustic properties of the modelled cylinder and tested the effect the number of people had on the soundwaves using acoustical software. Although *Le Cylindre Sonore* used digital devices to amplify natural sounds, *Aeolus*, by contrast, is an instance of using the natural environment and form for a sound generation. Whether a project uses digitally enhanced environmental sounds or the natural environment to produce sounds, they all use built form. *Orpheus* and *Cells of Life* both use landscape forms to communicate a story as an experiential voyage that engages all the senses including the aural. Landscape and topography can have a significant impact on the aural potential of the urban environment.

Through experimental investigations in this thesis work, the question asked is, what tools or instruments are available to architects, designers, researchers and composers and what forms do they create? Through six thesis labs experiments are conducted exploring the instrumental dimension of urban space. These experiments use both quantitative and qualitative techniques supported by reflection and examination to investigate the forms of sound possibilities of the urban environment. Quantitative tools introduced in the labs are coding programs for designers, acoustic and sound analysis software and sound recordings of urban environments. Both qualitative and quantitative tools and data used in this research encompass and entail some subjectivity for two reasons. Firstly, sound events cannot be isolated from the spatial and contextual conditions of the physical site. Secondly, listening does not have a strictly universal effect but is personal to the listener. Therefore, the experiments do not offer scientific, quantitative conclusions. Instead, a personal manifestation is documented.

Washington Square is in one of the world's most chaotic urban sound environments located in a culturally vibrant city with an all time high level of noise complaints. Found in the heart of Greenwich Village in Manhattan, and known as Washington Square Park, this park is an optimal site for this thesis design study. Recognised as one of the most culturally different and energetically social urban parks within Manhattan, Washington Square Park demonstrates a broad diversity of cultural and social performance and is an ideal site where one can examine and reflect on the urban sonic effect.

This thesis*, Aural Landscape: Composing an Urban Park* studies the sound environment from an architectural and musical point of view—seeking to generate a methodology of a composition of sonic effects in an architectural form and audible form and in doing so asks significant questions. What are the forms of these sonic effects? What sonic effects are in the reservoir of the urban environment? Which ones are present and which ones should be added? What is the psychological and sociological experience these effects produce? It is the final design composition, that produces an aid for architects and designers to study through a psychological and sociological lens — hopeful of diversifying our culture's aural behaviour to begin to listen discriminately and design with environmental noise in mind.

A final concluding essay reflects on working with sound during the thesis process and how sound research impacted the author's psychological and sociological view not only as a designer but as a

Sound and Environment
Part 1

Figure 3. - *Photograph of noise by artist Corbis.*

1.1 Noise

The explosive growth of urban cores in cities across the world is a recent prominent global trend. According to the United Nations Department of Economic and Social Affairs, 66% of the world's population will live in the urban environment by 2050.[3] This will have some positive impacts on the environment and the quality of people's lives: for example, the demand for natural resources used in constructing suburban neighbourhoods will be reduced and the number of commuters from suburbs to core areas will be decreased, making commuting times shorter and less costly. The increase in population will lead to an increasingly dense, urbanized world and will yield greater sustainability, but will also pose new challenges. On a basic level, this shift means we now face growing demand for modern infrastructure and living accommodations in the form of skyscrapers and industrial factories.[4] As a result, the construction of these buildings, and the range of activities carried out within these densifying and growing urban environments, will lead to an inevitable problem that significantly affects human health and the natural environment – that is, the problem of noise pollution.[5]

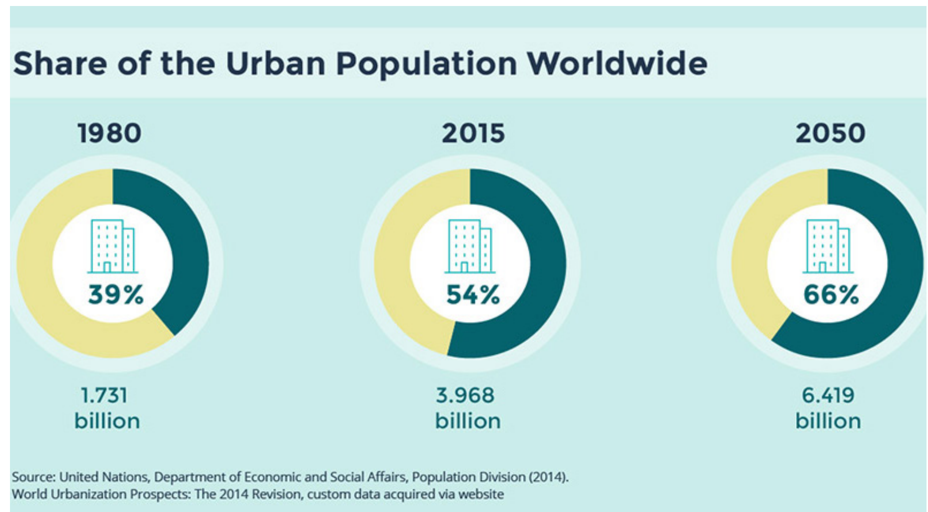

Figure 4. - *Graphic of Urban Population Growth.*

3 Article, World's Population Increasingly Urban with more than Half Living in Urban Area. Accessed August 12th, 2016 http://www.un.org/en/development/desa/news/popultion/world-urbanization-prospects-2014.html

4 Rinkesh, Understanding Noise Pollution. Accessed August 12th, 2016 http://www.conserve-energy-future.com/causes-and-effects-of-noise-pollution.php.

5 Ibid.

Today, the world is filled with an overpopulation of sounds; there is so much competing acoustic information to be processed that little of it can be perceived with any clarity.[6] The continued investment by governments in infrastructure and transportation, coupled with the advancement of technologies, will potentially harm people's listening skills, as did the Industrial and Electric Revolutions. During these revolutions, the many advancements in machinery and technology came with new, unavoidable sounds, from the mechanical noises introduced by inventions like the internal combustion engine to electronic sounds like the ring of a telephone. These sounds, which nobody had heard before, rapidly combined and multiplied, to produce another new phenomenon—that of the lo-fi soundscape. A lo-fi soundscape is a soundscape that makes identifying individual sounds difficult as the listener's aural perspective becomes lost in a background of noise—a type of soundscape that negatively effects people and their ability to accurately and effectively listen and interpret sound. As the advancement of these machines and technology grew, so did the extent to which people depend on them in everyday life, thus compounding the permanence and intensity of

6 R. Murray Schafer, The Soundscape: Our Sonic Environment and the Tuning of the World (Destiny Books,1994), 71.

the lo-fi soundscape. The noise of modern life in industrialized areas became almost impossible to escape. The way people dealt with the noise was to ignore it, an adaptation that made the new soundscape bearable by focusing our attention away from it, but which has done nothing to address the challenges posed by the soundscape's impacts.

Of course, the presence of technology and machinery in our contemporary world has only increased, although it has taken new forms. Today, the electronic sounds of the smart phone and other small handheld electronic devices are replacing the sounds of mechanical sirens, bells and whistles. This increase could potentially continue to add to the rapid growth of our lo-fi urban soundscapes, ultimately resulting in a population disconnecting from aural perception. Municipalities typically respond to this problem through the enforcement of noise reduction by-laws. On an individual level, the use of noise-cancelling headphones and the ubiquity of personal music devices suggest that strategies for ignoring, or tuning-out noise are now an integral part of contemporary urban life. Traditionally, the need to escape the constant noise of urban life is met by travel out of the city and into the country, for those individuals who have the means to do so. In contrast with the city, more rural or semi-rural areas outside of the city are typically hi-fi soundscapes, which contain sounds that can be heard individually and with clarity. However, this means of coping with noise by temporarily leaving is not an accessible option for many people, for economic or situational reasons; and even for those who do have this option, this approach does not improve circumstances in the place where they reside and work. As opposed to encouraging people to leave the cities to escape noise and ignore, perhaps educating people on the urban sound environment could begin to have a positive affect on people's views of urban noise and reduce the negative views of it in the Western world. A general education in the urban sound environment that produces a general common sense through studying the soundscape, aural architecture, the sonic effect and fundamental properties of sound is a starting point to begin to educate people on the urban sound environment.

1.2 The Soundscape

The term ‘soundscape’ was first mentioned in 1966 by Professor Michael Southworth in his article titled “The Sonic Environment of Cities.” In this article, Southworth states that an urban soundscape is comprised of many micro sound events that depend on various and random phenomena. These sound events change daily, weekly, and even seasonally. They depend on many factors such as time, context and other different circumstances.[7] For example, an urban street in the winter covered with fresh snowfall will sound much different in comparison with the same urban street in the summer without snowfall. These ever-changing factors and uncontrollable shaping of various and random sound events is what gives identity to a city. Southworth theorised that a city without sound would seem static and unchanging as people would ignore such an environment and withdraw into their private world. The aural activity would be non-existent and time itself would not be evident—life would seem frozen. This visual city would be very different from a city with sound as the individual would almost be withdrawn from the auditory space and everything outside of the visual field would be unknown.[8] Southworth did a study that looked at

7 Michael Southworks, The Sonic Environment of Cities Environment and Behaviour (Sage Publications, 1969), 51

8 Ibid, 52.

9 Ibid, 60.

the unique sounds perceived by several groups of people in Boston and how they reacted to the aural environment. The result was a list of pleasant sounds to which people reacted positively.[9] This marked the beginning of a wave of the studies of the soundscape in the 1970s. Notably, in Canada, R. Murray Schafer was beginning to research the urban soundscape extensively at this time.

In 1977, Schafer headed a multi-disciplinary research team at Simon Fraser University in Vancouver. The goal of the team was to study the relationship between humans and the sounds in their environments. Named The World Soundscape Project, Schafer's studies involved the fields of social, scientific, and artistic disciplines, such as acoustics, psychoacoustics, otology, noise abatement procedures, sound engineering, and music. [10]

Schafer's work was critical of the widespread tendency to consider noises as something we should ignore. He claimed that humans perceive noises as annoying when they do not listen carefully to what is happening around them. Schafer states that humans did not become surrounded by noise because they liked the sound, but

9 Michael Southworks, The Sonic Environment of Cities Environment and Behaviour (Sage Publications, 1969), 60

10 Merate Barakat, Sonic Urban Morphologies (Architectural Association School of Architecture, 2016), 17.

instead because they ignored it. As an alternative to this negative approach, he wanted to find a way to turn environmental acoustics into an affirmative research program, able to identify the sounds to be preserved, multiplied and encouraged. Only the full appreciation of the acoustic environment can provide us with the resources to improve the orchestration of the world's soundscape.[11]

Schafer invented and experimented with a concept he called *ear cleaning*. In his book titled, *Ear Cleaning: Notes for an Experimental Music Course*, he defined ear cleaning as any process that encourages a person to listen more discriminatingly, particularly to sounds of the environment.[12] This process is similar to a practice used in music for training a musician's ear. A popular form of ear cleaning in the urban environment is done through what is known as a soundwalk. A soundwalk, as defined by Schafer, is comprised of two parts: active participation in the soundscape on a planned walking route that can include the use of a map that guides the exploration of sounds related to the environment; and the intentional building of an awareness of sounds by listening discriminatingly in an environmental context.[13] As Schafer was developing ways to listen and map the soundscape,

11 Elizabeth Martin, PA 16 Architecture As A Translation of Music (Princeton Architectural Press, 1994), 34-35.

12 http://www.sfu.ca/sonic-studio/handbook/earcleaning.html. Retrieved 09/08/2017.

13 http://www.sfu.ca/sonic-studio/handbook/soundwalk.html. Retrieved 09/08/2017.

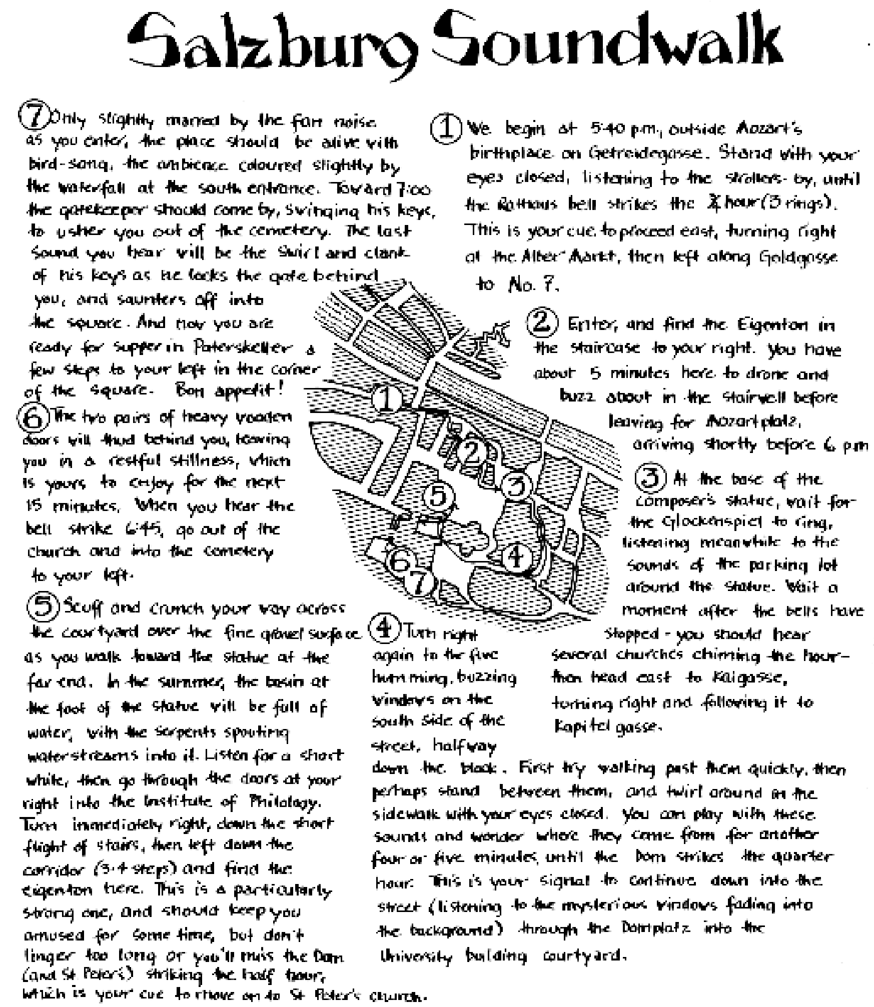

Figure 5 - *Map and Instructions for Slazburg Soundwalk, from European Sound Diary, 1977.*

he and his team were also coming up with concepts necessary to classifying a soundscape. Schafer intended to combine these different fields to consider sound properties, the perceptive mechanisms of humans and humans' behavioural responses to sound events into one comprehensive global approach, all in the hope of being able to design ideal sound environments.[14] This led Schafer to come up with a methodology for classifying a soundscape. In order to analyse the soundscape, Schafer suggests identifying the representative characters. The representative characters of a soundscape are those that are continuous or have a strong presence. Schafer then put them into a hierarchical system to classify them into one of three categories: keynotes, signals, and soundmarks.[15]

When relating to soundscapes, a keynote sound is that which is heard by a particular society continuously or frequently enough to form a background against which other sounds are perceived. 'Keynote' is a term used in music. In music, it is the leading note in a written, composed piece of music, and serves as a piece's fundamental tone.[16] The keynote in the context of urban soundscape studies is related to sounds that make up a sonic environment. They are often created by

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14 Merate Barakat, Sonic Urban Morphologies (Architectural Association School of Architecture, 2016), 17.

15 M.D. Fowler, Towards an Urban Soundscaping (Transcript blog, 2014), 105.

16 Ricciarda Belgiojoso, Constructing Urban Space with Sounds and Music (Ashgate, 2014), 36.

natural geographic elements such as wind, water, animals, trees and other elements that outline the character of a sound envirnoment.[17] In today's urban cores, an example of a keynote sound is the internal combustion engine: the ever-present sound of vehicles' motors is the leading or key sound present in the soundscape. An example in a coastal community would be the sound of the ocean. Keynotes are comparable to the ground in the figure-ground grouping of visual perception.[18]

The second of the three categories used in classifying a soundscape is that of sounds known as signals. Schafer derived the term 'signal' from the theory of communication; in the context of soundscape theory, he defined signals as sounds that stand out in the soundscape that can be conceived of as 'foreground' sounds. Foreground sounds are sounds that attract our attention. They are sounds that everyone can hear and understand in a community, such as bells, whistles, ringtones and sirens.[19] A typical signal heard in urban areas is the siren of emergency vehicles, the loud sounds of which are amplified and deflected off of buildings as they drive through the dense urban core. Signals, in contrast with the keynote, are sounds people can

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17 Barry Truax, Handbook of Acoustic Ecology (Cambridge Street Publishing, 1999), 48.

18 Ricciarda Belgiojoso, Constructing Urban Space with Sounds and Music (Ashgate, 2014), 36.

19 R. Murray Schafer, The Soundscape: Our Sonic Environment and the Tuning of the World (Destiny Books, 1994), 272.

attune to in the urban soundscape. Signals are often louder than the regular urban drone of a city and typically hold a specific meaning that triggers a feeling inside of us which makes us attune to that sound.

Finally, the term ‘soundmark,’ used to describe the third of Schafer’s three categories, is derived from the term landmark. According to Schafer, a ‘soundmark’ is a community sound that is unique or possesses qualities that make it specially regarded or noticed by the people in that community. He believes these sounds deserve to be protected because they make the acoustic life of a community unique.18 Soundmarks were one of the most researched aspects of The World Soundscape Project, and many of its projects focused on this unique type of community-based sound. One of these was the Vancouver Soundscape project, which was a study done in 1973 on Vancouver’s soundmarks. This study went on to influence one of the most successful soundmark projects, titled *The 100 Soundscapes of Japan*. This Japan-based study was a national project that involved the participation of the general public in rating essential aspects of the Japanese sonic environment, resulting in photographs, sound recordings, and maps.

This hierarchical system of classification would become the driving idea behind Schafer's work. Schafer's work was a positive step in understanding the urban soundscape. However, his system for classification did not elaborate on one's perception or the contextual aspects of the urban soundscape and therefore it is only considered a starting point to the deeper research into aural architecture.

1.3 Aural Architecture

Even though the generic definition of a 'soundscape' draws from research based in acoustic studies and tends to focus on auditory media or phenomena—a piece of music, a radio program, or an acoustic environment, for instance—the term itself is made up of two words: sound and landscape.[20] The term thus relates to the physical landscape as well as to the aural landscape. However, a soundscape is more dynamic than just a collection of sound events in the physical environment: it also includes the aural architecture of the environment.[21] Juhani Pallasmaa, a distinguished architect and architectural theorist, argues in his book *The Eyes of the Skin: Architecture and the Senses* that there is a visual dominance in today's

20 Ricciarda Belgiojoso, Constructing Urban Space with Sounds and Music (Ashgate, 2014), 33.

21 Ricciarda Belgiojoso, Constructing Urban Space with Sounds and Music (Ashgate, 2014), 3

technological and consumer culture. He states that this limits the practice and education of architecture to concentrate on the visual aesthetics of architecture. This visual dominance is problematic as we experience the world through a combination of five senses: taste, sight, touch, smell, and hearing. He points out that much architecture is produced and taught with only a consideration of the sense of sight in mind, and that this produces sensory realms that have led to a feeling of alienation in our environment.[22] This concentration on sight in architecture manifests in visual architecture. Visual architecture has created its language and has an extensive history to back it up. However, aural architecture is the aspect of real and virtual space that produces emotional, behavioural, and visceral responses in people. [23] Even though it employs some of the same background knowledge as visual architecture—for example, engineering, history, psychology and science—it lacks the language and written literature to back it up because aural architecture is not as easy to document as visual architecture. Barry Blesser, former MIT professor and most significant inventor of digital audio, stated in his book, *Spaces Speak, Are You Listening?* three reasons for this aural architecture's resistance to and resulting lack of documentation. First, aural expe-

22 Ricciarda Belgiojoso, Constructing Urban Space with Sounds and Music (Ashgate, 2014), 37.

23 Barry Blesser, Spaces Speak, Are You Listening? (MIT Press, 2007),15.

22 Ibid, 6.

riences are hard to record because everyone perceives sounds in different ways. This means there is a lack of physical and intellectual history of the subject.[23] Secondly, there is relatively little appreciation within our culture for the emotional importance of hearing and this, in turn, prevents value from being placed on the art of auditory spatial awareness. Thirdly, schools provide little or no training on the subject of aural architecture.[24]

Aural architecture is determined by its conscious, psychoacoustic contexts and many other factors to that lead to the experience of it and therefore it cannot be translated into literature as easily as visual architecture .[25] However, despite these challenges, in 1979, Jean-Francois Augoyard founded a group called CRESSON at the National School of Architecture of Grenoble. It was the goal of CRESSON to study not only the physical properties of urban settings but also the perceptual awareness of its users. Through a multidisciplinary lens they spent ten years researching topics such as psychology, sociology, urbanism, architecture, music and acoustics and coined the term sonic effect as the term to understand this ten year research project. The sonic effect is not a full concept like the term

23 Barry Blesser, Spaces Speak, Are You Listening? (MIT Press, 2007),15.

24 Ibid, 6.

25 Ibid.54.

SONIC EFFECTS: THEMATIC LIST

Major effects appear in bold type

ELEMENTARY EFFECTS	COMPOSITIONAL EFFECTS
Colouring	Accelerando
Delay	Blurring
Distortion	Coupling
Dullness	Crescendo
Echo	Crossfade
Filtration	**Cut Out**
Flutter Echo	Decrescendo
Haas	Doppler
Resonance	**Drone**
Reverberation	Emergence
	Mask
	Mixing
	Rallentendo
	Release
	Reprise
	Tartini
	Telephone
	Wave

Figure 6 - *Jean-Francois Augoyard and Henry Torgue's Thematic List of Sixty Six Sonic Effects.*

MNEMO-PERCEPTIVE EFFECTS
Anamnesis
Anticipation
Asyndeton
Cocktail
Delocalization
Erasure
Hyperlocalization
Immersion
Metamorphosis
Phonomnesis
Remanence
Synecdoche
Ubiquity
Wall

PSYCHOMOTOR EFFECTS
Attraction
Deburau
Desynchronization
Chain
Intrusion
Incursion
Lombard
Niche
Phonotonie
Repulsion
Synchronization

SEMANTIC EFFECTS
Delocalization
Dilation
Envelopment
Imitation
Narrowing
Perdition
Quotation
Repetition
Sharawadji
Suspension

ELECTROACOUSTIC EFFECTS
Chorus
Compression
Print-through
Expansion
Fade
Feedback
Flange
Fuzz
Harmonization
Larsen
Limitation
Noise-Gate
Phase
Rumble
Tremolo
Vibrato
Wha-Wha
Wobble
Wow

soundscape. It is an open ended survey of objects related to the general discourse of sounds. It gives characterization to the instrumental dimension of urban sound. The use of the sonic effect helped in assisting with acoustical measurement, acts as a multidisciplinary instrumentation for the analysis of complex sound situations, helps in visualizing the aural dimension, serves as a tool for architectural and urban intervention and most importantly acts as a tool for the general education of the experience of listening. This approach brought a new, dynamic way of comparing the physical environment, the socio-cultural milieu, and the individual listener.[26] Augoyard, Henry Torgue, and the team at CRESSON applied this approach in writing a book entitled, *Sonic Experience: A Guide to Everyday Sounds*. This book focused on the effects of sounds on listeners. In it, they define and explain sixty-six of these sonic effects, which they study from the following perspectives: physical and applied acoustics, psychology and physiology perception, sociology and everyday culture, musical aesthetics and architecture and urbanism. Some of these sonic effects require the presence of spatial contexts such as buildings and urban design such as a layout of roads and zoning if they are to occur. These sonic effects primarily apply to the city.[27]

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26 Jean-Francois Augoyard and Henry Torgue, Sonic Experience: A Guide to Everyday Sounds(McGill Queens University Press, 2005), 8.

27 Jean-Francois Augoyard and Henry Torgue, Sonic Experience: A Guide to Everyday Sounds(McGill Queens University Press, 2005), 12.

Some of these sonic effects are reverberation, resonance, cut-out, and filtration. This work laid the groundwork for future attention to aural as well as visual architecture; despite such landmark studies, though, a focus on the sense of sight continues to dominate within interpretations of humans' interactions with architecture.

However, scholarly exceptions to this dominant focus on visual experience continue to broaden our consideration of architecture to include the significance of other senses, including the aural. There are architects like Juhani Pallasma who devote their career to studying architecture with other senses in mind. Today, three influential architects who consider the aural aspect of architecture are Thomas Sheridan, Karen Van Lengen, and Victoria Myers. They argue that architectural schools should integrate aural classes into their curriculum to achieve a more productive and more satisfying built environment. Victoria Myers, a professor and architect, runs a studio at the University of Cincinnati called Sound Urbanism. This studio focuses purely on the aural aspects of urban design. Projects that have been considered within this studio are the Mix House by Sheridan and Van Lengen and also Van Legen's soundscape project titled Architectural Soundscapes. Van Lengen took sound recordings in twelve

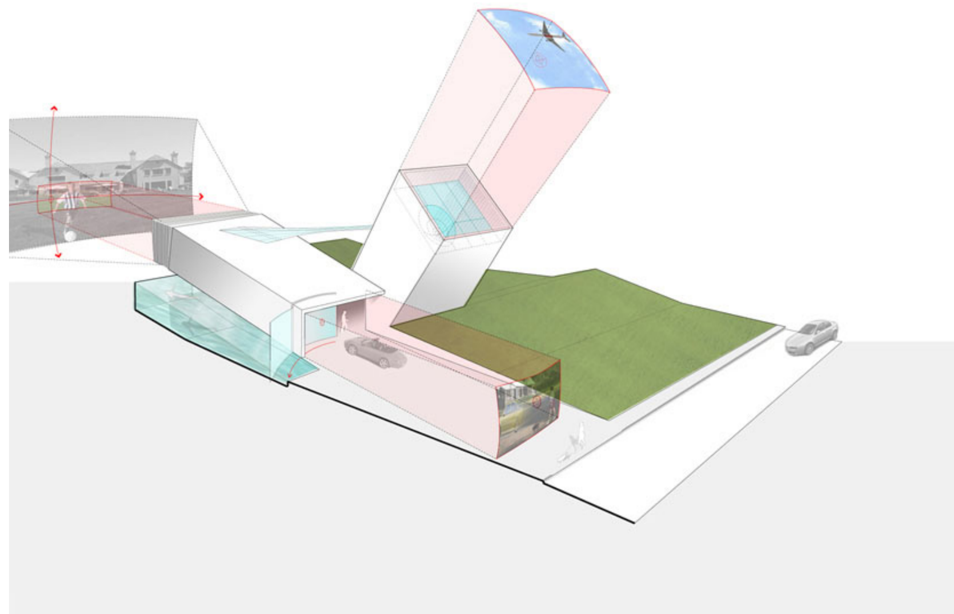


Figure 7 -*Karen Van Legen's, Conceptual Project titled Mix House.*

iconic buildings throughout New York and a visual video transcoded for each of the buildings. Listening to these recordings submerges one into the purely aural aspect of space. It is architects pursuing projects like these, even if they are conceptual, who form the beginnings of a pedagogy emphasizing the importance of auditory spatial awareness.

Such initiatives form the conceptual basis for an understanding of the relationship between space and sound. Auditory spatial awareness, a key aspect of aural architecture which Barry Blesser sees as an undervalued form of awareness, concerns more than just space that changes sound; however, it is also about the emotional and behavioural experience of space.[28] The existing knowledge about measuring acoustic processes is quite advanced. However, the knowledge gained to date concerning the phenomenology of aural space is lacking.[29] Barry Blesser believes that auditory spatial awareness influences people in four different ways: it influences social behavior; it gives one the ability to orient and navigate through space' and it affects the aesthetic sense of a place and enhances the experience of music and voice.[30] These four characteristics of auditory spatial

28 Barry Blesser, Spaces Speak, Are You Listening? (MIT Press, 2007),6.

28 Ibid.

30 Ibid.

awareness directly correspond to aural architecture: social, navigational, aesthetic, and musical spatiality.[31]

Another central concept in Barry Blesser's book *Spaces Speak, Are You Listening?*, is that of aural boundaries. Although most people typically only take visual boundaries into account, Blesser introduces the parallel concept of aural boundaries. The most straightforward example of this is known as the cocktail party effect.

This effect is most commonly experienced by two people having a conversation in a busy restaurant. The only conversation they hear is the conversation between themselves. The conversation between the two people causes this effect because it is above the background noise, making the other conversations inaudible. It is thus creating an aural bubble around the people in the conversation. Barry Blesser came up with the term 'aural space' as a tool for analysing this phenomenon. Aural space is defined and explained in turn by two related terms-acoustic arena and acoustic horizon: The acoustic arena is the arena where listeners can hear a sonic event because it has sufficient loudness to overcome the background noise centred at the source; listeners are inside or outside the arena of the sonic event.[32]

31 Barry Blesser, Spaces Speak, Are You Listening? (MIT Press, 2007),6.

32 Barry Blesser, Spaces Speak, Are You Listening? (MIT Press, 2007),11.

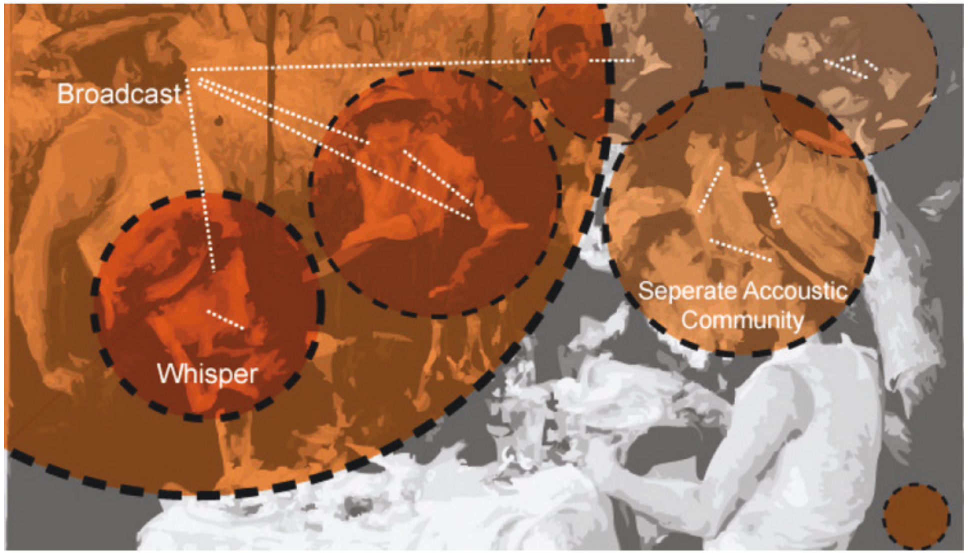


Figure 8 - *Graphic explaining Acoustic Arena vs. Acoustic Horizon.*

The acoustic horizon is the maximum distance between a listener and a source of sound at which the sonic event can still be heard. Beyond this horizon, the sound of a sonic event is too weak relative to the masking power of other sounds to be audible or intelligible.[33] All sound sources have an acoustic arena, and all listeners have an acoustic horizon.[34] Studying and identifying acoustic arena and acoustic horizon in the urban soundscape is a complex multidimensional task, but with a simple understanding of soundwaves and their physics, it is possible to gain a better understanding of these concepts and to apply them to design at a high level.

1.4 Soundwaves: Fundamental Properties of Sound

Soundwaves can be defined as the physical nature of the generation of sound caused by a mechanical vibration or the oscillation of a medium. In making this vibration or movement the wave thus creates a density change and a change in the volume of air. This volume of air attempts to return to a neutral state but in doing so creates another change in the volume of air and this change in volume is the energy that prorogates through the air, creating sound. This energy

33 Ibid.

34 Ibid,12.

is referred to as sound waves and can be defined as a longitudinal pressure fluctuation that moves through an elastic medium. This energy is thought of as longitudinal because the particle motion is in the same direction as the wave propagation. The medium can be a gas, liquid or solid, though in our everyday experience we most frequently hear sounds transmitted through the air.[35] Every sound has specific properties; some fundamental properties of soundwaves used in this body of research are frequency, sound levels and spherical spreading of a point source sound. The following section touches on the basic concepts of each one of these properties.

Frequency can be defined as a steady sound produced by the repeated back and forth movement of an object at regular intervals. This time interval over which the motion recurs is called the period. We can invert the period to obtain the number of complete cycles of motion in a one-time interval, which is called the 'frequency'.[36] Many fundamental properties of sound are related to frequency, such as wavelength, period and the speed of sound. Mathematically this is represented by the following formula:

35 Marshall Long, Architectural Acoustics (Elsevier Academic Press, 2006),xxv.

36 Merate Barakat, Sonic Urban Morphologies (Architectural Association School of Architecture, 2016), 85.

Frequency

$$f = \frac{1}{T} = \frac{c}{\lambda}$$

T	Period	(Seconds)
c	Speed of sound / Velocity	(m/s)
λ	Wavelength	(m)

Wavelength

$$\lambda = \frac{c}{f} = cT$$

f	Frequency	(Hertz)
c	Velocity	(m/s)
T	Period	(Seconds)

Speed of Sound

$$c = \sqrt{\frac{P_{atm}y}{p}} = \sqrt{\frac{E}{p}} = \lambda f = \frac{\lambda}{T}$$

P_{atm}	Atmospheric pressure (at sea level) = 105	Newton per metre square
y	Adiabatic Gas Constant = 1.4	At temperature 20^0 Celsius
p	Density of the medium = 1.18	Kilogram per metre cube
E	Elastic modulus	(stiffness)
f	Frequency	(Hertz)
λ	Wavelength	(Metre)

Sound Levels

Since the range of intensities is so extensive, a common practice is to express values in terms of level. A level is a fraction, expressed as ten times the logarithm of the ratio of two numbers.[37] It is best to think of levels as simple fractions. Often level is measured in units called

37 Merate Barakat, Sonic Urban Morphologies (Architectural Association School of Architecture, 2016), 96.

decibels. Commonly frequency spectrums use Hertz and decibels. Mathematically, levels can be represented by the following formula:

Sound Pressure Level

$$L_p = 10 \log_{10} \left(\frac{P^2_{RMS}}{P_{ref}^2} \right) = 20 \log_{10} \left(\frac{P^2_{RMS}}{P_{ref}^2} \right)$$

L_p	SPL	(Decibels)
P_{RMS}	Measured pressure (RMS) of	(Pascal)
P_{ref}	Reference sound pressure	$=2x10^{-5}$ (Pascal)

Sound Intensity Level

$$L_i = 10 \log_{10} \frac{I}{I_{ref}}$$

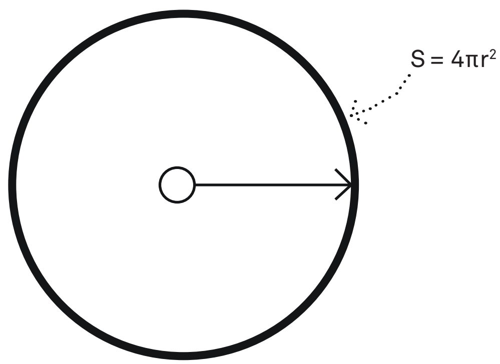
L_i	SIL	(Decibels)
I	Measured intensity of concern	(Watt per metre square)
I_{ref}	Reference sound intensity	$=10^{-12}$ (Watt per metre square)

Spherical Spreading of a Point Source Sound

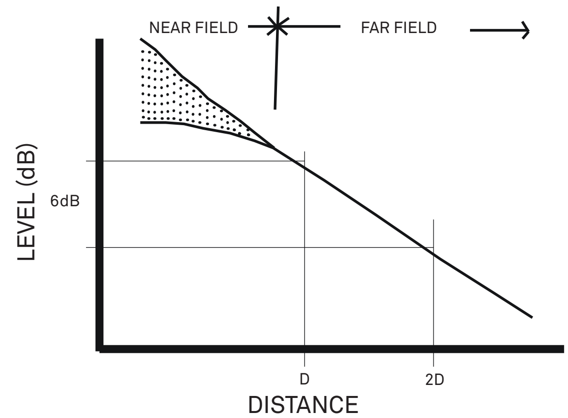
$$\Delta L_p = 10 \log \frac{r_2^2}{r_1^2} = 20 \log \frac{r_2}{r_1}$$

L_p	Change in sound pressure	(L1-L2)
r_1	Measurement distance 1	(m)
r_2	Measurement distance 2	(m)

The Falloff from a Point Source



S	Area of the measurement surface	(metre squared)
r	Measurement distance	(m)


NEAR FIELD
FAR FIELD
LEVEL (dB)
6dB
D
2D
DISTANCE

Precedents
Part 2

Figure 9 - *Photograph of Philips Pavilion at the 1958 World Exposition.*

Precedents

This chapter examines a number of precedents for built projects using acoustics, listening and built landscape forms to attain desired sonic environments. These examples will illuminate the methodical and theoretical approaches designers have taken to these built projects, and their wide range of potential forms and functions as structures and environments. Precedents that will be discussed to provide this context include the *Philips Pavilion*, *Pavilion 21*, *Public Acoustic Shells*, *Le CylindreSonore*, *Aeolus*, *Cells of Life* and *Orpheu*s.

2.1 Philips Pavilion

An influential intervention into music composition and architecture, the Philips Pavilion was commissioned for the 1958 World Exposition in Brussels to exhibit the technology of the Philips Corporation, an electronics company known at the time, as it still is today, for its innovations in sound production, lighting and electronics. Le Corbusier, at the height of his fame and nearing the end of his career, was

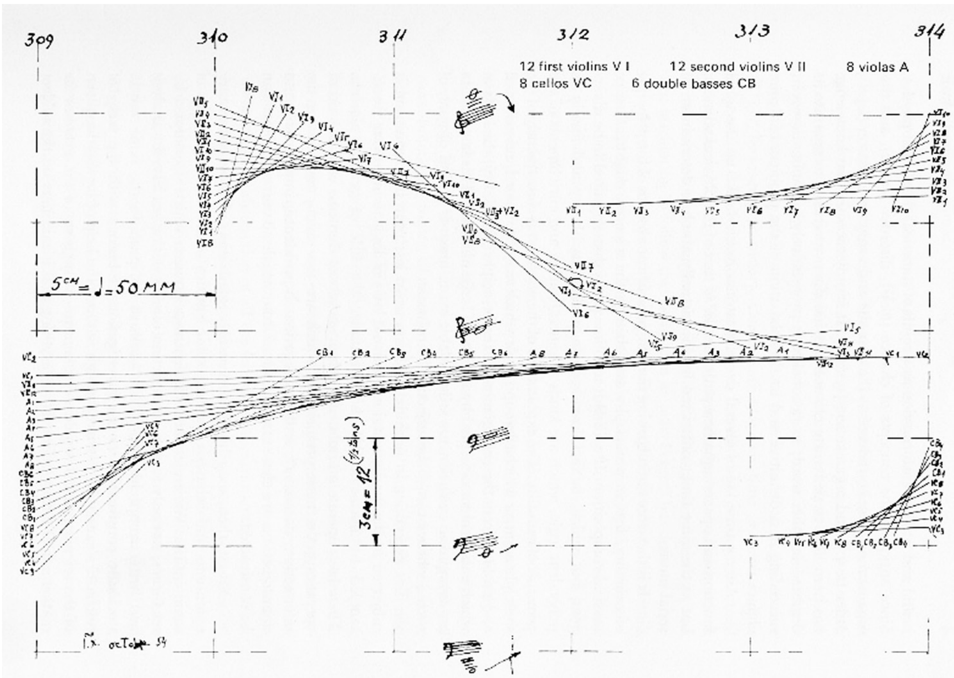


Figure 10 - *Sketch of String Glissandi, Bars 309-14 of Metastasis.*

selected by the company to design what Philips artistic director Louis Kaff called a “spatial-colour-light-music production.” Having just completed some significant buildings such as the chapel of Notre Dame du Haut in Ronchamp, France, Le Corbusier had considerable power behind him and Philips granted him the freedom to design whatever he wanted, with the single condition that he incorporate the Philips corporation’s current technology into the design.[38]

Kaff expected Le Corbusier not only to design the building but also to compose the sound installation and visual lighting effects to accompany the videos displayed on the interior of the structure at the World Fair Exposition. However, as he was entering the busy final years of his life’s work, Le Corbusier did not end up designing the visual and audio features of the pavilion himself; although he came up with the concept, an architect and composer from his office named Iannis Xenakis would become the chief visionary for the project. Le Corbusier also picked a world-renowned composer named Edgard Varese to compose the sound installation. Xenakis, a pioneer in his computational practice of extracting form from music, approached architectural design in much the same way as he approached his musical composition. In both practices, he employed mathematics and stochastic

38 http://hdl.handle.net/1903.1/29. Retrieved 09/11/2017.

processes. One of Xenakis's most famous and exemplary works was his extraction of polytopes from the music composition of Glissandi from his 1954 composition titled *Metastasis*. Xenakis trans-coded the sheet music from this piece into a three-dimensional built form, which served as an inspiration in his design of the pavilion.

Unfortunately, the Philips Pavilion was only a temporary structure, but its design continues to wield influence because of its extraordinary integration of sound and built form: the exterior was a visual language of sound and the interior was an audio-visual experience. Xenakis's process for design is comparable to today's computational designing, and he is now viewed as a computational design pioneer. The driving force behind his design was mathematics; for the Philips Pavilion, for instance, Xenakis proposed a combination of hyperbolic and paraboloid surfaces that would make up the superstructure of the pavilion, to result in a roof and walls that shared one seamless surface. Xenakis took responsibility for designing the light and worked with the composer Edgard Varese for the sound experience to go with the short film that would be projected on the interior walls of the pavilion. Xenakis used geometry, music, and sound to create one of the world's most influential works not only in architecture but also in music, as

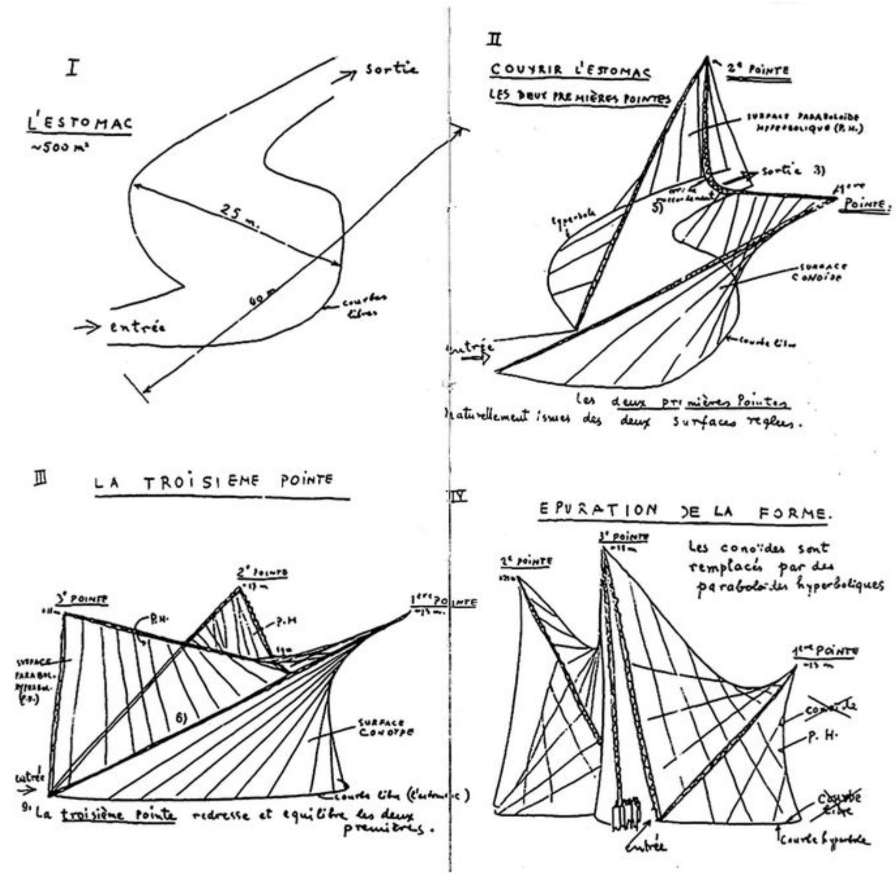
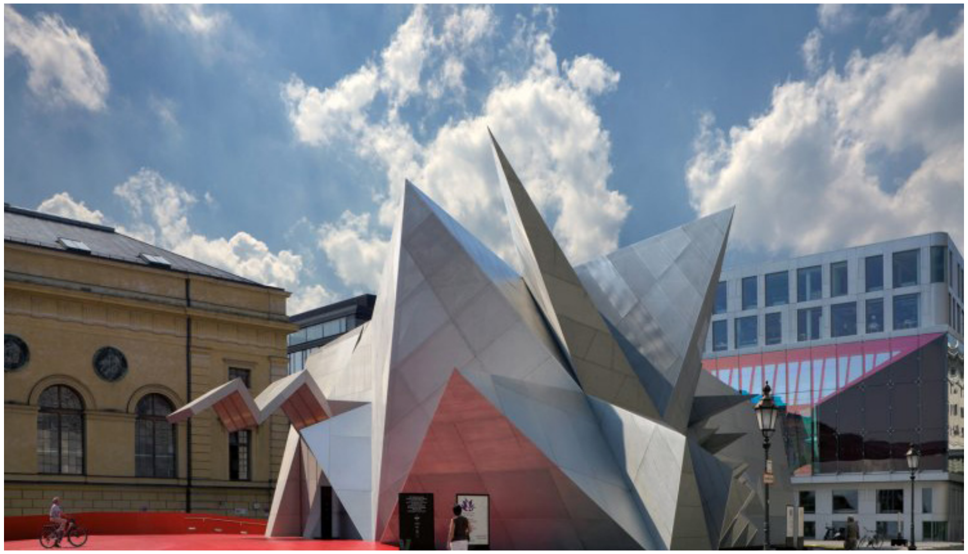


Figure11 - *Analytics of Polytopes for the Philips Pavilion.*



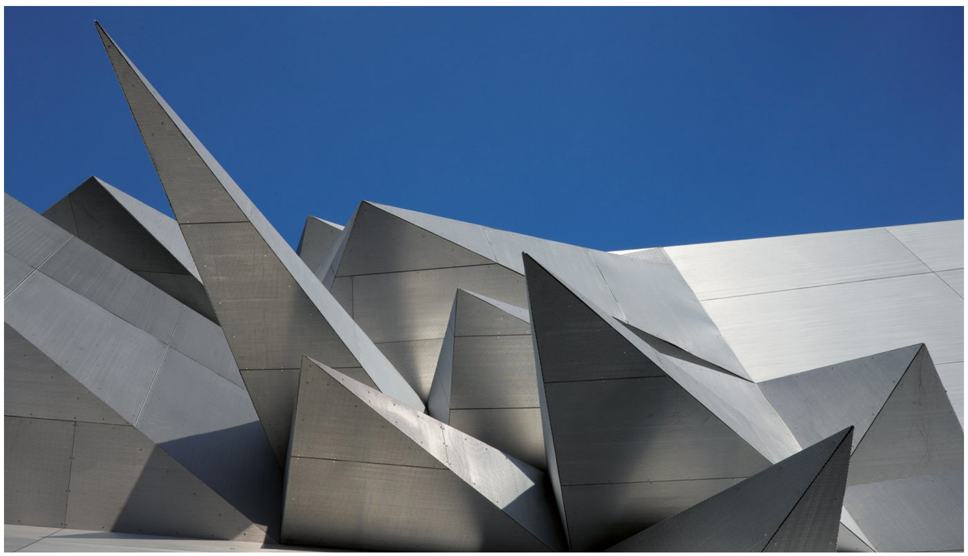


Figure 12 - *Pavilion 21 Mini Opera Space entrance by Coop Himmelblau.(upper)*
Pavilion 21 Mini Opera Space acoustic deflecting facade by Coop Himmelblau.(lower)

the sound installation is now considered a pioneering project in the evolution of what is known today as electronic music. Xenakis did not compose at the piano; instead, he composed using mathematics and computer science.[39] Xenakis's design of the building centered sound as a means of both conceiving and perceiving architectural form.

2.2 Pavilion 21

Soundscaping Scripting Models: Pavilion 21 Mini Opera Space

Upon its opening in 2010 in Munich, Pavilion 21 Mini Opera Space, designed by Wolf D. Prix and his firm Coop Himmelb(l)au, became a critical precedent for the practice and study of trans-coding sound. Pavilion 21 seamlessly blends spatial acoustics and cultural acoustics into an architectural device that integrates itself assertively into the architectural ensemble of Marstallplatz. The pavilion serves not only as a sonic buffer for the urban plaza of Marstallplatz, but also as a stage for the Bavarian State Opera festival. This pavilion takes key elements of its structure from music through its designers' use of trans-coding, and then lends that ephemeral structure to the practi-

39 Ricciarda Belgiojoso, Constructing Urban Space with Sounds and Music (Ashgate, 2014), 33.

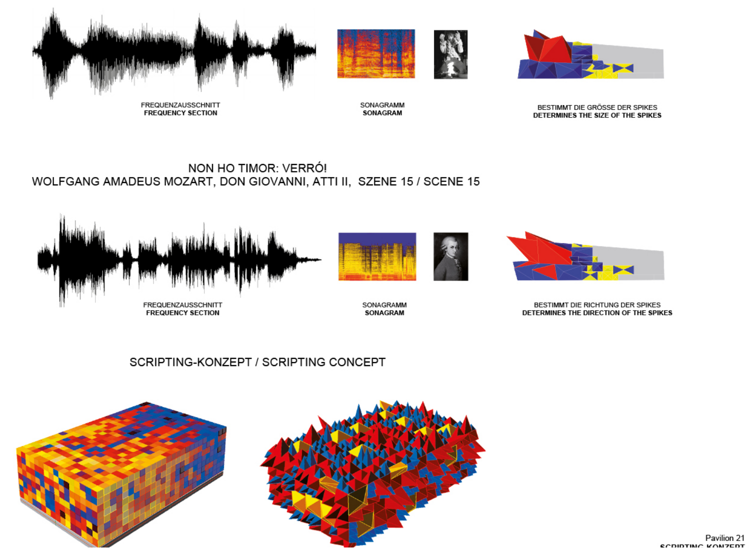
cal and atmospheric functions of supporting sound within the plaza during the festival.

Prix summarizes the pavilion's ephemeral ability to become a node for exchange around music when the festival takes place: "The architecture of Pavilion 21 addresses the ephemeral nature of drama and music: for the duration of the festival it becomes a new central Festival location - a place of encounter and exchange between artists and audience, between music and other forms of contemporary art."[40] The use of trans-coding was key to the design of architectural elements that support that ephemeral quality.

This trans-coding of music into the structure's design can be seen in its spikes, which are evidence of the use of digital media in the practice of Coop Himmelb(l)au in their employment of parametric scripting. The driving force for the trans-coding of music into a spatial form in the design of the pavilion was the combination of a sequence from the song 'Purple Haze' by Jimi Hendrix and a passage from 'Don Giovanni' by Mozart.[41] Through the analysis of frequency sections from these pieces of music and the combination with the computer-generated three-dimensional model, the sequences are translated

40 Bachler, Nikolaus. The Art of Theater, 6.

41 Ibid, 7.



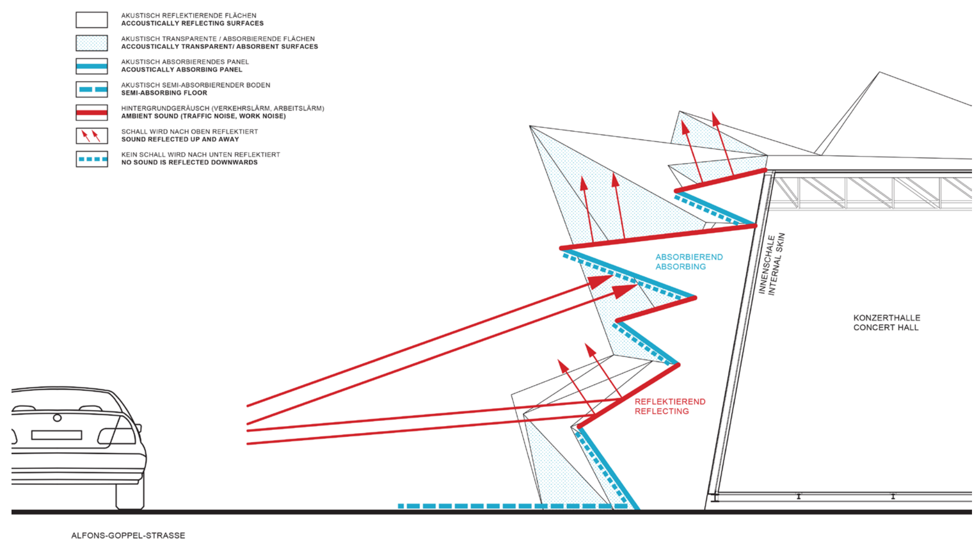


Figure 13 - *Graphic of the testing of trnascoding the audio spectrum of 'Purple Haze' by Jimi Hendrix into an acoustical responsive facade .*

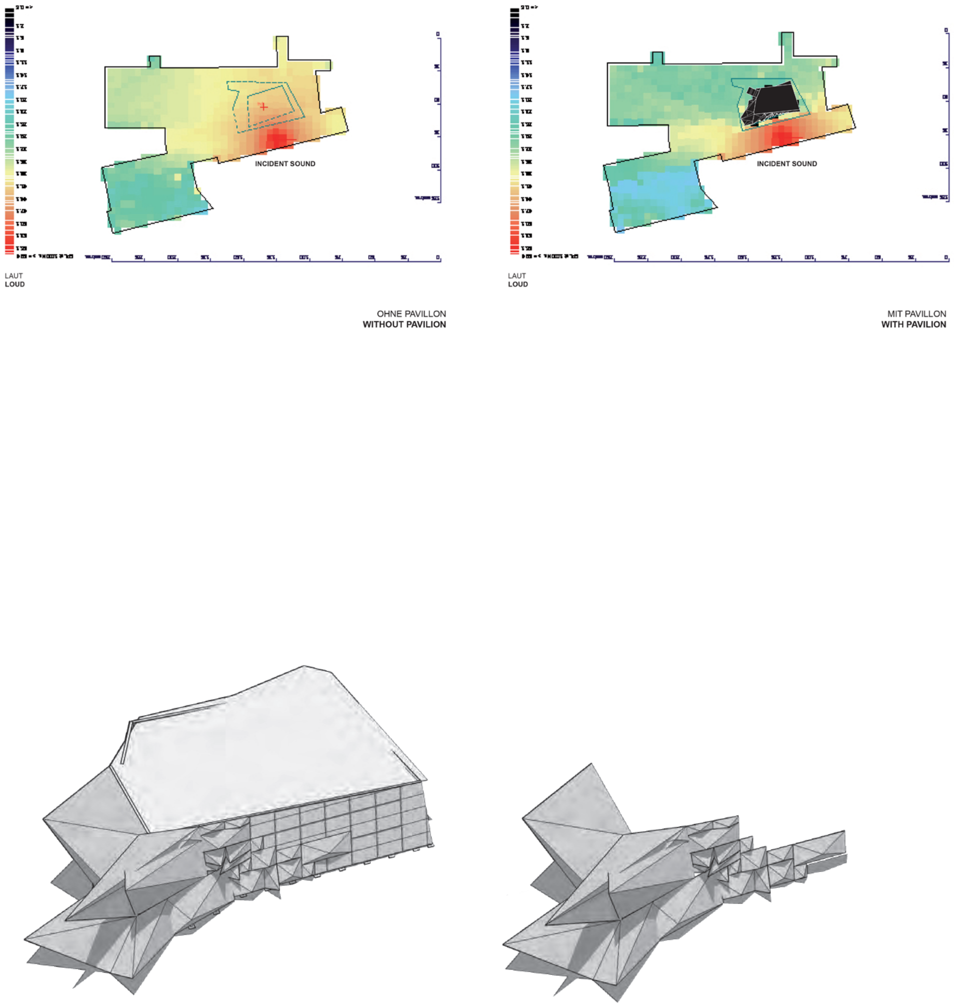


Figure 14- *Graphic of incident sound with and without pavilion. (upper)*
Graphic of the performance of the transcoded facade.(lower)

into pyramidal ‘spike constructions’ by means of parametric ‘scripting’.[42] The song ‘Purple Haze’ was used to determine the length of the spike and the song ‘Don Giovanni’ was used to determine the direction of the spike.

The creation of place through the mediation of sound is one of the structure’s functions. The progressive spiking of the exterior of the portable opera space acts not only as a notation of ‘frozen’ music but reflects, diffuses and absorbs some of the local urban ambiences. The architects of Coop Himmelb(l)au, acting both as aural architects and acoustic architects, study and apply the basic understanding of acoustics as the driving force of the design, all the while balancing this with a coherent design strategy that takes a noisy non-space and transforms it into a place.

Wolf D. Prix, the designer of this pavilion, describes how its ephemeral nature allows it to draw extant things and ideas together for the visitor through its aural and acoustic architecture:

> It is our aim to upgrade the square, which despite its central location lies somewhat off the beaten track, into a lively urban cultural forum for Munich and its visitors. This public forum

42 Bachler, Nikolaus. The Art of Theater, 11.

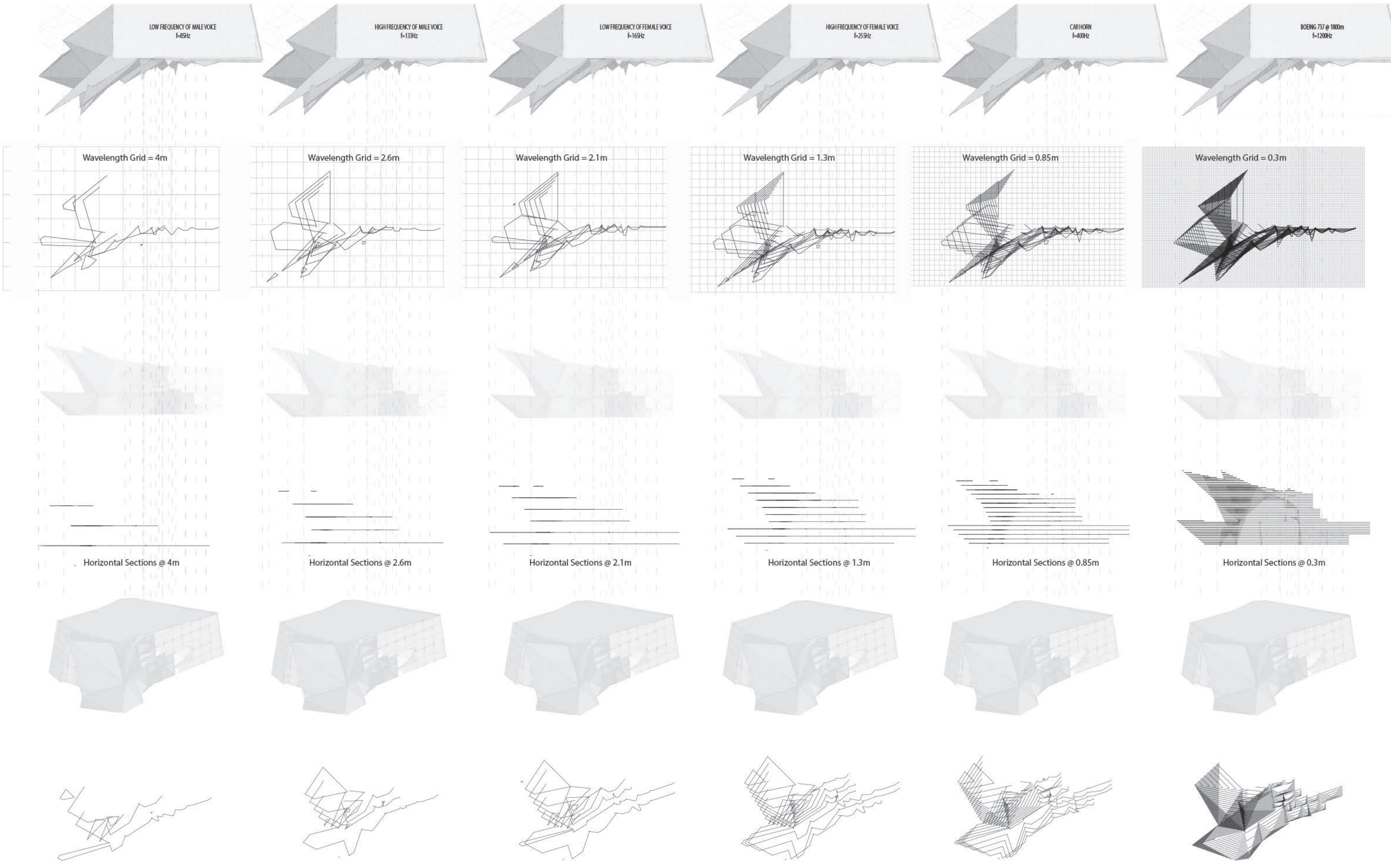
is situated between surrounding theatres, the Resident and the green oases of the Hofgarten and Englischer Garden. The design by Coop Himmelb(l)au lies like a crystal between the neoclassical buildings of the Resident and the facade by Olafur Eliasson, both futuristic and yet reminiscent of the nearby Alps. A 'temporary building' with its roots firmly in Munich, and yet one which is ready to permit us to embark on a journey around the world.[43]

Analysis

Two methods were created for the abstraction of the trans-coding strategy used by Coop Himmelb(l)au. The first method involved doing a thorough analysis of the accessible drawings. The plans and sections were examined, and a three-dimensional model was reproduced based on the information found. The area of concentration for the analysis was that of the exterior faced spikes. The facade was blown apart into its spikes and analysed to determine which ones act merely as a facade and which ones start to determine interior and exterior space. The spikes were then reconstructed based on the

43 Bachler, Nikolaus. The Art of Theater, 7.

Figure 15 - *The analysis involved using typical sound levels of the male voice, female voice, car horn and a Boeing 737 @ 1800m. The frequency of these sounds were found and used to find the wavelengths of each sound. The waelengths were than used as section cut intervals. These section cuts at different intervals began to reveal the different geometries of the transcoded facade.*


LOW FREQUENCY OF MALE VOICE
f=85Hz
HIGH FREQUENCY OF MALE VOICE
f=133Hz
LOW FREQUENCY OF FEMALE VOICE
f=165Hz
HIGH FREQUENCY OF FEMALE VOICE
f=255Hz
CAR HORN
f=400Hz
BOEING 737 @ 1800m
f=1200Hz
Wavelength Grid = 4m
Wavelength Grid = 2.6m
Wavelength Grid = 2.1m
Wavelength Grid = 1.3m
Wavelength Grid = 0.85m
Wavelength Grid = 0.3m
Horizontal Sections @ 4m
Horizontal Sections @ 2.6m
Horizontal Sections @ 2.1m
Horizontal Sections @ 1.3m
Horizontal Sections @ 0.85m
Horizontal Sections @ 0.3m


LOW REQUENCY OF MALE VOICE
f=85Hz
HIGH FREQUENCY OF MALE VOICE
f=133Hz
LOW FREQUENCY OF FEMALE VOICE
f=165Hz
HIGH FREQUENCY OF FEMALE VOICE
f=255Hz
CAR HORN
f=400Hz
BOEING 737 @ 1800m
f=1200Hz
Horizontal Sections @ 4m
Horizontal Sections @ 2.6m
Horizontal Sections @ 2.1m
Horizontal Sections @ 1.3m
Horizontal Sections @ 0.85m
Horizontal Sections @ 0.3m
Wavelength Grid = 4m
Wavelength Grid = 2.6m
Wavelength Grid = 2.1m
Wavelength Grid = 1.3m
Wavelength Grid = 0.85m
Wavelength Grid = 0.3m


LOW FREQUENCY OF MALE VOICE
f=85Hz
HIGH FREQUENCY OF MALE VOICE
f=133Hz
LOW FREQUENCY OF FEMALE VOICE
f=165Hz
HIGH FREQUENCY OF FEMALE VOICE
f=255Hz
CAR HORN
f=400Hz
BOEING 737 @ 1800m
f=1200Hz
Vertical Sections @ 4m
Vertical Sections @ 2.6m
Vertical Sections @ 2.1m
Vertical Sections @ 1.3m
Vertical Sections @ 0.85m
Vertical Sections @ 0.3m
Wavelength Grid = 4m
Wavelength Grid = 2.6m
Wavelength Grid = 2.1m
Wavelength Grid = 1.3m
Wavelength Grid = 0.85m
Wavelength Grid = 0.3m

portion of the facade that acts as interior and the portion of the facade that acts strictly as a sound wave reflector and absorber. Horizontal sections were then cut to reveal the interior and exterior spaces of the facade. These revealed the void space created by these spikes. This showed that no two walls or ceilings were parallel to one another. As Prix described, in the structure's design, shape is determined by the exclusion of surfaces that would reflect sound. These sound reflecting, parallel wall and ceiling surfaces are avoided and are therefore tilted or skewed.[44]

A study based on known frequencies in the urban environment was used in the design of this pavilion as well. From these frequencies, the wavelength of sound was found using the speed of sound through air. The following section shows images of this study and the series of diagrams produced. The results were mapped to show the forms the different frequencies theoretically produce.

This was a methodology produced to study the facade of the opera house. The graphs show the percentage of the facade that is diffusing and reflecting sound waves.

44 Bachler, Nikolaus. The Art of Theater, 10.

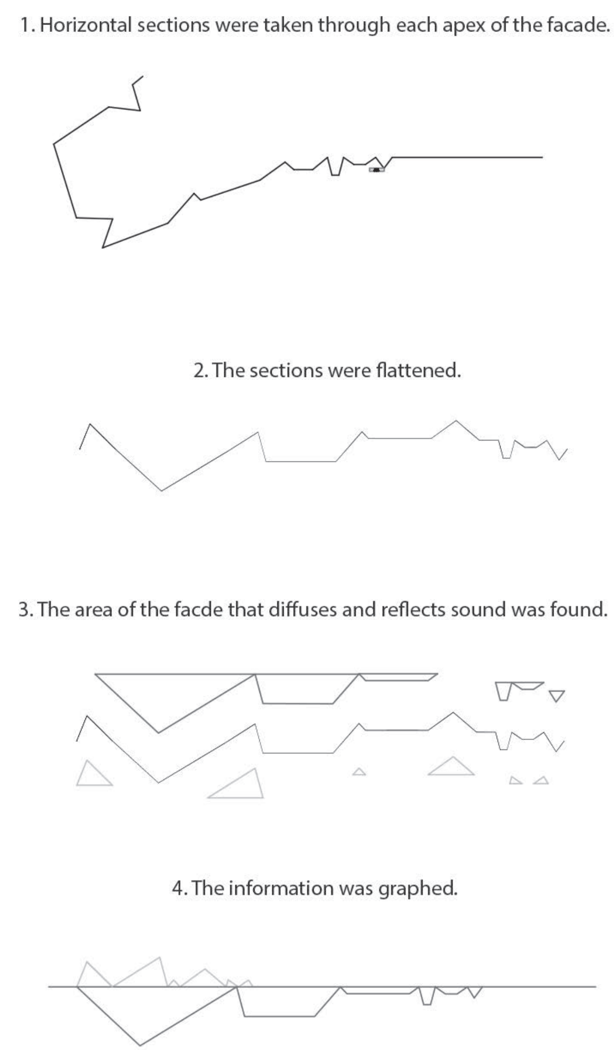


Figure16 -*Graphic explaining the process used to graph the sections.*

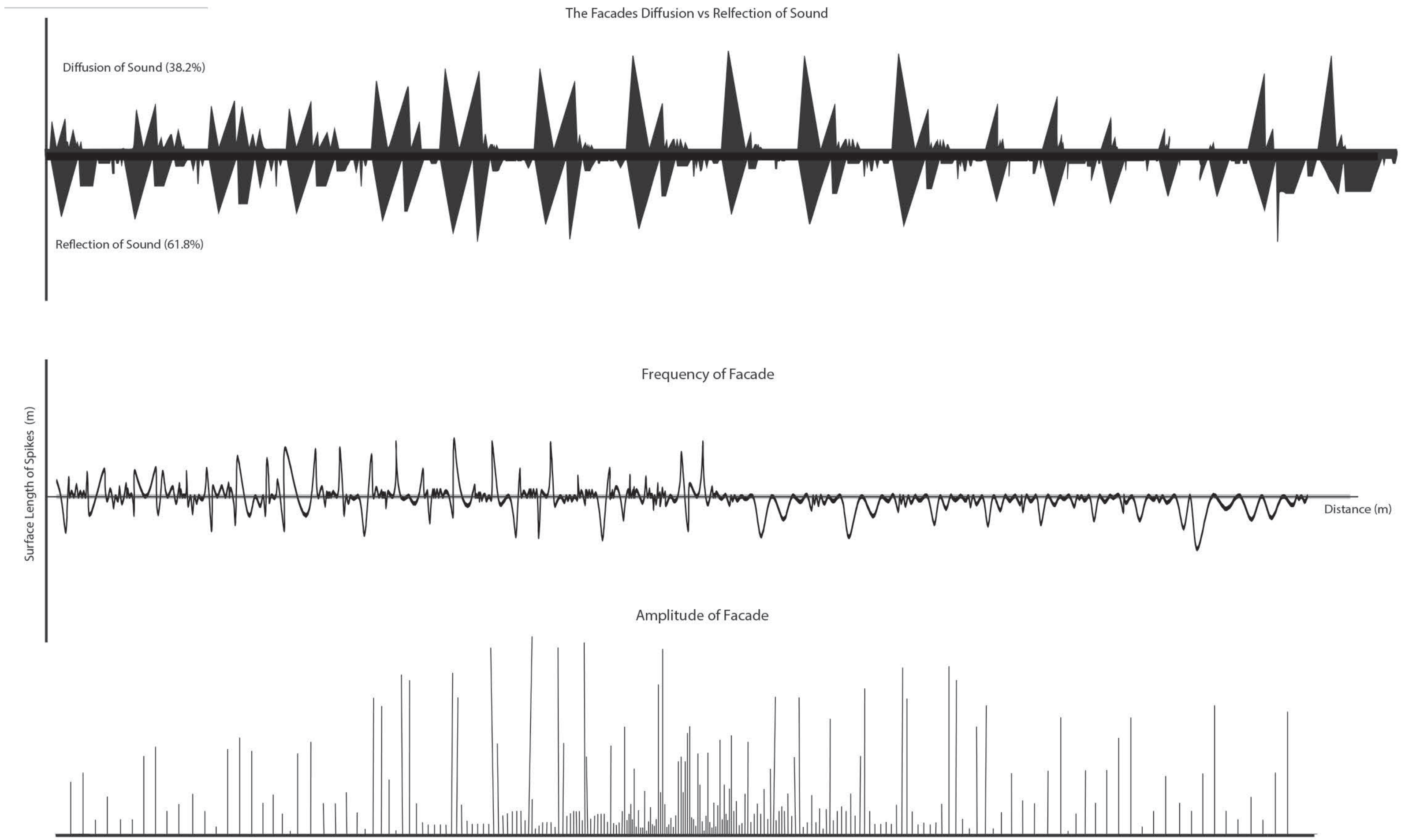


Figure 17 - *Graphs showing the Deflection vs. Reflection of Sound, Frequency and Amplitude of the facade.*

2.3 Public Acoustic Shells

Designed as a public performance and gathering space, the acoustic shells designed by the Flanagan Lawrence studio are located beside the beach in Little Hampton, West Sussex, United Kingdom. These shells, which are sunken into a seaside garden, act as a stage and shelter for the people of the community. The shells not only visually enhance the green space with their stark white and thin form but also provide a public space that can satisfy an essential social need, which is not provided anywhere else in the area. As seen in the figure, the shells invite both musicians and performers and the general public to sit and enjoy or explore. One shell faces the green space and acts as the main stage while the other shell faces the water and acts as a bench where people can sit and listen to amplified sounds of the sea. The acoustic design of the shells creates a reflective surface

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2.4 Le Cylindre Sonore

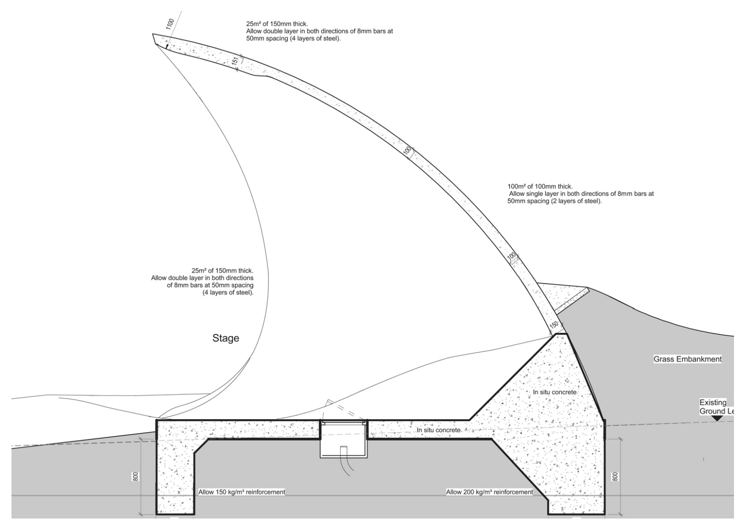


Figure 18 - (upper)*Photograph of people listening to the ocean being amplified by the acoustic shell.*
(lower) *Graphic of a section through the acoustic shell.*

Digitised Sound: Le Cylindre Sonore

Le Cylindre Sonore is a sound installation that was not only designed by an aural architect but also gives visitors the chance to become aural architects through the choice of where they are going to either sit or stand. As Barry Blesser has described, aural architecture is not an exclusive domain of the designer but rather everyone can function as an aural architect:

> Aural architecture is not the exclusive domain of a handful of acoustic professionals who have an opportunity to design classrooms, concert halls, or churches. In a genuine sense, we are all aural architects. We function as aural architects when we select a seat at a restaurant, organise a living space or position loudspeakers.[45]

In 1987, the installation of Le Cylindre Sonore in Parc de la Villette, designed by Bernhard Leitner, explored the notion that we all function as aural architects. Leitner's installation places eighteen speakers in a cylindrical space. Each of the single sounds produced by each

45 Barry, Blesser, and Linda Salter. Spaces Speak, Are You Listening? Experiencing Aural Architecture, 6.

speaker creates its own space which the viewer/ visitor must enter. As Leitner describes it, “In the process, the visitor inevitably becomes aware of one’s own body as being part of the unified space of the sound installation.”[46] A specific spatial position or pose is designated for one’s body by the experience of the space. In the case of Le Cylindre Sonore, there are stone cubes that act as stools for one to sit on. “The human figure, in general, plays a key role in Leitner’s installations,” Leitner explains.“By allocating to the visitor a specific pose and specific place, the artist makes one a visible part of his installation - ultimately, a picture.”[47] Secondly, the tone that fills the cylinder gives the visitor a feeling of the sound flowing through one’s body and he or she begins to perceive him or herself as part of the space of the installation as a whole.

Figure 19- *Photograph of people visiting the installation.(upper)*
Photograph of the stratigically placed seating in the installation.(lower)

Leitner conceives installations as creating separate, solitary space for one, in contrast with other uses of sound in other public spaces, which often aim to create a group experience:

> Since no attempt is made to gratuitously entertain the ex hibition visitor one is, hence, not distracted from focused

46 Bernhard, Leitner. - P.U.L.S.E., 8.

47 Bernhard, Leitner. - P.U.L.S.E., 10.

listening. Moreover, most likely, it is this that the uniqueness of these installations above all constituted: they are created for one single person. They single out the individual visitor and allocate him his place. In so doing, they constitute a dis tinct alternative to the pervasive disco aesthetics, which aims at generating a group experience. Focusing on the sounds of life in the immediate environment.[48]

By contrast, in Leitner's sound installations the visitor is elevated into a state of solitary meditation.[49] This focused listening and meditation are one of Blesser's fundamental theories for experiencing a sound-scape as an aural architecture.

When you listen carefully with your eyes closed, when you attend to the feel of a specific acoustic space, be it a concert hall, cathedral, restaurant, kitchen, or forest, you engage in attentive listening -intensely focusing on the sounds of life in the immediate environment. It is this combination of sound and attentive listening that creates a sonic illumination in Le Cylindre Sonore and gives the ability to visualise spatial geometry aurally. [50]

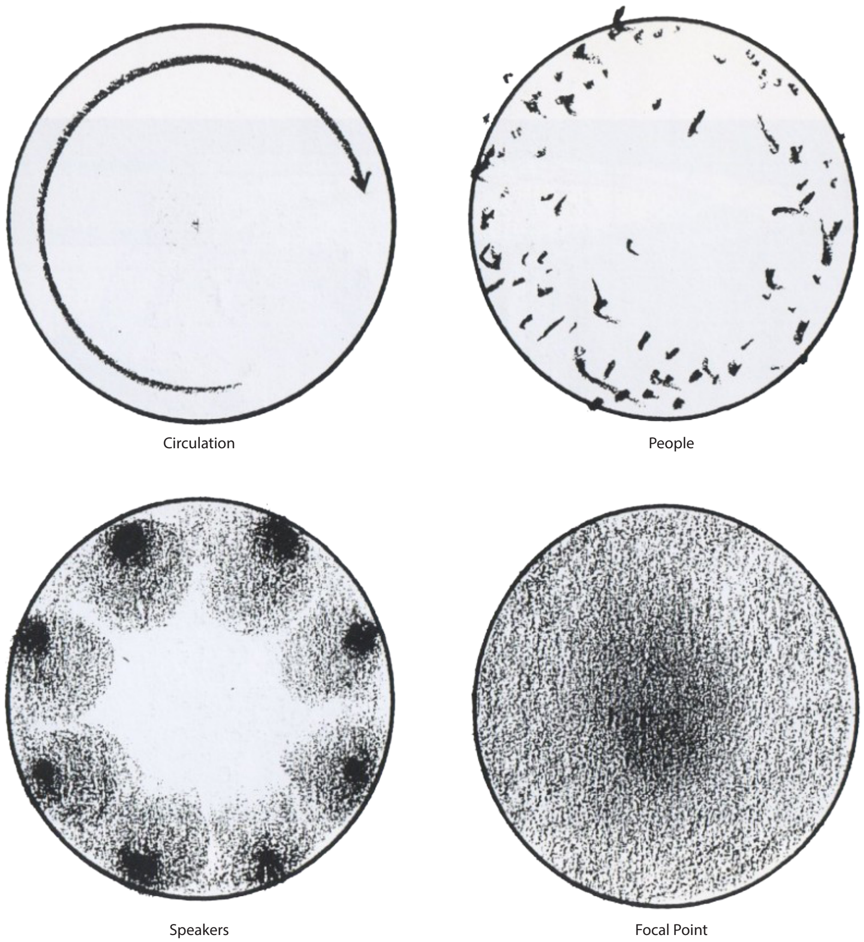


Figure 20 - *Graphic showing the gradation of the sound, people, location of the speakers and the focal point created from the circular shape.*

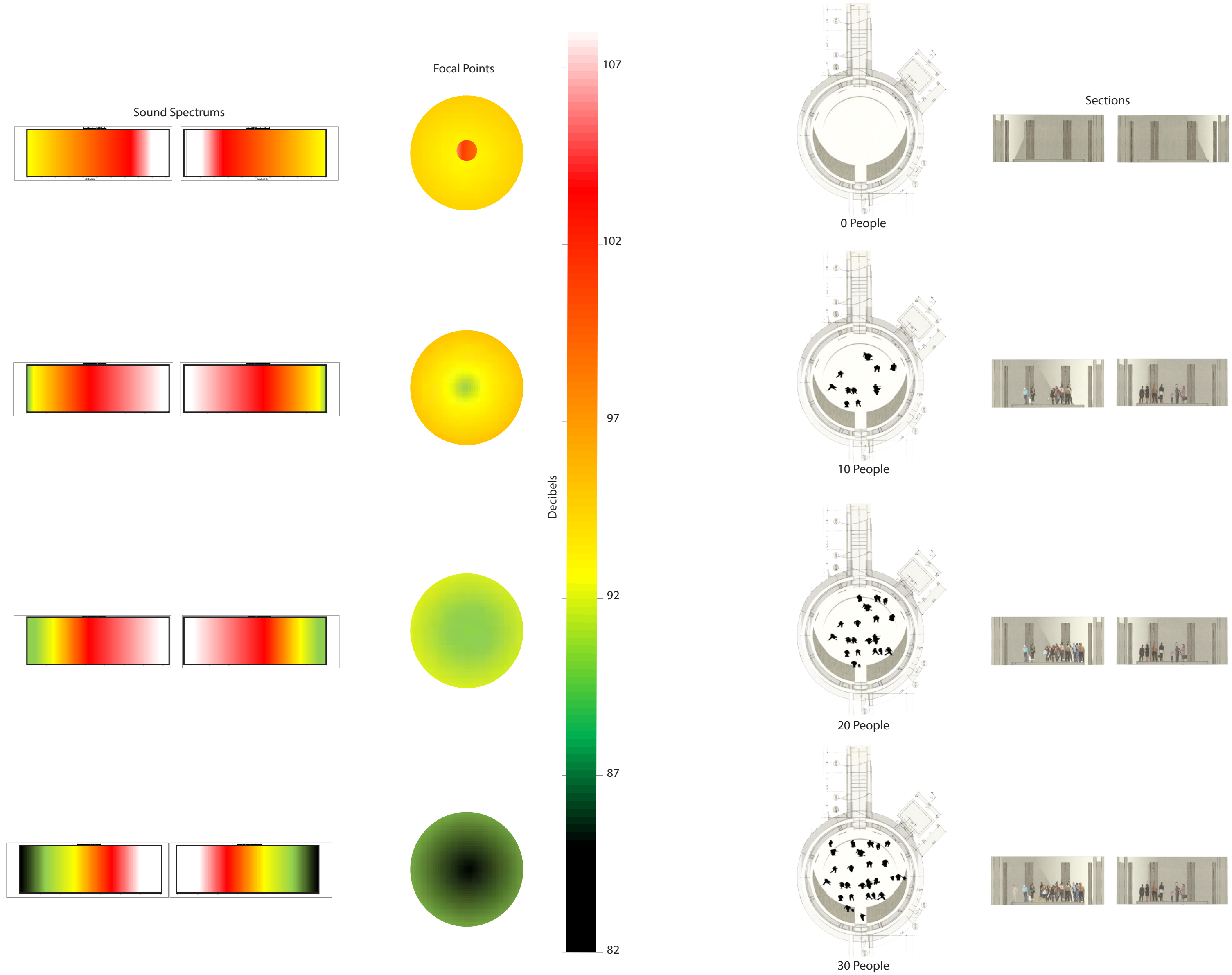
48 Bernhard, Leitner. - P.U.L.S.E., 12.

49 Ibid.

50 Bernhard, Leitner. - P.U.L.S.E., 15.

The analysis of this project involved using a computational acoustic program to see how the people inside the cylinder affected the sound waves being emitted by the speakers. Four different situations were created: one, with the cylinder empty, another, with ten people in it, a third with twenty people in it, and a fourth with thirty people in it. What was found is that the cylinder itself acts as a concave sound wave deflector and creates a focal point of sound in the centre of the cylinder. The more people that are in the cylinder at once, the weaker the concentrated focal point. These findings thus provides a sonic reinforcement for Leitner's installation's focus on the single visitor and not the group.

Figure 21 - *Graphic showing the results of the analysis done with acoustic software. The cylinder was modelled and tested with different decibel levels and different number of people in acoustic simulation software to explore the size and intensity of the focal point and the effect people have on the sound waves. (right)*


Sound Spectrums
Focal Points
Decibels
107
102
97
92
87
82
Sections
0 People
10 People
20 People
30 People

2.5 Orpheus

As Kim Wilkie's website describes, "Orpheus at Boughton Park is an early eighteenth century garden of land and water; avenues and vistas; rhythm and reflection."[51]

Kim Wilkie, a historian, farmer and world-renowned landscape architect was commissioned by the Duke of Buccleuch and Queensbury to undertake the task of renovating and restoring the gardens of Boughton House, a historical family estate where the Duke lived in Northamptonshire, United Kingdom. Kim Wilkie was chosen to create a new feature of the garden, which was completed in 2008-2009. The ancient Greek myth of Orpheus inspired Wilkie's design for the new garden. In Greek mythology, Orpheus was a musician and poet of superhuman ability. It was believed he was so great he could make the birds sing and the trees dance. The most famous story about Orpheus was his love for Eurydice, his wife, who was killed, prompting him to travel to the underworld to bring her back with his music. He charmed the underworld with his musical ability and was able to bring his wife back.[52] It is this myth that is trans-coded into Wilkie's land-

51 Kim, Wilkie. Orpheus. http://www.kimwilkie.com/uk/orpheus-at-boughton

52 https//:wwworpheus-med.org/legend. Retrieved 09/14/2017.

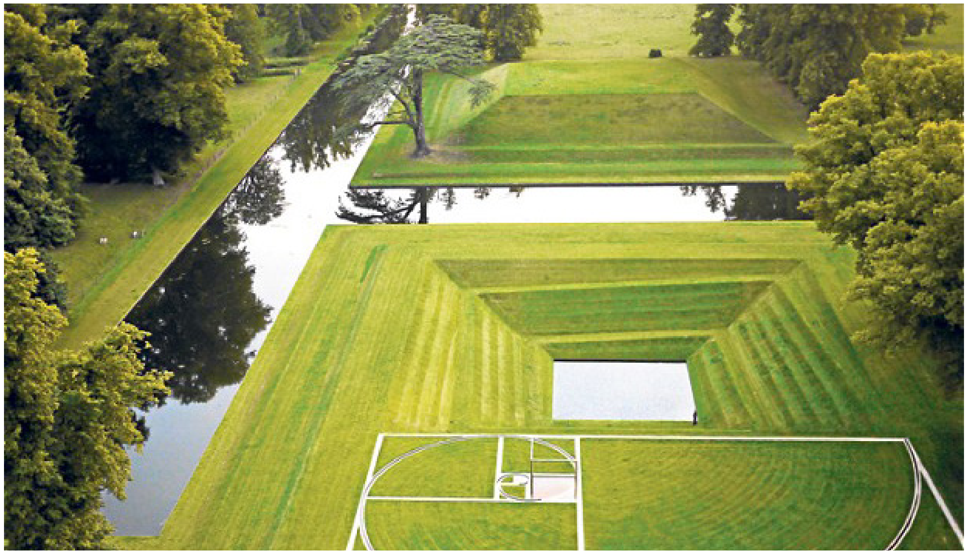


Figure 22 - *Photograph of Orpheus.*

Figure 23 - *Photograph of Orpheus.*

scape. The inverted grass pyramid descends seven meters below the level of the restored garden. The inverted pyramid is lined with a ramp that follows the perimeter of the landform. As one descends the ramp around the perimeter of the pyramid, one is met by a reflecting pool of water at the bottom. The water is meant to reflect the sky, acting like an oculus. This inverted pyramid paired with the reflecting pool represents Orpheus's descent to the underworld. It is also a re-enactment of a scene from the 1950 movie titled *Orpheus*, directed by legendary twentieth-century director Jean Cocteau, in which Orpheus steps into the Underworld by dissolving a mirror with his fingertips.[53] The inverted pyramidal landscape and ramp on the outer edges is the physical representation of walking underground to the 'underworld', and the reflective quality of the water resembles the reflectivity of a mirror. Also found in Wilkie's composition is a large landscape of the Fibonacci series, a series of numbers where each number is the sum of the two preceding numbers. When a continuous spiral is drawn through each proportional square of the Fibonacci series, a shape is produced that is commonly seen in nature, and a proportional system found in art and humans. This part of Wilkie's landscape evokes the ability of Orpheus to come back from the underground through his

53 http://www.dirt.asla.org/2009/10/19/kim-wilkies-orpheus-excavation/. Retrieved 09/14/2017.

powerful musical ability.

2.6 Cells of Life - Jupiter Artland

Molecular biology and astrology may seem unlikely to be considered relevant to architecture, let alone landscape architecture. However, Charles Jencks, a cultural theorist, landscape architect and architectural historian, made a career out of trans-coding molecular biology and astrology into landform art and what he refers to as swoops and mounds. Jencks is no stranger to molecular biology as he is also co-founder of Maggie's Cancer Care Centre, which is made up of centres designed by famous architects such as Frank Ghery, Thomas Heatherwick, Steven Holl and Richard Rogers, among others. These centres are at major hospitals throughout the United Kingdom and take a new approach to cancer treatment. Jencks refers to these centres as 'architecture for hope', and they are designed as a new mixed building type for healing based in different roots than healing centres of the past. Jencks refers to this hybrid quality is a response to the condition of cancer—its myriad causes and bewildering number of

Figure 24 - *Photograph of Cells of Life.*

possible therapies. The ultimate goal of these centres is to help cancer sufferers help themselves. It is the art integrated into the centres and the buildings themselves that make up the 'architecture of hope'. As someone walks into a centre, they are meant to feel like they are entering another world that encourages them to live with cancer and not lose hope.[54]

Figure 25 - *Photograph of Cells of Life.*

This same trans-coding method that blends Jencks's interests in biology, cancer, cells, life and astrology is also brought to his landscapes. In Jencks's *Cells of Life*, eight landforms and a connecting causeway surround four lakes. The theme of the project is the life of the cell, cells as the basic units of life, and mitosis, or the way one cell divides into two. Curving concrete seats have cell models surrounded by liesegang rings in rocks. Their red iron concentric circles bear an uncanny relationship to the many organelles inside the units of life. From above, the layout presents their early division into membranes and nuclei, a landform celebration of the cell as the basis of life.[55]

54 Jencks Charles, The Architecture of HopeMaggie's Cancer Caring Centre's (Frances Lincoln, 2010), 230.

55 https://www.jupiterartland.org/artwork/cells-of-life. Retrieved 05/15/2016.

2.7 Sound - Aeolus

An acoustic wind pavilion by Luke Jerram installed at London's Canary Wharf, this structure uses the power of the wind based on the principles of the aeolian harp. The wind passes over the tubes and sends the resonant frequencies created by the vibration from the wind passing over the tubes. The arch shape of the pavilion concentrates the sound to the centre of the interior surface where someone would stand to experience the different frequencies.

Not only does the wind travel over the outer edge of the tubes but also over specifically placed cables. The tubes then amplify the vibrating cables — the tubes act as an amplification and also as a viewing portal. The tubes combined with the curved shape concentrate the sonic energy on the person in the pavilion.

As mentioned above, this pavilion is mobile, which means it is set up in different locations around the world in different environments. It is

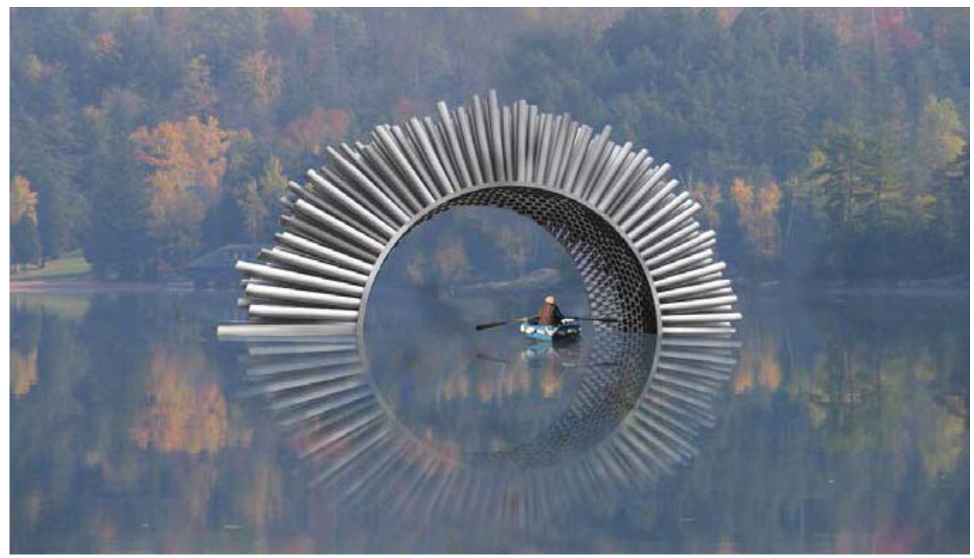


Figure 26 - *Photograph of Sound Aeolus in the city. (upper)*
Photograph of Sound Aeolus in the water. (lower)

set up in the city, in the middle of the water, or on a beach. This makes the sonic wind pavilion a powerful piece as the location changes just as the wind changes. These different locations have different wind conditions and therefore different sonic experiences. This simple art installation engages the general public to slow down and listen to an aural experience.

Site
Part 3

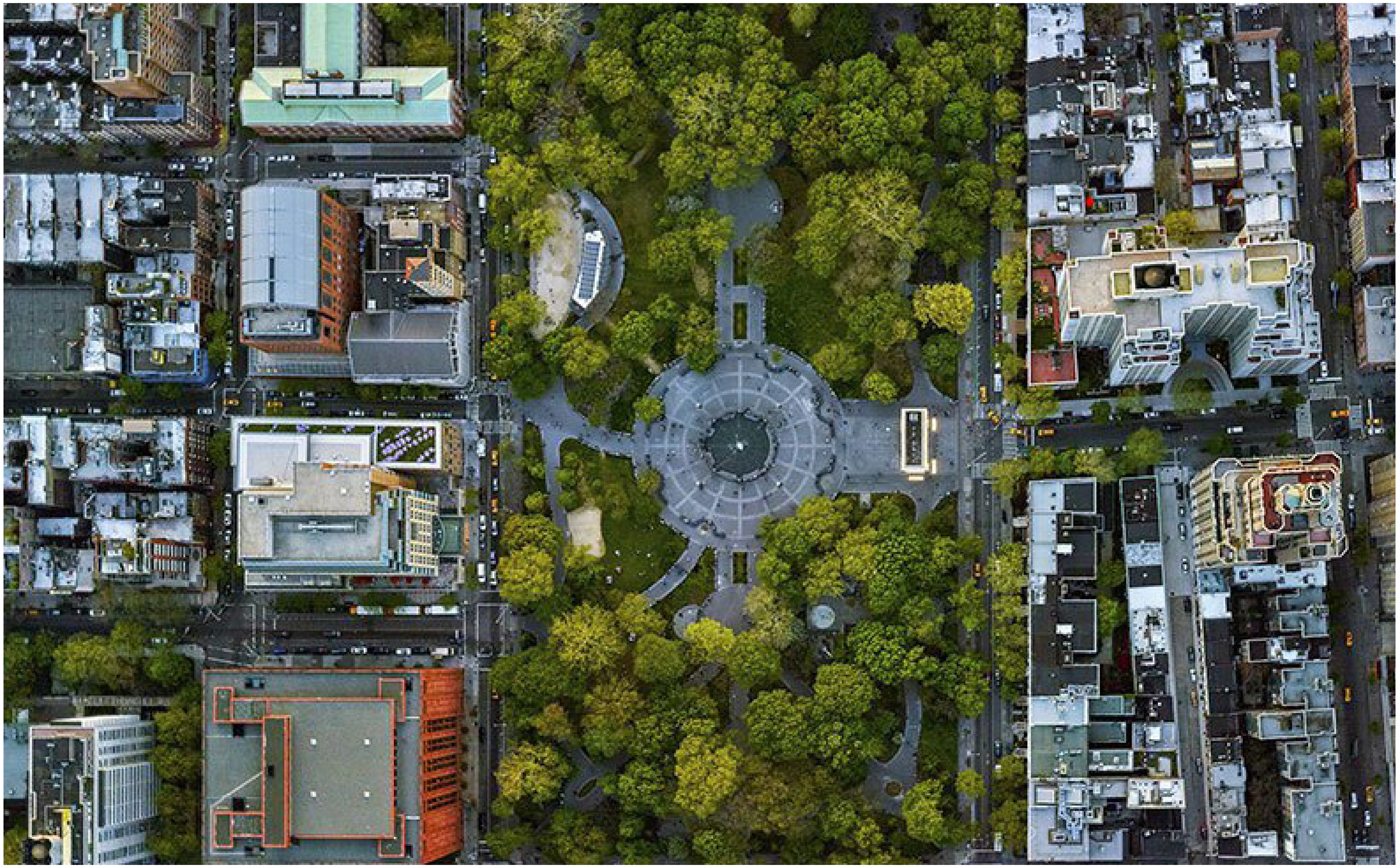


Figure 27 - *Aerial Photograph of Washington Square Park post 2014 renovation, by Jeffrey Milstein.*

3.1 Introduction

Manhattan, New York is, famously, one of the noisiest cities in the world. Its rate of noise complaints is also, as a result, among the highest in the world. In fact, complaints about noise in New York city are ranked as one of the most significant quality of life issues within the city.[56] This cultural stigma that associates noise with disturbance causes this negative perception of the city's noise level. However, is it not the very nature of this instrumentation of complex sounds in the urban environment that makes us hear? Manhattan's complex urban sound environment led to its selection as a city to explore within this project.

Exploring all of Manhattan's ever changing urban sound environment would be impossible and require a large team of researchers from many diverse backgrounds and several years of examination and reflection in order to add to the overall knowledge of the city's complex urban sound milieu. However, for the purpose of this level of research it is possible to find a unique part of the urban sound environment within Manhattan to further explore. One of its most iconic features, Man-

56 http://nautil.us/issue/38/noise/noise-is-a-drug-and-new-york-is-full-of-addicts. Retrieved 09/15/2016.

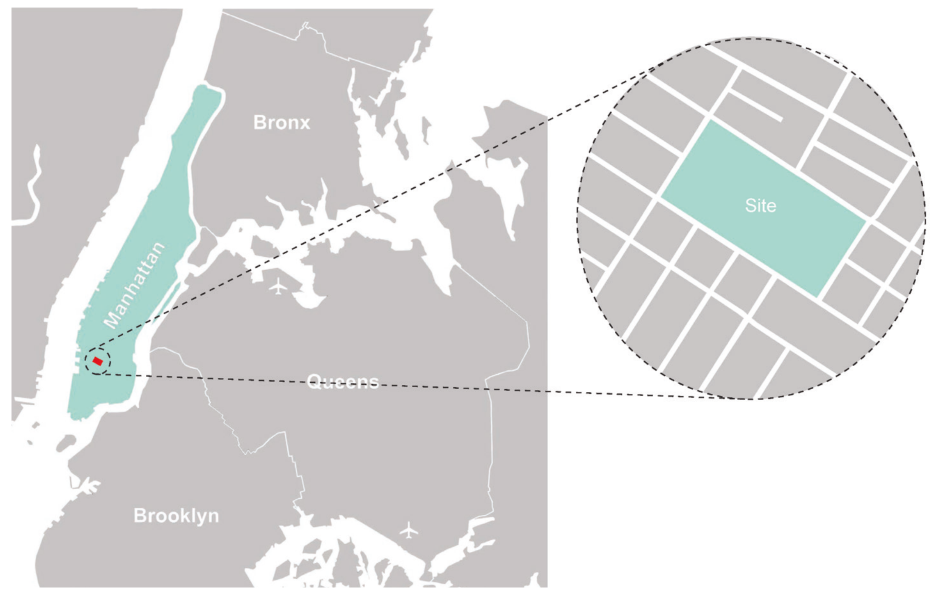


Figure 28 - *Location map of Washington Square Park.*

hattan's Central Park, is one of the most widely-known and celebrated urban green spaces in the world. Placed in the centre of the city, the green space is the heart of Manhattan and a significant element of Manhattan's unique urban character. The sheer size and scale of the park causes it to have transformative interactions with and impacts on the city's urban sound atmosphere. However, although a hi-fi soundscape such as Central Park may seem like the most obvious choice as a site for studying the instrumentation within the city, the park is not the site selected for this project. Instead, the many green spaces in New York prompted the question, what other green space might be studied to offer new insights into the instrumentation of the urban sound environment without the challenges posed by the size and scale of Central Park? The answer: Washington Square Park.

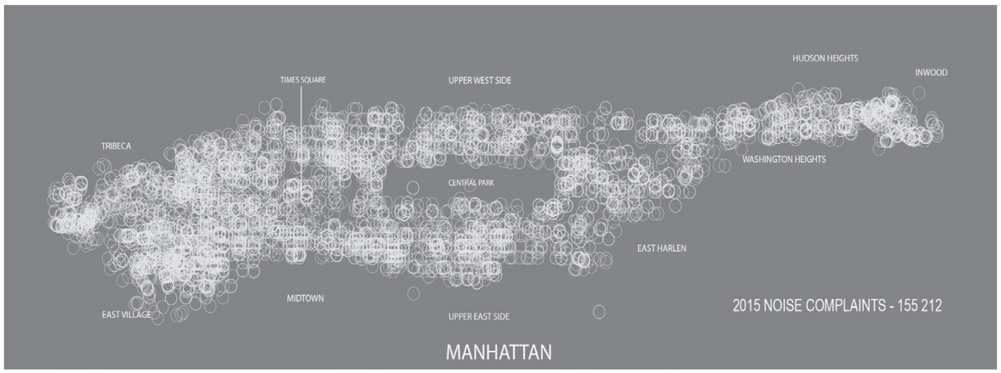


Figure 29 - *311 data of 2015 Noise complaints mapped onto Manhattan.*

This park, which is about ten acres in size, was chosen as a site for exploring and composing the instrumentation of the urban sound environment because of factors including its historical significance, smaller scale, placement among small and large building forms, existing program, cultural diversity, and acoustic richness. Washington Square Park is also of New York's most densely used green spaces.

These factors inspire the analysis of the performance of the park, the way sounds are played and conducted. The high exposure, diversity of people and urban setting of Washington Square Park provides a rich opportunity to study the urban sound milieu from a sociological, psychological, urban and architectural point of view. The site has attracted people from around the world for many years, in part because of its long and colourful history.

3.2 History

Centuries before Washington Square Park became a park, it was a marshy ground marked by features including water flow and a trout stream.[57] Some land was traded in 1642 to African-born enslaved persons for farming their crops.[58] After the Revolutionary War, the site was used as a potter's field, a public burial place where poor and indigent people, mostly victims of yellow fever, were laid to rest.[59] After 20 years the field was full and on July 4th, 1829, the cemetery was declared the Washington Parade Ground. Within a few years of being a parade ground, a prime residential neighbourhood formed around the grounds. Three sides were surrounded by elegant houses and

57 https://washingtonsquareparkconservancy.org/history/. Retrieved 08/18/2016.

58 https://washingtonsquareparkconservancy.org/history/. Retrieved 08/18/2016.

59 https://washingtonsquareparkconservancy.org/history/. Retrieved 08/18/2016.

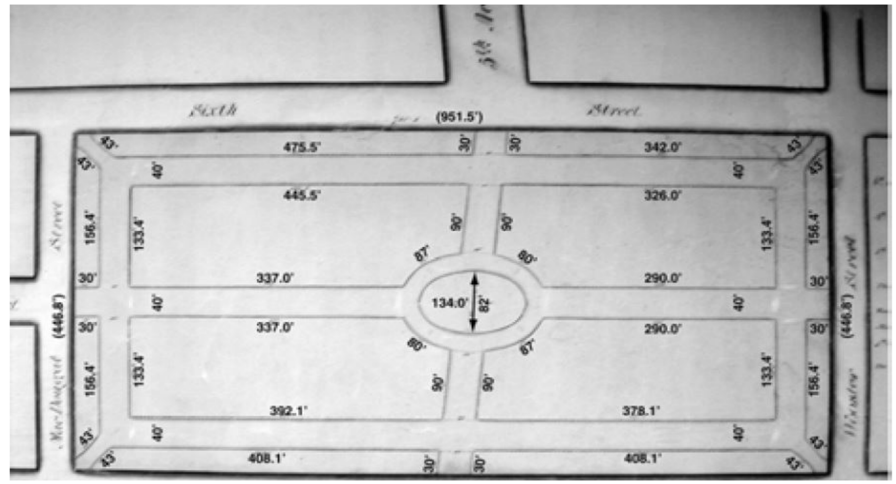


Figure 30 - *Photograph of Washington MIlitary Parade Ground Survey 1829.*

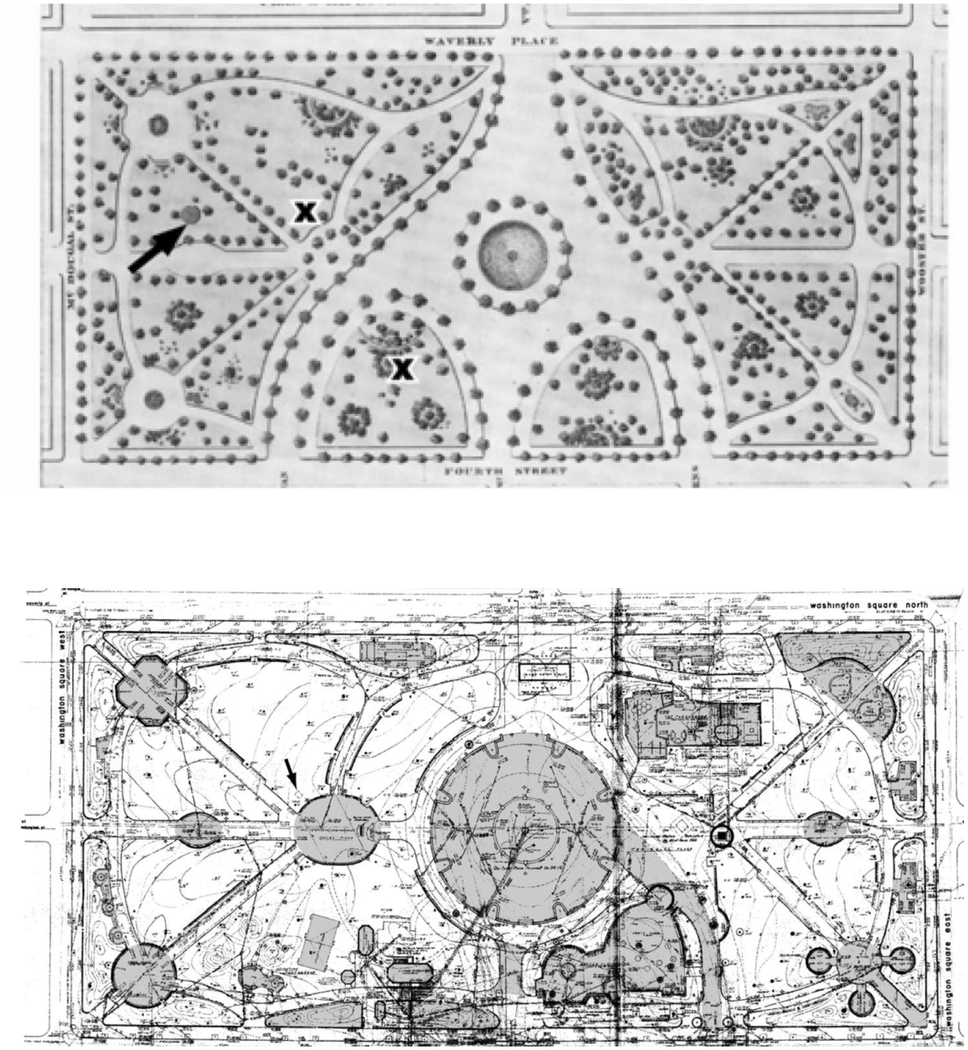


Figure 31 - *1879 plan of improvements to Washington Square Park. (upper)*
1934 park plan with 1970 park plan overlay.(lower)

another by New York University's first building, a large, Gothic revival structure. The parade ground became known as Washington Square, and was known for its associations with patriotism and polite society. However, this harmony would be disrupted as the square also attracted protesters for demonstrations from its early days. For instance, during the construction of New York University's buildings, protesters congregated in the Square to protest the use of prison labour in this construction. And in 1863, when the Civil War draft took place, Washington Square Park became the site for protests against the war.

In 1870, the Square was taken over by the New York's parks department. Tammany "Boss" William M. Tweed organized the city's first public parks and transformed the parade ground into a stylish, landscaped park. The redesign was led by Igray Pilate and Montgomery Kellogg, both of whom worked closely with Frederick Law Olmstead on Central Park. In their hands, the park was transformed from a straight-line military design to an elegant design featuring curving pathways outlined by plantings, interrupted by small gathering places. A fountain was brought in from 59th street at Central Park. In 1889, the Washington Square arch was built. It was designed by Stanford

White to commemorate George Washington's inauguration at federal Hall on Wall Street. The arch was built to ensure the parade would always pass through the park. During the activism of the twentieth century, artists, writers and radicals began to move into the neighbourhood, and as they did, the park's function as a site for protest was bolstered, with protests concerning issues such as labour, pacifism and women's rights among the many that took place there. Just as the Square began to transition back from its status as a site for protest, Robert Moses proposed to put a road in connecting Fifth Avenue through the park to the other side. Again, protests against this proposal took place. The protesters were successful, and the design of Washington Square did not change at that point, although later the park would eventually have a road going directly through the centre of the square that would interrupt the Square and the fountain. With the roads closed, the central plaza around the fountain would begin to flourish as performance space. The space attracted many major performers, such as Bob Dylan. To this day, Washington Square Park is known for its live performers, from musicians to actors to buskers. In 1970, the sunken plaza around the fountain would open up, three small mounds were built, curved seating areas were added, a wood-

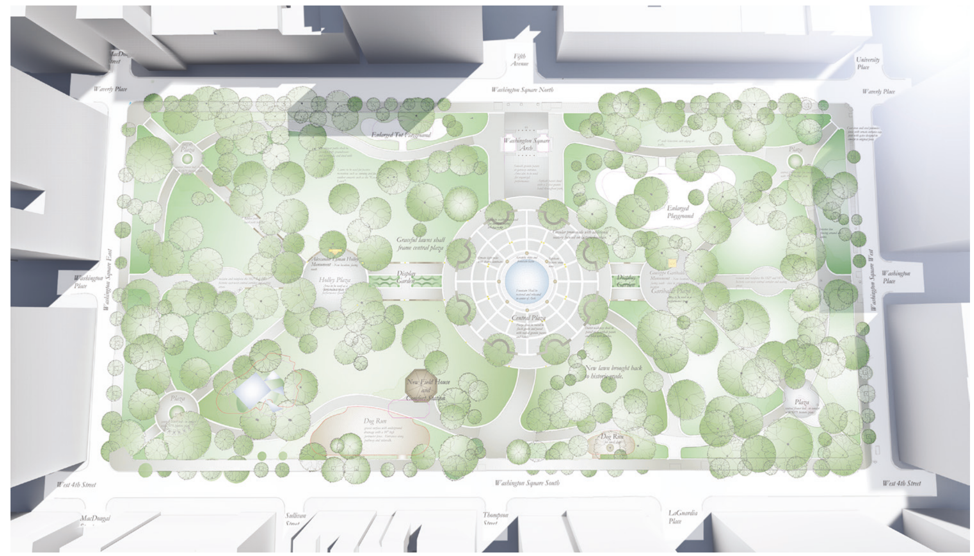


Figure 32 - *Map of current Washington Square Park.*

en adventure playground was installed, and a stage and bocce court were constructed. It was not until 2002 that the Square's arch was restored to its original glory. On April 30th, 2004 the arch was rededicated for the 215th anniversary of George Washington's inauguration. The most recent renovation was completed on June 10th, 2014. The renovation included new and expanded lawns, planting beds, conservation of the Alexander Holley monument, repaired paths, new benches and lighting, enhanced playgrounds, stage, and bocce court, a new chess plaza and dog run, along with a new house and comfort station. The most controversial aspect of the renovation was the moving of the fountain. The fountain was originally designed to be offset from the arch. This provided a sweeping connection from Fifth Avenue to Thompson Street, creating a plaza and a visual delight at the end of Fifth Avenue once you passed through the arch.

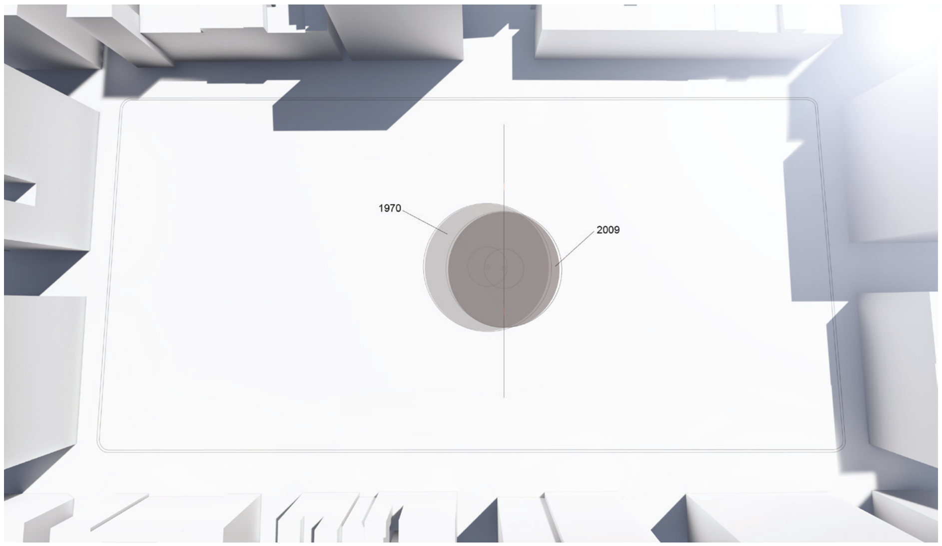


Figure 33 - *Graphic of the fountain re-location 1970 vs. 2009.*

Complex design decisions, such as those involved in the renovation of Washington Square Park, must be looked at not only from a visual perspective but as if the urban environment were a composition of aural instruments. Using research into the sonic effect to study the site promises to shed light on compositional features that could potentially enhance the sound environment. A study of the park's aural components from psychological, sociological, physical acoustics, and musical aesthetics perspectives of the existing park may help to inform residents and designers in making design decisions. Such a study of the park—such as that to be offered below, through a multidisciplinary lens using the paradigmatic concept of the sonic effect—would not only be useful to a design or renovation of the park itself, but it would also have a broader significance by advancing the scholarly and architectural dialogue about listening to the everyday urban sound environment as a means of informing design.

3.3 Existing Site Analysis

A study of the existing site, as it is, using soundscape analysis techniques, is first necessary in order to develop an understanding of the park's sound milieu of social-cultural community. The exploration of the existing site is important to highlight some of the existing programs and context surrounding the site and within the community that could have implications for its aural interaction with and impact on the city around it; such an analysis would benefit and contribute to

Figure 34 - *Graphic of the existing context.*

the sonic experience of Washington Square Park by presenting its current features as an aural environment, how these features are created, and how they may be protected or enhanced. These existing features are its scale, context, culture and program.

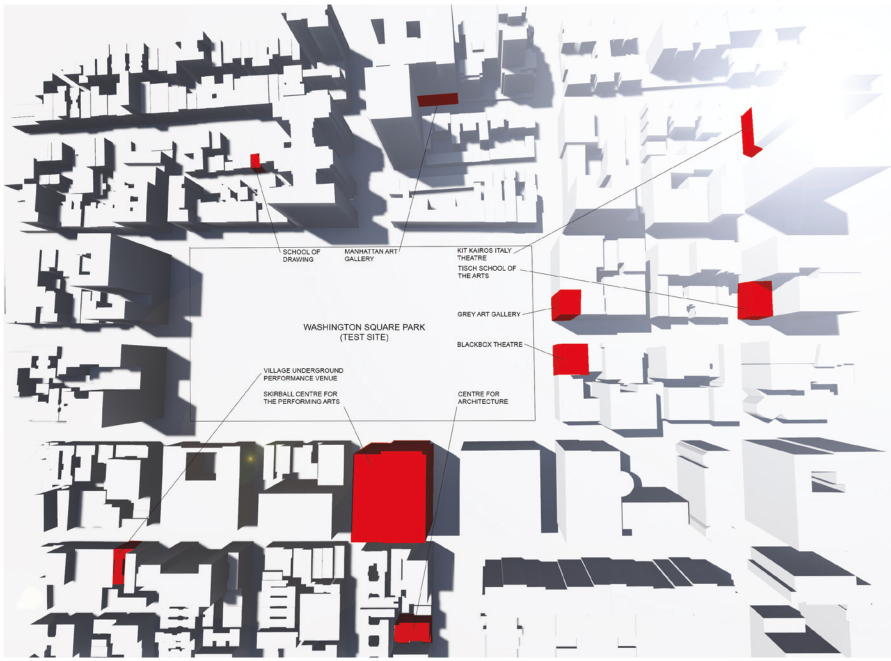


Figure 35 - *Graphic of the existing context.*

The park is surrounded primarily by residential buildings that typically stand four to five storeys in height. Mixed in among these stands a variety of much taller buildings ranging from fifteen to twenty-plus storeys. The most prominent large building to the south of the park is New York University. The surrounding local context for the park is consistently characterized by buildings on a larger scale, creating a dense urban typology neighboring the park. The park itself measures one hundred and fifty feet by three hundred feet. The park has some large open areas and some smaller areas with dense vegetation. Throughout, the park contains a consistent array of large trees. The surrounding buildings and park are separated from each other on all sides by a road with medium to heavy traffic.

Today, the surrounding dominant contextual element encompassing the site is New York University. New York University surrounds the park on its Southern and Eastern sides. The North Western side of the park is mostly residential. The other adjacent area predominantly comprised by residential buildings is to the northeast, on both Fifth Ave and University Place. The rest of this surrounding context is mixed-use. Mixed-use is found throughout New York and is the dominant building program for not only the surrounding area of the site but throughout Greenwich Village and Manhattan.

One of the most impactful programs and contexts related to culture in the area is New York University's Skirball Center for the Performing Arts. This large and prominent building is directly across from the park on Washington Street North. This close proximity creates a strong connection between the centre and the park and encourages students to bring their performances and music into Washington Square. Just north, one block away from the performing arts centre, stands New York University's Center for Architecture which promotes the understanding of architecture through design and educational programs for students in kindergarten to grade twelve, families and the general public. The Center for Architecture uses a visually dominant curriculum which often excludes any aural aspects of architecture. They focus on things such as building performance in terms of thermal bridging but do not take sound transmission into account. Another example would be exploring geometry from a visual perspective through models as opposed to sound exercises such as listening to the urban environment. The study of the park could potentially have an impact on the centre's students, families and general public as the goal of the study is to shed light on and engage people in urban sound which is most often under examined in schools. The study of the park would providing students with an opportunity to engage with a consideration of sound and architecture at an experiential, real-world level. To the east of the park, directly across the street, is the Blackbox Theatre, Grey Art Gallery, Tisch School of the Arts, and Kit Kairos Italy Theatre. Washington Square provides ample space for sound installations, performances, and gallery space to enhance people's engagement with sound. A short walk up Fifth Ave and to the east is the Manhattan Art Gallery and to the west is the School of Drawing. Finally, to the southwest of the park is the Village Underground Performance Venue where many independent and talented artists perform on a nightly basis. The area has no shortage of people who study and engage in sound and or art in their daily lives. This culture of music and sound has a direct impact on the existing program of Washington Square.

Washington Square Park has some existing programs within the park as part of its current design. Some of the key areas supporting programs are the arch, the kids' playground, the fountain and large plaza, stage, penetague courts, dog runs, the mound play area and the dedicated chess areas.

At the northeast edge of the park is the arch. The arch acts as a natural gathering spot, where musicians assemble underneath the arch to project their sound. The form of the arch when standing directly under it concentrates the sound waves towards the centre, attracting people to gather around and listen to the musician. Moving toward the southwest, there is a playground for kids nestled amongst the trees. At the centre of the park is a large circular plaza with a fountain in the centre. This area attracts many performers and spectators. The new renovation called for making the fountain smaller and moving the fountain to centre it with the arch. The white noise created by the fountain creates an ambient backdrop where people tend to gather to have conversations amongst one another. Continuing east, not far from the fountain is a concrete stage where acoustic performers often set up for performances. The stage is raised and nestled amongst the trees, creating an intimate atmosphere between the performer and spectator. On the south edge of the park are a large and small dog run. Continuing back up to the northwest there is an existing curved building. The building is predominantly used by the public for its washroom facilities. Just to the west of the facilities building is a landscaped mound that acts as a second play place for kids. The western-most edge of the park contains two areas for chess games. These areas have become well known over the years for their intense chess battles and are a gathering spot for spectators. It is worth mentioning that this area is further distinguished by the fact that the largest and oldest known elm tree in North America stands by the northernmost chess plaza is, another feature that draws in and engages visitors to the area.

3.4 Sonic Effect Analysis

Architecture and Urbanism

With an overall understanding of the existing scale, context, culture and program of the existing park now summarized, next, the park will be studied from the point of view of the sonic effect. Using the nine major sonic effects from the book titled, *Sonic Experience*, the cut-out, the drone, the filtration, the imitation, the mask, the metamorphosis, the niche, the resonance and the wave will be explored from the categories of architecture and urbanism. Through this study it is hoped that some of the existing instruments of the urban sound environment of Washington Square park are revealed to further examine its compositional arrangement.

The Cut-Out

All constructed spaces create an interruption in the sound environment. The urban environment in particular is a place where this effect readily occurs due to the diversity of sounds, built forms, surfaces

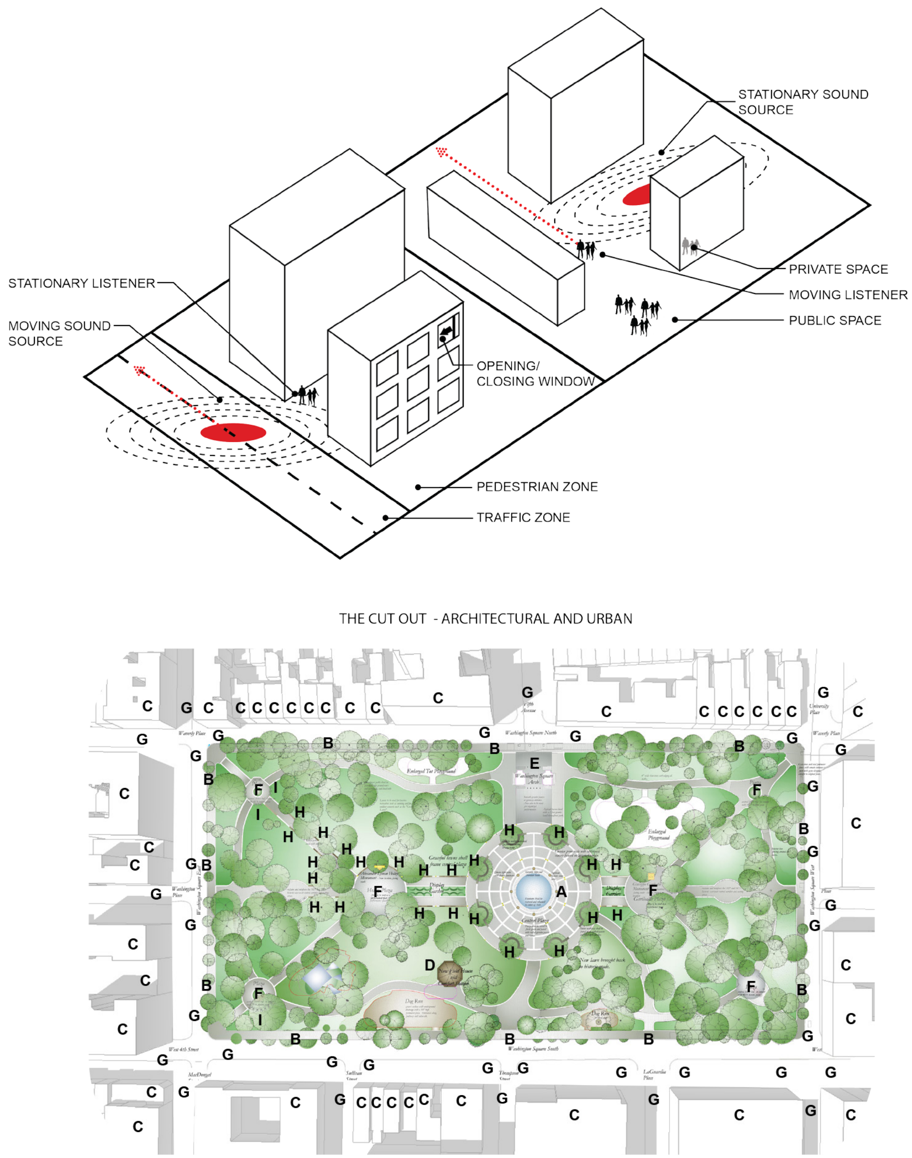


Figure 36 - *Vignette of the cut-out sonic effect.(upper)*
Graphic showing potential locations of the effect. (lower)

and the movement of people. The effect is plentiful and it is nearly impossible to identify or predict each and every occurrence. The cut out effect is commonly experienced when either the listener or sound source is moving within the built environment. Washington Square Park and the surrounding urban environment create many opportunities for this effect to occur and to be experienced. Some of these opportunities are pedestrians walking past the existing fountain found at the centre of the main plaza or a pedestrian hearing a vehicle drive by. In the case of the fountain, the sound source is stationary and the pedestrian is the moving listener. As the pedestrian walks through the plaza and gets further away from the fountain the sound of the fountain fades and the pedestrian experiences what is known as the cut out effect. The opposite, also a common occurrence in Washington Square Park is when the listener is stationary and the sound source is moving. A ready example of this in Washington Square park is when a pedestrian is standing on the outer limits of the park on the sidewalk and is listening to vehicular traffic drive by. As the car approaches from afar and as it drives by the stationary pedestrian, into the distance, the pedestrian experiences another cut out effect. As the map shows, the park is surrounded by streets with vehicular traffic. The road surrounding the park creates great potential for existing opportunities of the effect due to stationary listeners and moving sound sources encompassing the perimeter of the park.

The Drone

The urban sound environment often does not contain natural elements such as vegetation and gardens. However, Manhattan has many green spaces and Washington Square Park is no exception. Although the drone effect usually involves some kind of acoustical amplification such as speakers that amplify the natural sounds of wind rushing through the leaves of the trees, Washington Square Park has some of the oldest and densest canopied trees where this effect has the potential to occur naturally. As the wind blows through the tree canopies the leaves create a natural drone and due to the large number of trees in the park the drone effect can be experienced by visitors. Another potential area where visitors can experience the drone effect within the park is at the washroom building. The continual running of modern day HVAC systems create a drone effect within the park. This

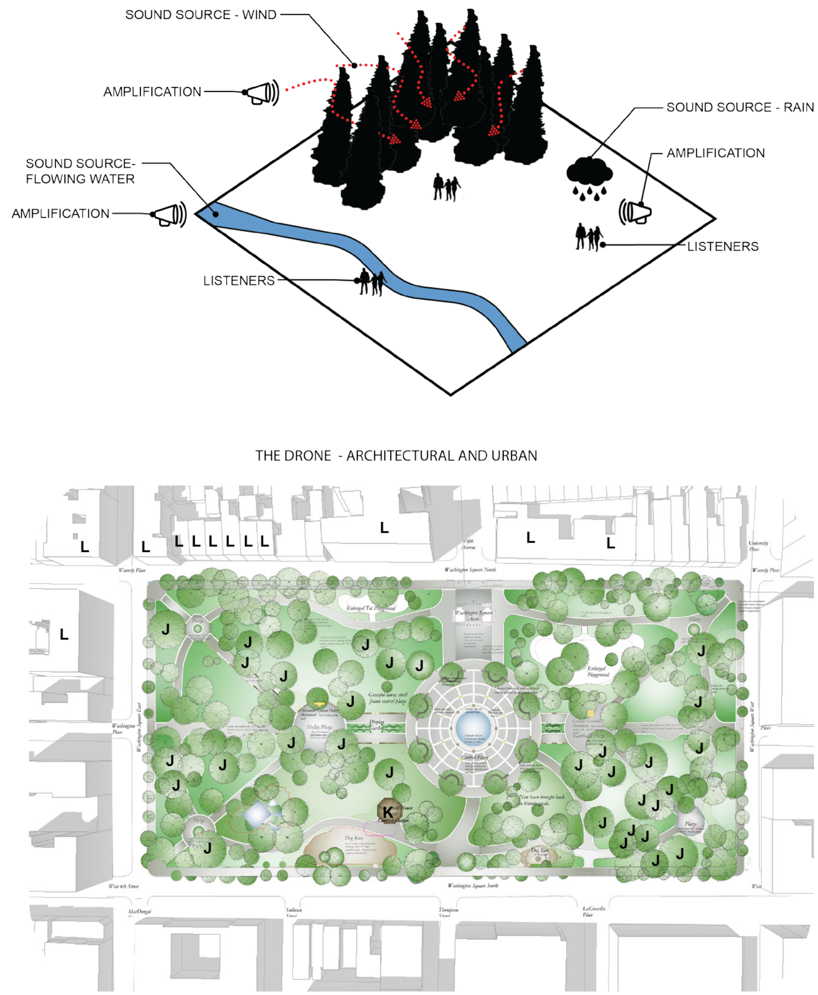
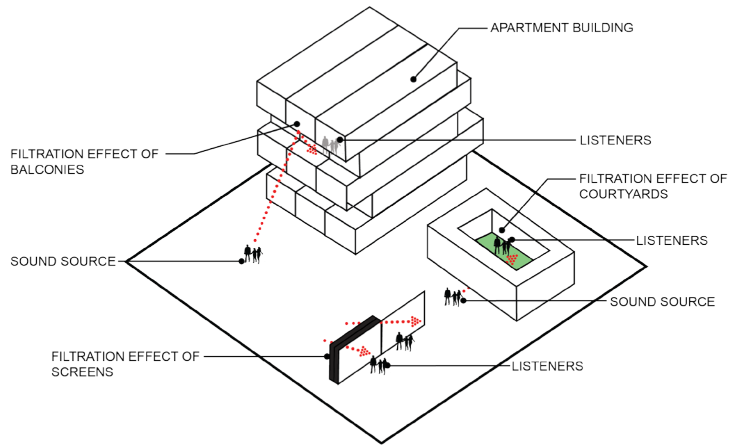


Figure 37 - *Vignette of the drone sonic effect.(upper)*
Graphic showing potential locations of the effect. (lower)



THE FILTRATION - ARCHITECTURAL AND URBAN

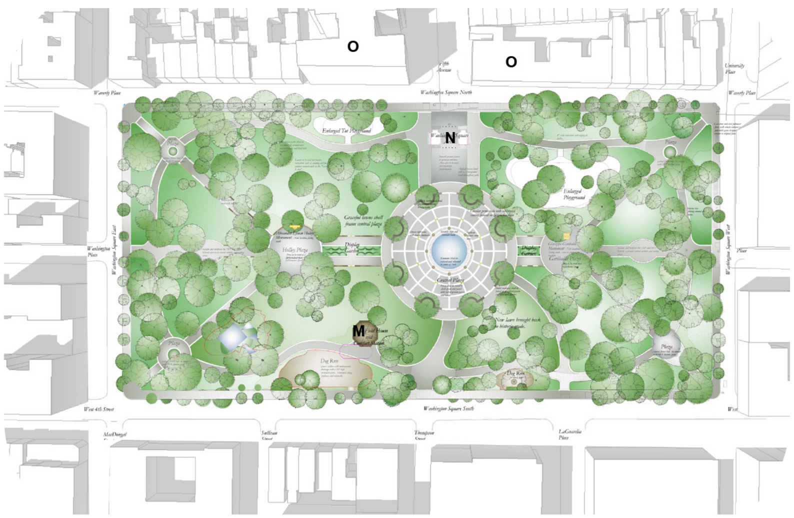


Figure 38 - *Vignette of the filtration sonic effect.(upper)*
Graphic showing potential locations of the effect. (lower)

same drone effect can be experienced on the outer edges of the park as Manhattan has many window air conditioner units running in the summertime that create their own drone effect over certain areas of Greenwhich Village. As the map shows there are many mature trees densely placed within the park and the residential high rise buildings that surround the park have great potential for window mounted air conditioner units running continually in the summertime, making the drone effect a common experience in the area.

The Filtration

In the urban sound environment the filtration effect is linked directly with the architecture of the physical objects' arrangements throughout the sound environment. Courtyards of older houses were a common example of this filtration of exterior sounds. Although Washington Square Park does not have many existing physical objects to act as filters there are some obvious objects that would create this effect. One of these is the experience of walking from the exterior to the in-terior or vice versa. The only real interior exterior structure currently accessible to pedestrians in Washington Square Park is the washroom building. As one would walk from the exterior to the interior the doorway of the building and the walls act as natural filters to the urban sound environment. This same ‘doorway’ filter could possibly be experienced as one stands under the Washington Square Arch as it is built of thick concrete walls and limestone and is at a large enough scale to provide a filtration effect. The other prominent example on within the outer border of Washington Square Park would be the balconies on the apartment buildings off of Fifth Avenue. The balconies, furniture and plants that people commonly have on their outdoor patios act as a filter of the urban sound environment prior to the sound entering through windows and walls. The filtration effect can play a vital role in the management of urban sound.

The Imitation

The Imitation effect is produced in one or two ways. One is through the introduction of ‘natural’ sounds such as water, leaves and wind. This effect as referred to by Schafer as the hi-fi soundscape is commonly not experienced in a lo-fi soundscape such as Manhattan. However, Washington Square Park has some existing vegetation that has the

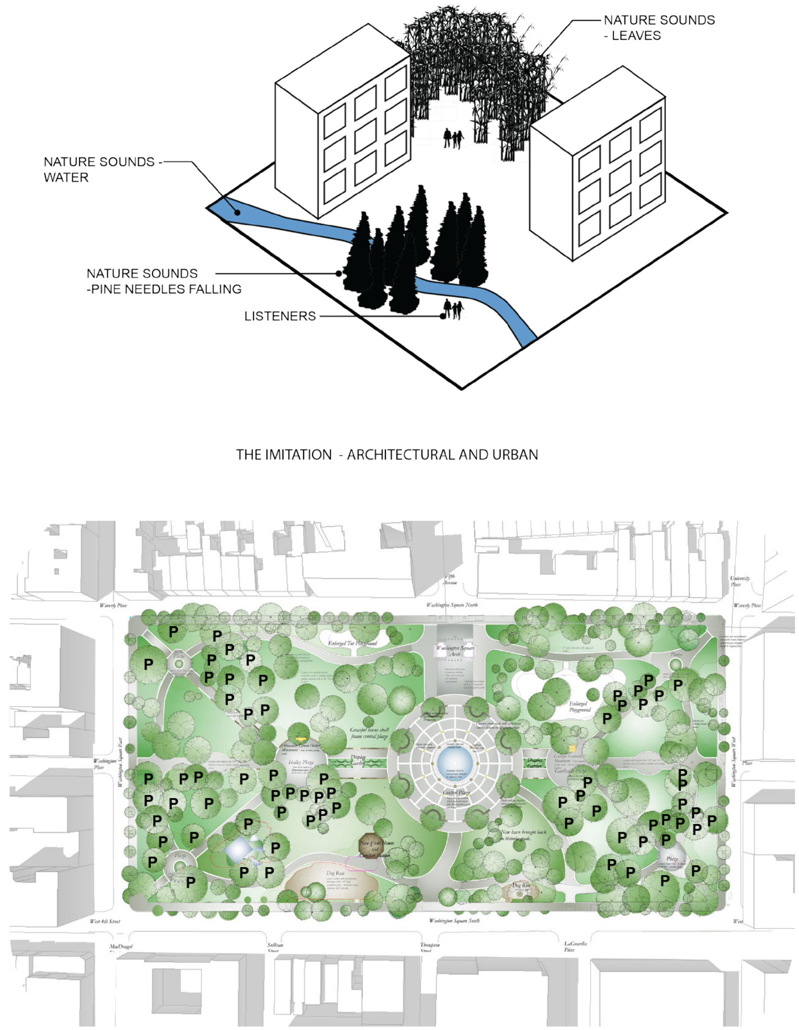


Figure 39 - *Vignette of the imitation sonic effect.(upper)*
Graphic showing potential locations of the effect. (lower)

Figure 40 - *Vignette of the mask sonic effect.(upper)*
Graphic showing potential locations of the effect. (lower)

potential to produce natural sounds. The smaller plaza areas where only one or two benches are placed among the dense vegetation are one of the greatest areas for this effect to be produced. Currently, the effect of the wind in the leaves can create this experience. Although the fountain is water it is rushing water and was not designed as a natural flow and therefore probably would not create the calming serene feeling the imitation effect produces. However, Washington Square Park's close proximity to streets and its scale might not allow for the effect's full potential and the vegetation in the end acts more as a filter than a full imitation. The second way the imitation effect can be produced in the urban sound environment is by creating an architectural construction that represents characteristics of a past era. This is not currently found in Washington Square Park and it is unlikely that the sound qualities of a past era can accurately be reproduced.

The Mask

In an urban sound environment there are two types of masks. There is the favourable and then there is the parasitic. In the analysis of Washington Square Park the most prominent mask is the fountain found at the centre of the plaza. This mask would lean toward the favourable type because it is in an open area and helps drown out the urban drone that is Manhattan. This creates an aural environment good for one on one conversations between people and is one of the reasons why people tend to gather around it. Even though the fountain has the ability to mask the urban drone, the urban drone itself is an important mask. This effect again depends on the context and each and every single individual's perception of sound.

The Metamorphosis

This effect takes place when a reverberant location is filled with a density of people who are producing multiple sound sources. This effect is found in the existing streets of Manhattan at rush hour on the sidewalks as a density of people are walking, producing the sound of hammering footsteps on the concrete. This effect can happen in Washington Square Park as dense numbers of people often walk the main entrance off of Fifth Avenue and the plaza. The park is also known for parades. A marching parade through Washington Square park would again create such an effect. Another common occurrence

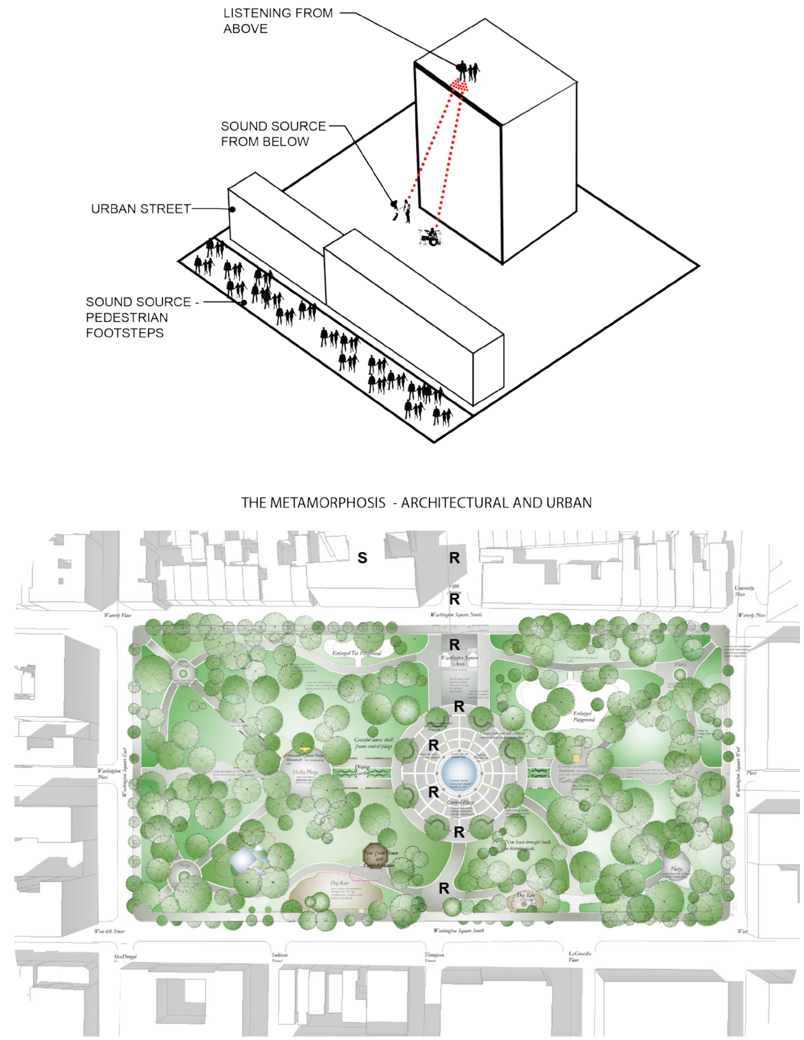


Figure 41 - *Vignette of the metamorphosis sonic effect.(upper)*
Graphic showing potential locations of the effect. (lower)

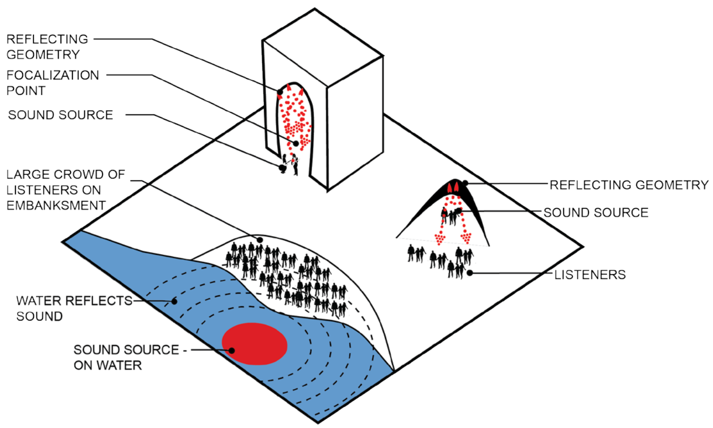


Figure 42 - *Vignette of the niche sonic effect.(upper)*

of the metamorphosis effect can be experienced by listening to the urban sound environment from above in a taller building. The residential buildings with balconies that surround the park provide an opportunity to experience the metamorphosis effect. The current park does have the Washington Square Arch which stands about thirty meters high. If the rooftop of the arch was still accessible to the public as it was in the past listening above to the city below would be possible in the park. Listening form above equalizes the sound sources frequencies making it difficult to isolate sound shapes and provides an excellent way to perceive a transformation in the sound ambiance of the urban sound environment.

The Niche

This effect relies heavily on geometry of built space and the location of the sound source to the listener. The combination of reflections created by the shapes and materials of the built environment create this effect. The existing Washington Square Park does not have much built form supporting the effect to occur. However, the Washington Square Arch can produce this effect and is often used by musicians.

This effect can occur by standing directly under the arch and speaking up toward the centre or keystone of the arch. The sound reflects off the curved surface of the arch and focuses the sound toward a common point under the arch. Often musicians stand under the arch to reflect their sound off the arch to a focal point to intensify the sound for listeners.

The Resonance

This effect is most commonly found in the urban sound environment on narrow streets lined with buildings. When a sound source is placed in between the buildings on the narrow street it produces what is known as a standing wave. This standing wave is often created between two parallel walls as multiple reflections take place off of the even surfaces and different facades. This resonance often creates an increase in sound impulse and the listener experiences murmurs. The existing Washington Square Park does have any parallel walls for this to occur, however some of the streets surrounding Washington

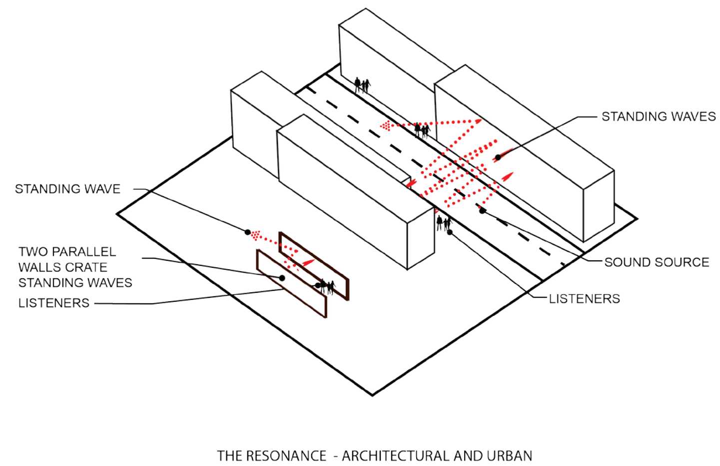


Figure 43 - *Vignette of the resonance sonic effect.*

Square are narrow and lined with buildings.

The Wave

This effect is produced by atmospheric elements that create a sound source that causes a cyclical wave. A common example would be the movement of the water in a lake or the sea. The waves produce a cyclical sound source. Although Washington Square Park is not close to a large body of water this same cyclical sound source affect can be produced by the wind or rain. Wind has the potential to carry sound and also be a source of sound. Wind follows the same sound cycle as a wave in the ocean. The wave effect often submerges the listener in an environment from which they cannot escape unless removed from the environment. An example would be a windy day in Washington Square Park. The listener cannot escape the effect except by going inside, removing oneself from the exterior.

With the study of the existing Washington Square park complete and the exploration of its instruments underway, the question raised next is what is the sonic instrumentation of Washington Square Park? The instrumentation is explored through a multidisciplinary lens through

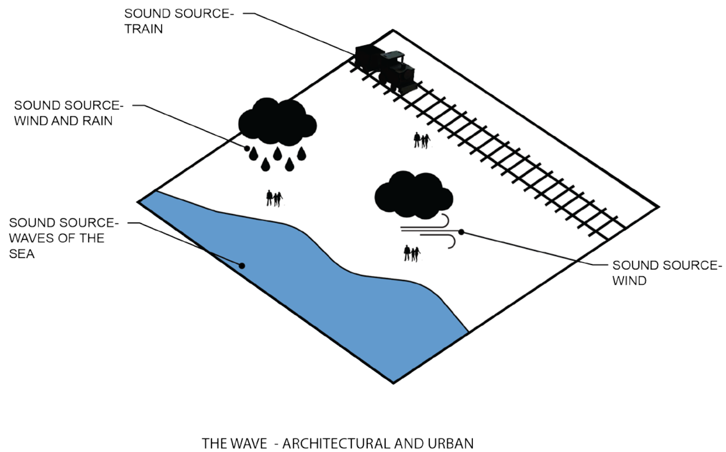


Figure 44 - *Vignette of the wave sonic effect.*

experimental research involving acoustical measurement, exploring tools for visually representing sound, applications for architectural and urban intervention and the general experience of listening to explore the psychology and physiology of perception, sociology and everyday culture.

Experiments

Part 4

4.1 Introduction

Exploring the existing Washington Square Park using an architectural and urban perspective of the sonic effect has revealed that the urban sound environment is a composition of manmade built physical objects and objects found in nature. These objects play a vital role in shaping the urban sound environment with respect to many of their properties, including their scale, shape, location and material. However, these physical forms are accompanied by non-physical factors such as the individuality of one's perception of listening adding to the significance and effects of the physical objects beyond mere physical factors. This raises a key question: what are the forms of constructed space that shape the sound opportunities of our urban environment? The multidisciplinary approach to studying this instrumentation employs tools including acoustical measurement, methods for visually representing sound, and applications for architectural and urban intervention. These tools are harnessed to attend to the general experience of listening, in order to explore the psychology, physiology and sociology of the urban sound environment and how we engage with it.

The sonic effect is not a fully defined or limited concept; it is instead an open-ended idea that enables exploration into a wide array of general discourse about sound, opening the field of soundscapes up for further exploration and interpretation. The sonic effect becomes a particularly rich concept when analyzed from a range of fields and perspectives, beyond just that of acoustics. This next chapter delineates five experiments relating to the mathematics of sound, the instrumentation of the urban environment, and the visualization of sound and listening to show the full potential and wide-ranging significance of the concept of the sonic effect.

The experimentation involved in this thesis project involves a self-conscious attention to the nature of creativity itself, and particularly to creativity as a process that occurs in phases. Creativity is commonly understood as the intellectual ability to make or conceive of creations, inventions, and discoveries, in a way that brings novel relations, entities, and unexpected solutions into existence.[60]

However, it is not just the product of creativity, but the processes of creativity, that must be considered if the sonic effect—and the experi-

60 https://www.researchgate.net/post/what_is_the_nature_of_creativity. Retrieved 09/22/2017.

ence of it—is to be understood in its many dimensions. According to Yingxu Wang, professor and researcher of computer and brain science at the University of Calgary, creativity as a cognitive process consists of two phases. The first phase is the search-based process of discovering a novel relation, and the second is the justification, which is inductive and logical.[61] The following experiments engage with and enact both phases of creativity as a cognitive process through five labs. Each lab consists of creations, inventions and discoveries that bring novel relations or unexpected solutions between sound, music composition and architecture into being. Various methodologies were used in the labs, an eclectic blend that embraced a more intuitive and experimental approach to architectural design.

Despite this mixed-methods approach, the labs themselves are organized in a uniform way. Each of the labs is organized in sections titled *Introduction*, *Method* and *Results*: the introduction provides an overview of the components being studied in the lab; the method is outlined via a work-flow diagram of the experiment and how it was executed; the results include an observation of what was learned or drawn from the experiment. The experiments all employ inductive

61 https://www.researchgate.net/post/what_is_the_nature_of_creativity. Retrieved 09/22/2017.

reasoning, a form of reasoning which places the focus on the formulation of the problem being tested in order to raise new questions and possibilities, to view old problems from a new angle that engages creative imagination and marks exploration in science and architecture.[62] This inductive focus on the formulation of problems is employed throughout the labs. The solution to the problems complements the possibilities raised by the inductive process to form hypotheses and theories to be applied in Part 5 - Composition of this thesis. The labs not only showcase the thesis project's exploration into the mathematics, geometry, and perception of sound, but also reveal an exploration into the unconscious creative process itself, to foreground the creative power of perceptive and intuitive approaches to invention and discovery. It is important to state that many times during this journey of exploratory research I felt lost, and many times I felt I had discovered something new and exciting. The creative process leads a cognitive mind down a road that is anything but straight, and into many different fields of study. The labs presented in the following section showcase some of the experiments done related to the creative, open-ended exploration of the urban sound environment. As Einstein said, "If at first, the idea is not absurd, then there is no hope for it." [63]

62 https://www.researchgate.net/post/what_is_the_nature_of_creativity. Retrieved 09/22/2017.

63 https://www.creativecreativity.com/2007/11/11/einstein-on-cre/. Retrieved 09/22/2017.

Lab 1

4.2 Lab One - A Tool for Visual Representation

Introduction

The inspiration for the research discussed in the following section arose from a comment by Adrian Blackwell, a professor of architecture at the University of Waterloo. During a final studio presentation, he said: “The relationship between the architecture and Schafer is interesting. However, look at the geometry of sound.” This comment would go on to serve as the inspiration for labs one, two, and three. Before the geometry of sound could be explored, however, it was first necessary to determine the method and means by which this could be done. At the time, a coding class for designers was offered during the summer semester. The class was an introduction to the coding language used by designers known as ‘Processing.’ This experiment tied directly into the coding class for designers and was the starting point for my exploration into the visualisation of sound.

This experiment aimed to investigate the coding language ‘Processing’ as a tool for exploring the geometry of sound. Processing is an open-source coding program created by Casey Reas and Benjamin

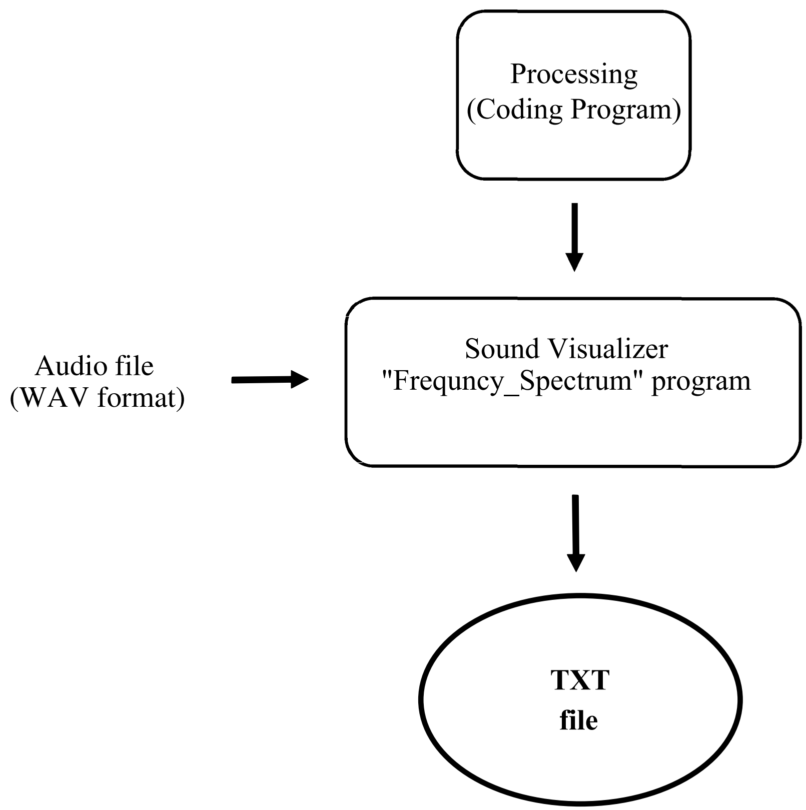


Figure 45 - *Work flow diagram Lab 1.*

Fry, both from the MIT Media Lab. This language offers a more graphical way of coding that was specifically designed for the electronic arts, new media arts, and visual designers. The main goal of the creators was to get people without a computer science or programming background involved in programming. The program uses a graphical user interface and a simplified syntax based on Java, a standard programming language that is used worldwide. The program's simple and elegant design makes it a program of choice among architects working in computational design, who prize the program for its intuitive usability. The end goal of this experiment was to be able to export a text file with the frequency, time and amplitude extracted from the audio file. This would play an essential role in supporting further visualisation in future experiments. One of the first steps in that process was to take an audio clip, typically from the urban soundscape, and create a frequency spectrum analyser using Processing.

The motivation behind the exploration into Processing was the promise of achieving the ability to visualise sound. Initial research into the topic of visualising sound led to the analysis of frequency spectrums. Frequency can be defined as the rate at which something occurs or is repeated over a particular period of time.[64] Spectrum can be defined

64 https://en.wikipedia.org/wiki/Frequency. Retrieved 10/12/2017.

as a set of values that varies across a continuum. Together, the frequency and spectrum of a time-domain signal is a representation of that signal in the frequency domain. The frequency spectrum can be produced with a Fast Fourier Transform (FFT), producing the resulting values of amplitude, time and frequency.[65] A Fast Fourier Transform is a common method used in the analysis of audio clips to produce a frequency spectrum. An FFT uses an algorithmic formula to return the amplitude of the requested frequency band. Processing comes equipped with an audio library called Minim. Minim was created by Damien Di Fede, a highly creative coder and composer. The Minim library uses APIs (Application Program Interface), which are sets of routines, tools and protocols for building software applications. Minim uses APIs such as JavaSound, Tritonus, and Javazoom's MP- 3SPI making it easy to put audio into visual sketches. Minim has many outside-the-box capabilities such as an audio player for WAV and MP3 files, audio recorder, audio input and output as well as its ability to perform an FFT. This provided a starting point to begin to visualise and analyse audio clips.

One objective of this lab was to make it possible to export the analysis in the form of a text file that could be used in other programs

65 https://en.wikipedia.org/wiki/FFT. Retrieved 10/12/2017.

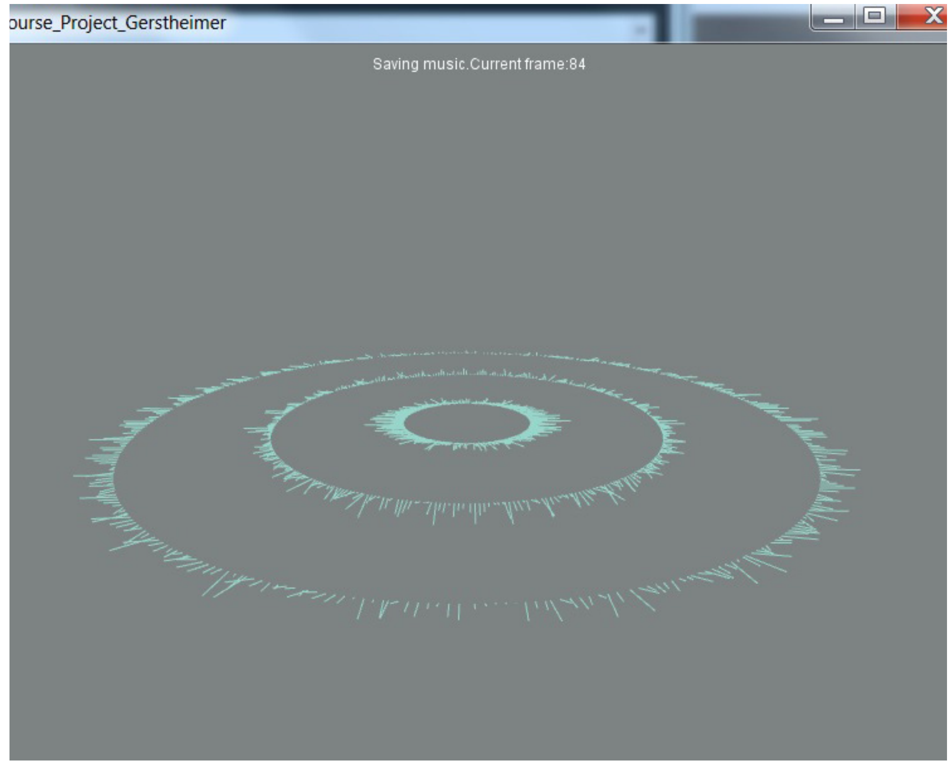


Figure 46 - *Graphic of Sound Visualizer.*

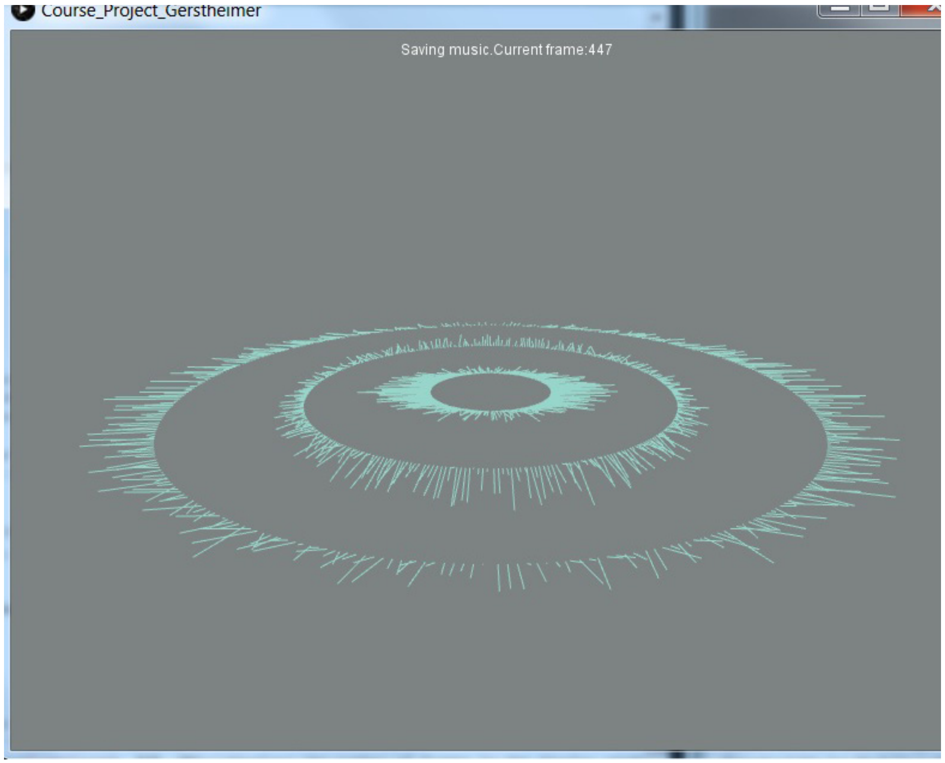


Figure 47 - *Graphic of Sound Visualizer.*

such as Grasshopper 3D. Grasshopper is a graphical scripting program designed for architects. This experiment would act as the first step in extracting data from audio clips toward visually producing the geometry of sound. The end visualisation of the frequency spectrum was not the only important element here. Another goal was to gain the ability to produce a frequency spectrum and extract information from the audio clip and export a text file that could later be fed into other programs. At this point, the audio clips were sounds found in the urban soundscape — particularly those that are commonly heard in New York close to the chosen site. As an example, some of these sounds included traffic and horn honking, two familiar sounds in the urban sound environment.

Method

The coding project conducted for this research functions as a sound spectrum analyser. The processing sketchbook consists of three tabs: Sound_ Spectrum_Analyser_Gerstheimer, Frequency_Spectrum, and Class_Saver. The first tab consists of all the setup and parameters for the sound spectrum analyser.

To begin executing the experiment, ,the plug-in 'Minim audio library' was loaded into Processing. The Minim library was then imported into the sketch.

The Minim object variables were then initiated. These objects included the Minim sound engine, the AudioPlayer, and FFT (Fast Fourier Transform).

The program was then set up with the function void setup(). Inside this function, the screen size, type of renderer (P3D), buffer rate, font type and size, the frame rate were all determined, and the sound clip was loaded.

The function void draw() was then initiated. This part of the code was kept as clean as possible. Within this block of code, there is a spectrum() function: the frequency spectrum, which is defined in a separate tab labelled Frequency_Spectrum. The number of frames were printed in the sound clip to the console and made appearances in the display window.

The Frequency_Spectrum tab was where the frequency spectrum was drawn. The first function created was a void spectrum()function. In this function the background colour was set, a pushMatrix was

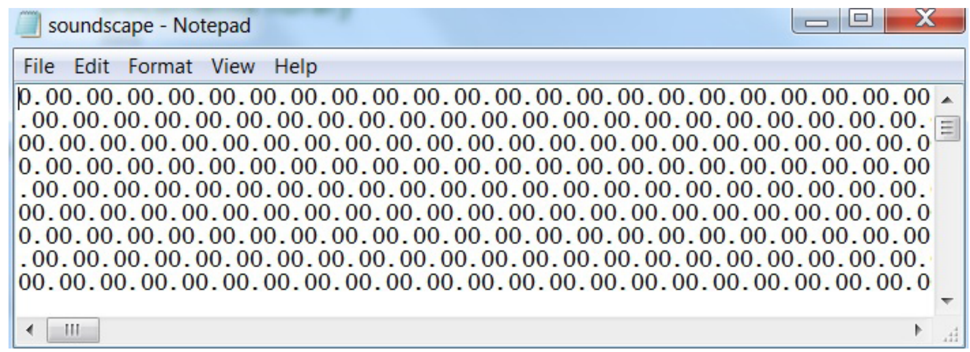


Figure 48 - *Graphic of text file export from Sound Visualizer.*

started, and the frequency spectrum was translated and rotated into a 3D view.

The frequency spectrum was then displayed as three rings that were made from three lines. This was the first geometric sound shape that was created.

The final tab in the sketchbook is the Class_Saver. This includes early efforts to extract specific data from the Sound Visualizer in order to create a class that would save a text file with the results of the analysis from the frequency spectrum. In attempting this, first, the global variables were declared, and then the constructors were defined along with the functions.

Results

In this section of the project it was my intention to visualise sound by coding a frequency spectrum and then attempt to extract data from the sound file, such as frequency, amplitude and time. The exploration of Processing and making a frequency spectrum went fairly well. However, there were some challenges and errors along the way. It should be noted that even though the Minim library uses an FFT, an

FFT is an estimate of frequency components which are not known unless the audio clip is put through an FFT. That being said, the purpose of the frequency analysis was to come up with a method to get useable data out of an audio clip. The accuracy of the data about the audio clip is unknown.

FFT is a means of determining the amplitude for low frequency and high-frequency sounds. It analyses the frequency spectrum or time-domain. The raw data is the sound file. This data needs to be analysed by an algorithm in order for data to be extracted from it. One methodology for doing this is the FFT. FFT gives the amplitude at different frequency levels and extracts amplitude at different resolutions of the FFT. The resolutions are usually to the power of two. Common resolutions are 256, 512 and 1024. These resolutions are essentially the number of bands in the visualisation and the level of detail.

Overall, the experiment was successful in producing sound as geometry. However, extracting data in the form of a text file for frequency, amplitude and time was not. Since coding is not the primary focus of the next experiment, a pre-made frequency spectrum analyser was used to extract data from sound clips.

Lab 2

4.3 Lab Two - A Tool for Visual Representation

Introduction

The unsuccessful attempt to extract data from audio clips in Lab two sparked a new goal: the search for a similar program for extracting data from audio clips. After an in-depth search for such a program, Carlo Sammarco's sound extractor came to light. He is a student at Arizona State University and his program for extracting sound is titled "Frequency_Amplitude_Quantifier." This program made it possible not only to visualise sound in three dimensions but also to extract the frequency, amplitude and time of a sound clip. This experiment uses a work-flow from Sammarco's Frequency_Amplitude_Quantifier to Grasshopper 3D, a scripting program for architects and designers used to create geometry from audio information and display it as three-dimensional geometry in Rhino, a three-dimensional modelling program widely used within the architectural field.

Method

In this experiment, sound clips were downloaded from www.soundsnap.com, which is an open source website containing high-quality sound recordings. The sound files were used as input into the Frequency_

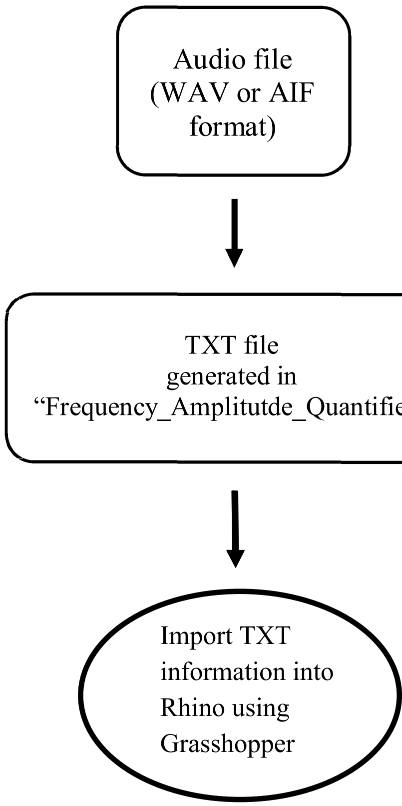


Figure 49 - *Work flow diagram Lab 2.*

Amplitude_Quantifier application. The saved text file containing the extracted data, frequency, amplitude and time formed the raw data for this experiment. This raw data was used as input into the Grasshopper 3D script. The script's purpose was to visualise the data in three dimensions and transform the data in three dimensions.

Part 1

The work-flow for enabling the Grasshopper script to transcode audio information into geometry involved the following steps:

Four audio clips were selected, all recordings of urban sounds found in New York. The four sound clips chosen were: subway lines, sounds of heavy traffic, people protesting, and Chinatown. The credit for these recordings goes to Frank Serafine and Airborn Sounds, two regular uploaders and sound specialists of soundsnap.com.

The frequency amplitude quantifier program was used to extract data from the audio clips. This produced a data table that contained three critical pieces of information: frequency, time and amplitude. The first column represents the frequency; the second column represents the time interval during which the sample was taken, and the third column is the amplitude. These numbers would be used as data to be inputted into Grasshopper 3D.

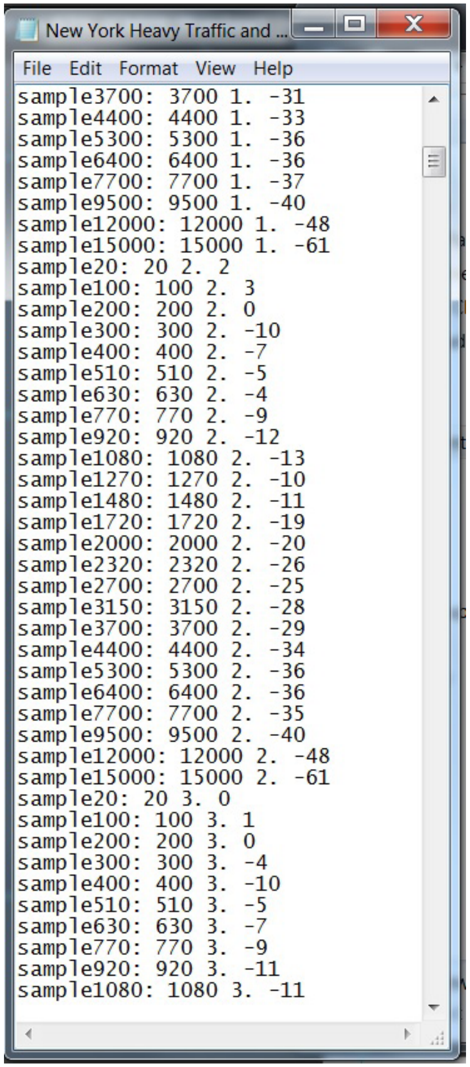
Part 2 - Visualizing Data with Grasshopper 3D

The following outlines the workflow of the Grasshopper script's transcoding of audio information into geometry.

The first part of the definition was used in ASU's Digital Culture class, and credit goes to Carlo Sammarco for the script. The data was input into Grasshopper via a file path link. The extracted data was split into its three categories of frequency, time, and amplitude. This data was listed in Grasshopper. The data on the three categories of frequency, time and amplitude were then separated, converted into points, and made into curves. Finally, the curves were turned into a three-dimensional surface using Grasshopper's simple loft command. Finally, sliders were added to control the scale of the frequency, amplitude, and time of the three-dimensional audio surface. The Z-axis corresponds to the amplitude, the X-axis corresponds to the frequency, and the Y-axis corresponds to the time.

Results

The experiment yielded four different three-dimensional geometric



New York Heavy Traffic and ...

File Edit Format View Help

```
sample3700: 3700 1. -31
sample4400: 4400 1. -33
sample5300: 5300 1. -36
sample6400: 6400 1. -36
sample7700: 7700 1. -37
sample9500: 9500 1. -40
sample12000: 12000 1. -48
sample15000: 15000 1. -61
sample20: 20 2. 2
sample100: 100 2. 3
sample200: 200 2. 0
sample300: 300 2. -10
sample400: 400 2. -7
sample510: 510 2. -5
sample630: 630 2. -4
sample770: 770 2. -9
sample920: 920 2. -12
sample1080: 1080 2. -13
sample1270: 1270 2. -10
sample1480: 1480 2. -11
sample1720: 1720 2. -19
sample2000: 2000 2. -20
sample2320: 2320 2. -26
sample2700: 2700 2. -25
sample3150: 3150 2. -28
sample3700: 3700 2. -29
sample4400: 4400 2. -34
sample5300: 5300 2. -36
sample6400: 6400 2. -36
sample7700: 7700 2. -35
sample9500: 9500 2. -40
sample12000: 12000 2. -48
sample15000: 15000 2. -61
sample20: 20 3. 0
sample100: 100 3. 1
sample200: 200 3. 0
sample300: 300 3. -4
sample400: 400 3. -10
sample510: 510 3. -5
sample630: 630 3. -7
sample770: 770 3. -9
sample920: 920 3. -11
sample1080: 1080 3. -11
```

Figure 50 - *Exracted data table: frequency, amplitude and time from sound clip.*

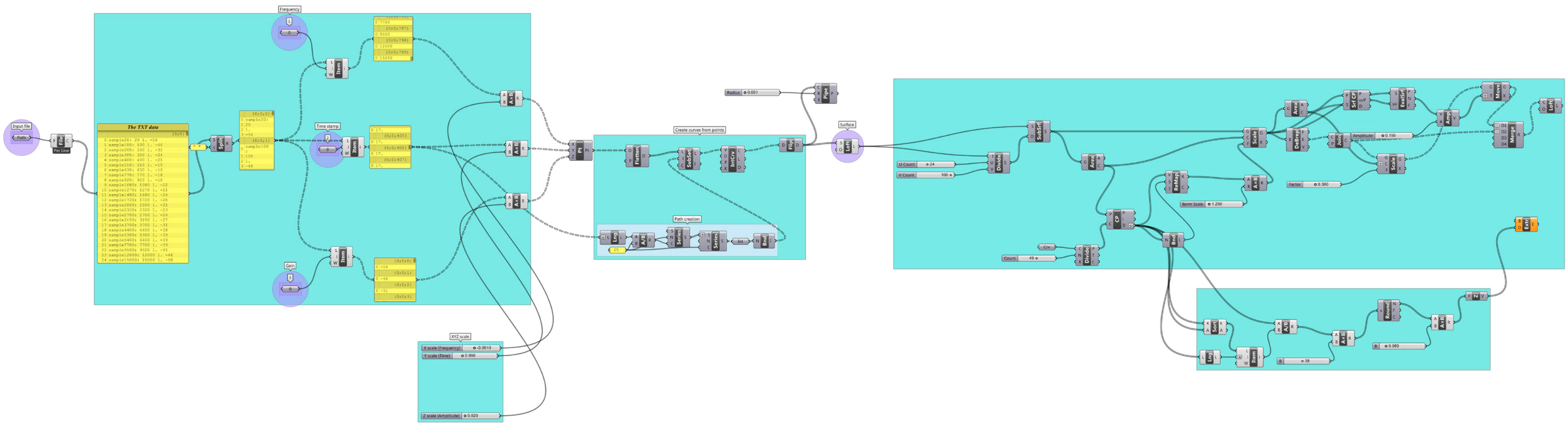


Figure 51 - *Visualizing sound Grasshopper Script result.*

surfaces that were derived from the four different audio clips. This methodology was presented during the first semester's final studio presentation and received mixed reviews. The main comment made regarding this particular result was that it was a direct translation of the sound and not a valid method of transcoding. However, the act of transforming the sound file into the raw data is a method of transcoding in itself. The sound went from being audible to visual, in the form of raw numbers. Also, when some of the sliders were changed in the Grasshopper script, some exciting things began to happen. The Grasshopper script stretched the frequency, time, and amplitude of the extracted data from the sound clip. Individual "berms" were formed in all different sizes and elevations. This began to formulate an image set resembling parts of a landscape.

Overall, the experiment was successful in digitally extracting data from a sound-clip and then effectively feeding that data through a Grasshopper script to produce a three-dimensional virtual model. However, the data extracted from the sound-clips and the way this data was used in the script were weak in terms of the process of transcoding. This was an area of weakness simply because the resultant 'landscapes' frequency spectrum was basically a direct translation of a

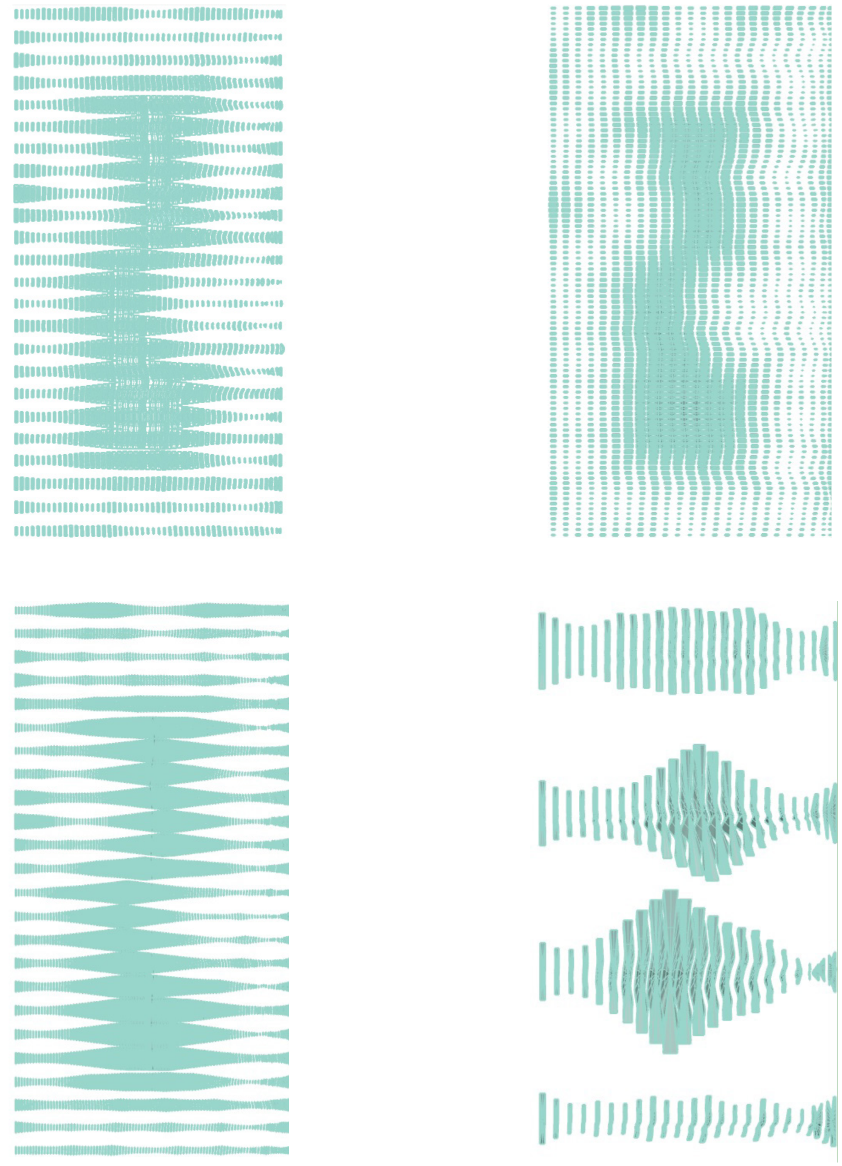


Figure 52 - *Visualizing Sound Plans, subway lines (top left), heavy traffic (top right),people protesting (bottom left) and Chinatown (bottom right).*

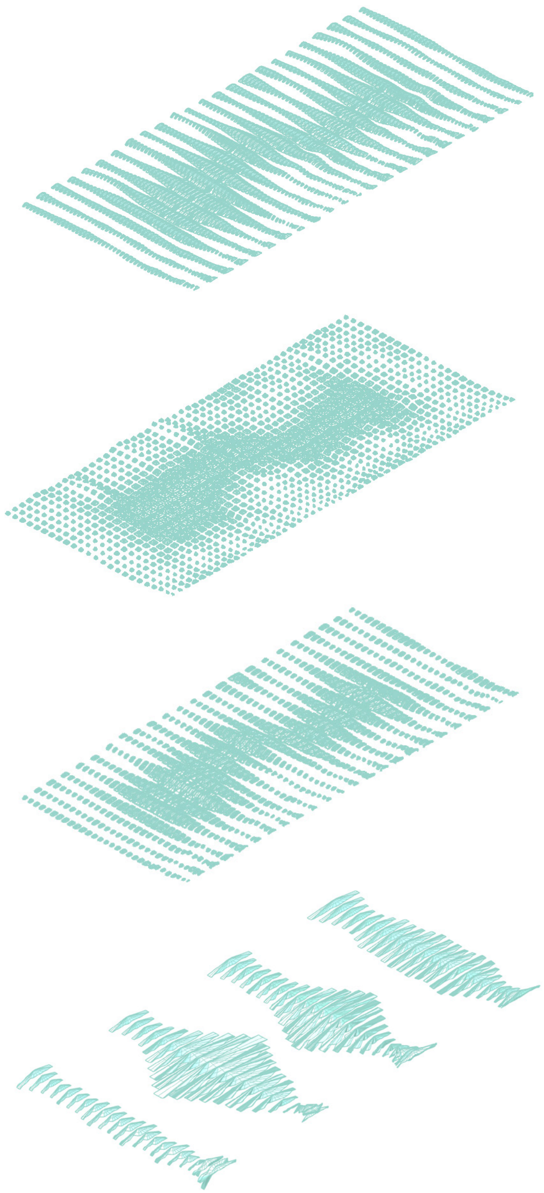


Figure 53 - *Visualizing Sound ISO, subway lines,heavy traffic,people protesting and Chinatown (top to bottom).*

two-dimensional sound spectrum but in three dimensions. However, this was a significant phase of the research because it led to the exploration of geometry and sound from a different perspective, as seen in the next experiment.

Lab 3

4.4 Lab Three - The Shape of Sound

Introduction

A theory advanced by some thinkers posits that sound created life on Earth and that everything around us is made from tiny vibrating particles. The term Cymatics is used to describe both this phenomenon and the scientific study of visible sound. This experiment explores potential methods for visualising Cymatics to seek a deeper understanding of the phenomenon's beauty and possible applications.

The word 'cymatic' is derived from the Greek word meaning 'wave'. Until recently, this field of inquiry was relatively obscure, but is now becoming more and more popular both in the scientific and non-scientific fields. Cymascopes are the key instruments used in this area of study as tools for visualising the geometry of sound. A Cymascope is a vibrating plate with a medium placed on it, usually water or sand; the plate is then set in vibration by a specific frequency, causing the medium to form different geometric shapes. These geometric shapes are the natural waveforms produced by the sand or water being vibrated. The shapes formed by the Cymascope can be found reflected in the environment, in both natural and constructed forms.

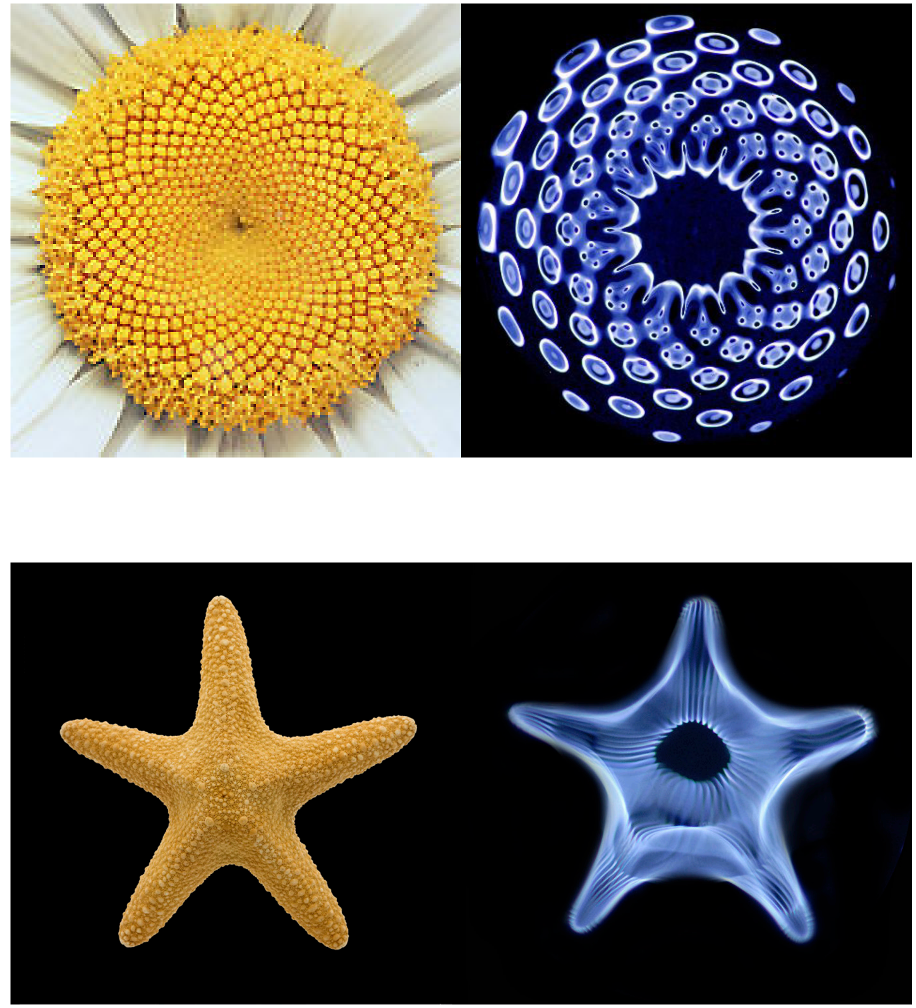


Figure 54 - *Head of a daisy cymatic (upper). Starfish cymatic, by John Stuart Reid (lower).*

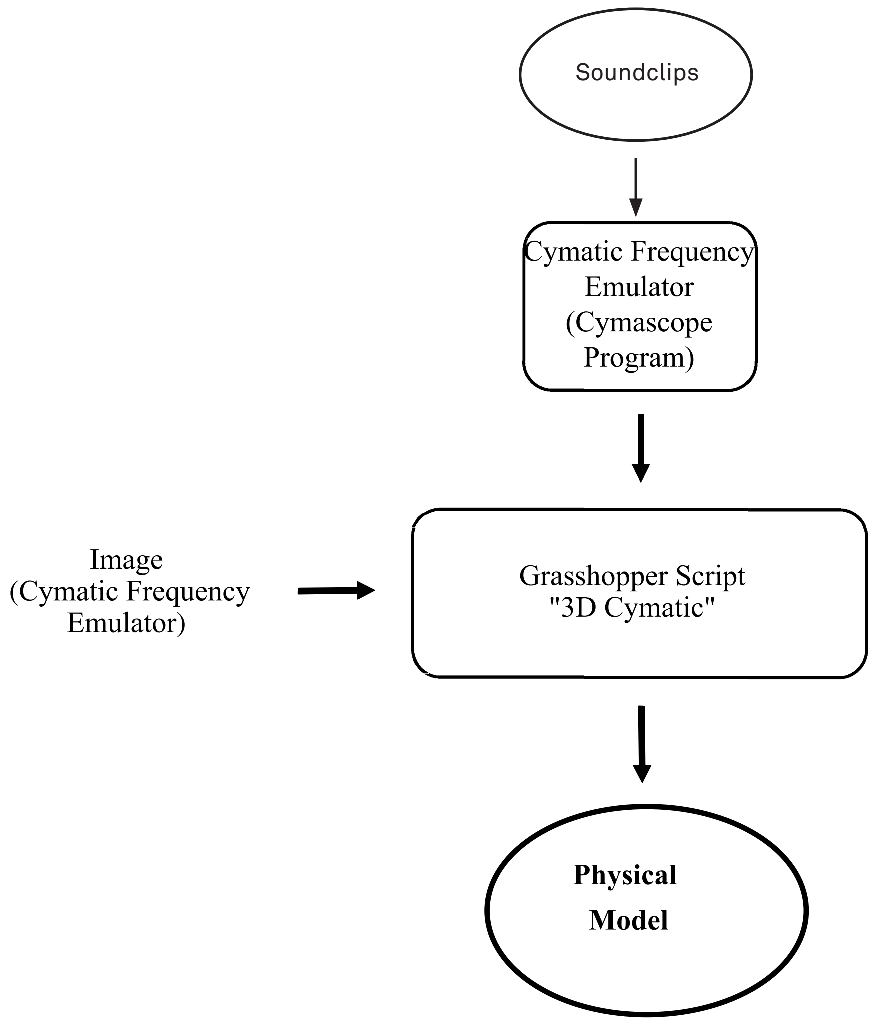


Figure 55 - *Work flow diagram Lab 3.*

In architecture, Cymatics can be found in many sacred ancient buildings; for example, the phenomenon can be viewed on display in churches in the form of rose windows. Many occurances of Cymatics in both the built and the natural world are discussed throughout the 2007 book *Cymatics: A Study of Wave Phenomena and Vibration* by Hans Jenny, the grandfather of the field. One example Jenny offers is the flower known as the daisy. The geometric pattern seen on the head of a daisy is a twin spiral. A similar twin spiral is created on a Cymascope when it is vibrated at 78 Hertz. Similarly, a pentagonal geometric shape formed in cymatics using a Cymascope closely resembles the pentagonal pattern found on a red-knob starfish.

This experiment applies findings from the field of Cymatics to visualise the form of urban sounds heard in New York. The same four clips of urban sounds used in Lab two were input into the Cymascope program.

The world around us consists of many beautiful patterns and sounds. Although these beautiful patterns and sounds exist in the urban core of New York, the overabundance of noise in the city can make them difficult to discern. Further, when they are detected, these patterns

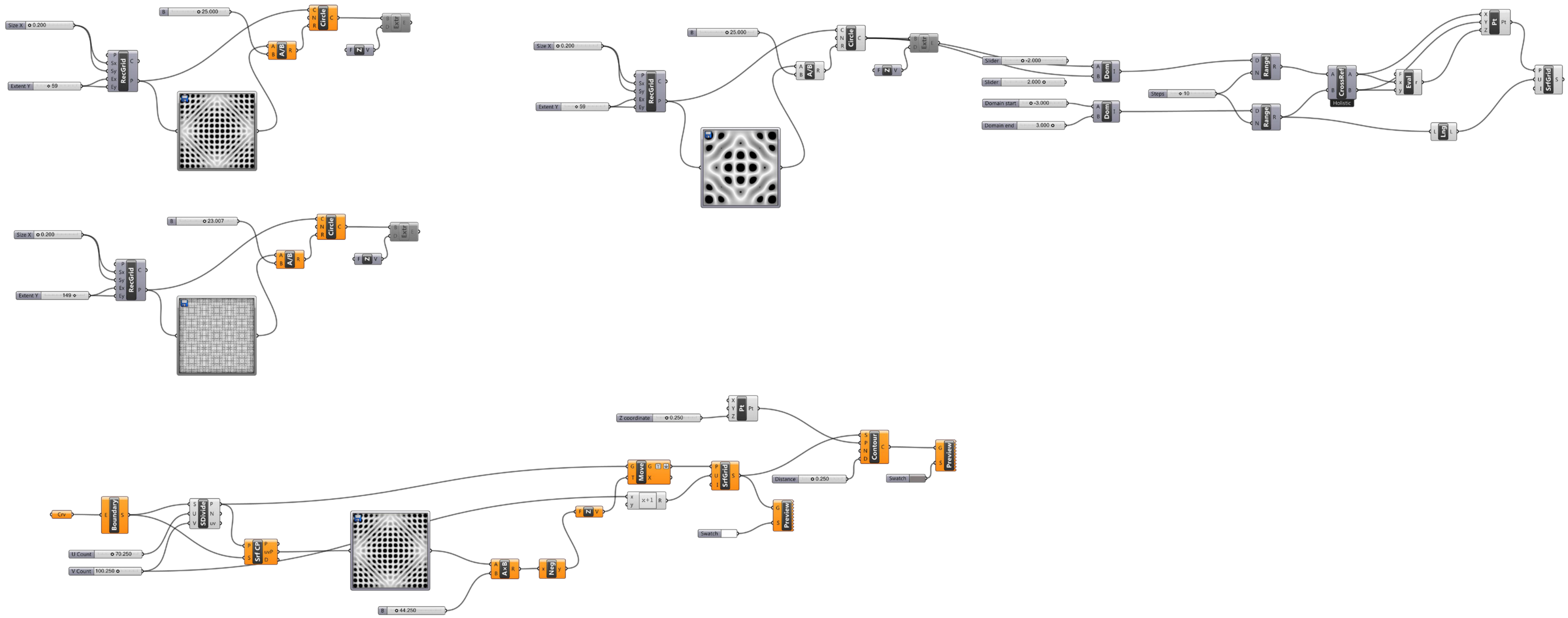


Figure 56 - *Cymascope - Grasshopper Script result.*

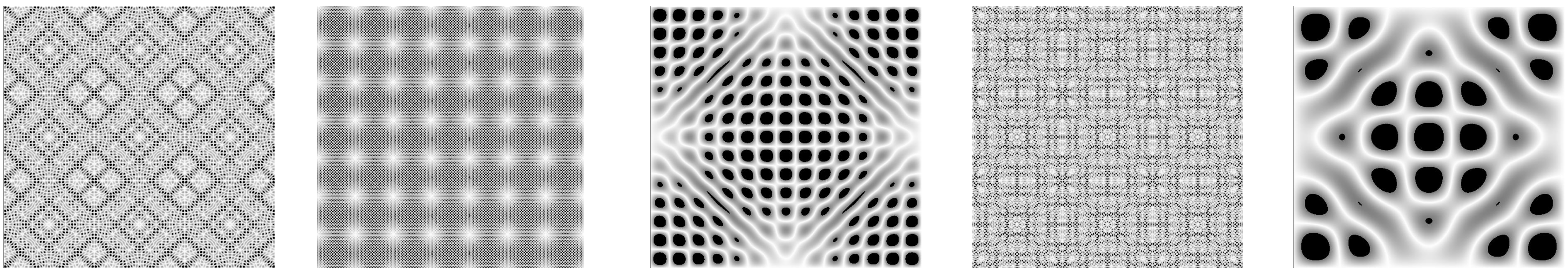


Figure 57 - *Cymatic Frequency Emulator geometric results (left to right), 264Hz, 432Hz, 190Hz, 510Hz and 19Hz.*

are typically heard rather than seen. This experiment takes these urban sounds and transcodes them into two-dimensional and three-dimensional visuals using the philosophy of Cymatics.

Method

Broadly speaking, the methodology used in this process of transcoding urban sounds into visuals consisted of listening to sound clips and extracting the frequency of the unique sounds of New York. The method employs analysis software, an attentive ear, a digital cymascope, a Grasshopper script, and a physical model of the digital model. The detailed process used to create the final geometry consists of the following steps.

First, audio clips were loaded into Audacity, a software used for audio analysis. The audio clips were carefully listened to in repetitive successions and analysed for the sounds of New York. Sounds were circled and labelled and the corresponding frequencies were recorded from the frequency spectrum in Audacity. Then another piece of software was introduced—a software named Cymatic Frequency Emulator, produced by a company called Secret Energy. The Cymatic Frequency Emulator software was used as a digital cymascope. The

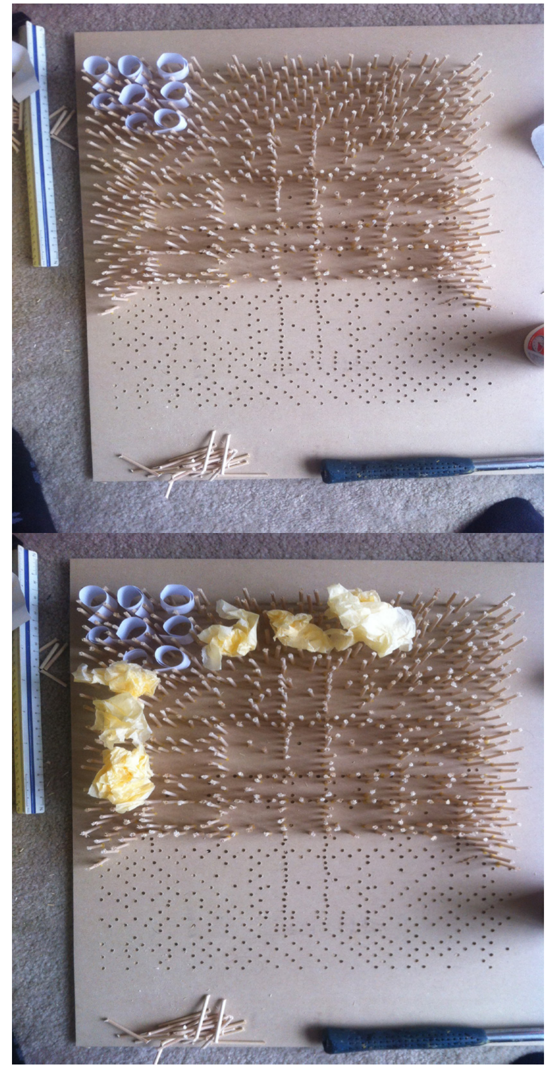


Figure 58 - *Physical model of 3D Grasshopper Script result.*

Figure 59 - *Physical model of 3D Grasshopper Script result.*

following geometric patterns were produced at different Hertz:fromlefttorighttheimagesare264Hz, 432Hz,190Hz, 510Hz and 19Hz.

The two-dimensional image was approached as a solid and void exercise. The dark circle areas of the geometric pattern were extruded as a solid and the white parts of the geometric pattern were left as voids. A simple Grasshopper script was developed to extrude the geometric pattern into a three-dimensional model.

This digital model was then translated into a physical model. The physical model was produced by printing out the two-dimensional pattern and applying it to a piece of medium density fiberboard. Holes were then drilled where the black areas were seen on the geometric pattern. Dowels were then cut at various lengths as produced by the digital model and stuck into the holes. These dowels are thus producing an artificial landscape of trees or a similar type of installation that one could walk through and experience. The height of these solid extrusions was determined somewhat randomly, guided by the general goal of developing some path or walkable place in plan form.

Results

This model helped to shift the focus of the project onto the perception of sound and brought the research of the thesis to an ear level and began to deemphasise the visualisation of sound.

The main observation to be noted regarding this particular experiment was that the use of the Cymatic Frequency Emulator software to produce the visual sound wave was an arbitrary step in the process because it was not known what was producing the shape in the software. Nonetheless this experiment began to shed light on the connection between sound and the natural environment.

Lab 4

4.5 Lab Four - The Rhythm of Our Cities

Introduction

The next experiment was inspired by a comment made by Ila Berman, a former professor at the University of Waterloo. During a thesis committee meeting, she said, “Everything can have a rhythm, including our cities.” This comment would go on to serve as the inspiration for Lab four.

This experiment represents the beginning of a turning point in the development of this thesis. Instead of concentrating on the visual by taking sound clips and trying to derive geometry from them, the focus began to shift toward an emphasis on thinking about sound from the ear’s perspective, in much the same way as a composer uses his or her ear to study and create music. The main idea explored in this experiment was listening as a process, and a means of perceiving and discovering. It represented a shift toward listening to the sound clips of New York, rather than simply using them as raw data to plug into a script or program.

Method

This new focus on listening began with a print-out of the frequency spectrum; while listening attentively and discerningly to the clip, marks were

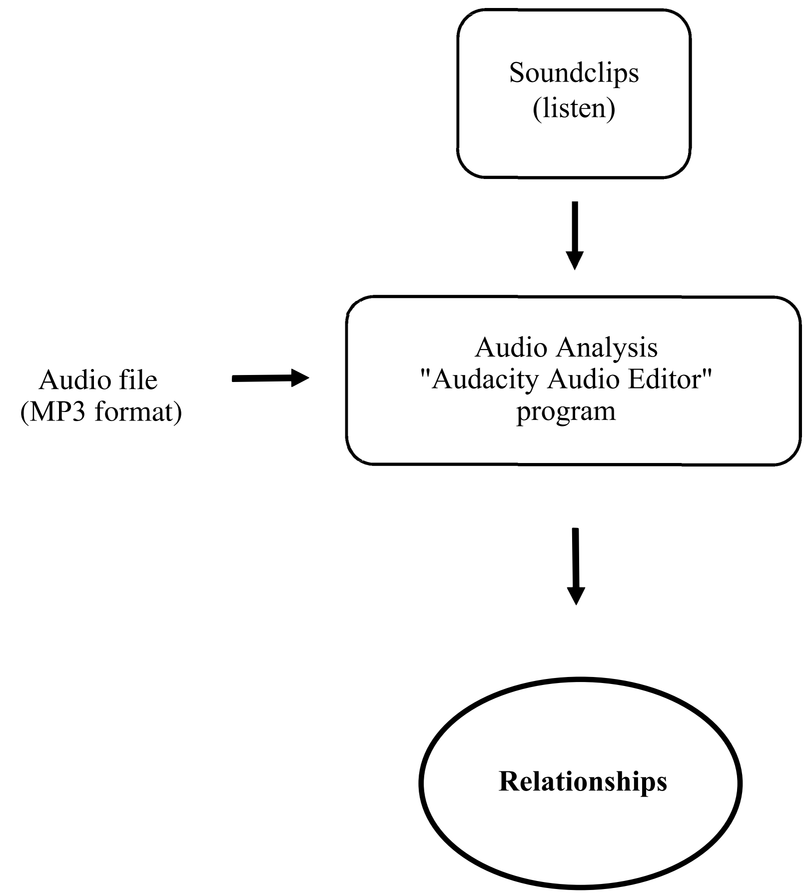
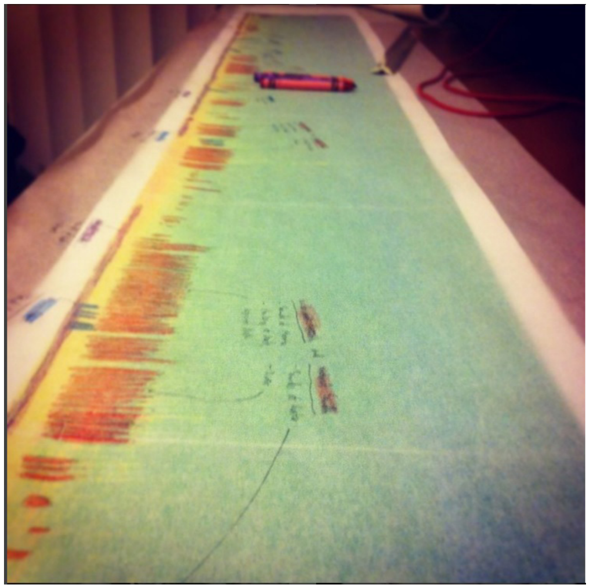


Figure 60 - *Workflow diagram Lab 4.*

hand drawn on the printed out spectrum, tracking and documenting what individual sounds were heard, and what patterns emerged from those sounds. This practice represented a process and methodology for studying sound that were distinct from approaches employed in previous labs.



This new approach also prompted the investigation of musical terms. The sounds and patterns noted through this process were studied in terms of their translation to elements of music and then considered in terms of architectural form. The process began with defining and understanding some simple musical concepts such as rhythm, beat, tempo and pitch. Rhythm is the element of time in music. When you tap your foot to the music, you are 'keeping the beat' or following the structural rhythmic pulse of the music. The tempo is the speed of the beat expressed in beats per second. Pitch is the highness or lowness of a sound. Considering these elements sparked an investigation into how to analyze audio for its rhythm, beat, tempo and pitch. The program Audacity was reintroduced as a tool in this new light, and studied for its ability to analyze audio clips with respect to these four principles. After reading Victoria Myers' book the *Shape of Sound*, and studying one of hMA's projects, a relationality between musical scores and architecture started to come into view.

Figure 61 - *Frequency spectrum analysis.*

With the influence of Victoria Myers' works, this experiment prompted a deeper study into the musical composition of elements like rhythm, beat, tempo and pitch and how these can be related to sound, the city, and the site. Upon listening to the sound clips of Manhattan, and with the musical definitions in mind, the relationship between the musical concepts and the city soundscapes began to develop.

The first musical term that sparked a connection with the soundscape was that of beat. While listening to the soundscapes, the ear picked up repetitions of sounds. This sparked a contemplation of repetitiveness in nature and the urban environment and the relationship between these two forms of repetition. A list was composed naming elements of the landscape and things of the city that had 'beat'. This exercise yielded the observation that something as simple as the planting of trees has a beat. When a landscape is designed by a landscape architect, the trees are planted at a certain spacing apart from each other depending on their size, species, and canopy. Working from this fact, the realisation arose that there exists a sort of technicality of the composition of a landscape that is produced by factors such as the types and properties of plants. This can be understood as the beat of the trees. The existing trees for example in Washington Square Park were planted at specific 'beats' or

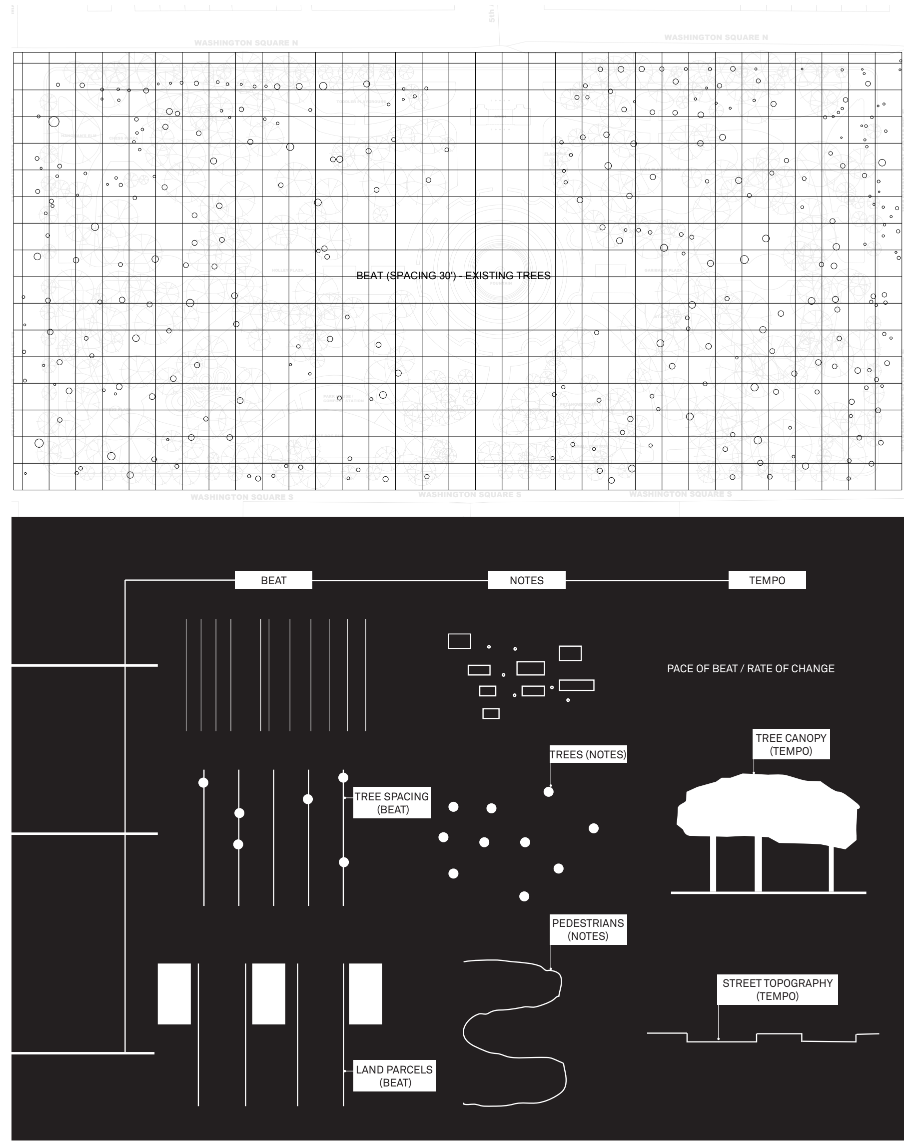


Figure 62 - *(Rhythm Analysis) - Landscape analysis - exisiting trees (upper), Chart summary of Rhythm and music as it relates to sound, land scape and the urban environment. (lower).*

spaces. It then became clear that an investigation into whether the trees in Washington Square Park have a defined beat could prove useful. To achieve this, gridlines at various scales based on the common spacing of the species of the existing trees on the site are overlaid onto the existing site. This created a regular 'beat' of the landscape. This same conceptual approach was then related to a fundamental urban component of Manhattan: the blocks of land, which are all of a certain dimension—the dimension of a traditional block in Manhattan is eighty meters by two hundred and seventy-five meters—form a repetitive element that creates a beat of the city.

The chart summarizes the basic ways in which aspects of rhythm in music can be understood to relate to sound, landscape and the urban environment. This chart includes a summary of how rhythm relates to the city and architecture. For example, the beat was seen as the datum; notes were seen as a field; the tempo was seen as surface topography; and pitch was seen as material. An example of the datum is the fact that landscape architects plant trees at certain intervals to accommodate growth. This relates to the sound analysis of beat, as the beat is measured in beats per minute and creates a common spacing much like the 'beat' of the trees. The existing trees were seen as notes or the field of the site. The canopies were seen as the tempo of the topography of the landscape. The relationship was derived in such a way that each musical element is connected with a corresponding architectural element. This relationship was derived as follows from the earlier sound analysis listening exercise:

Beat = Datum

Notes = Field

Tempo = Surface Topography

Pitch = Material

This relationship between musical and architectural elements was applied as an analytical tool for interpreting the sound clips and the existing landscape of Washington Square Park and Manhattan, in an effort to reveal a beat, tempo and notes of the landscape and the urban in each. The first part shows the procedure of sound analysis. It is followed by an analysis of the landscape and finally the urban.

Sound clips from around New York were used in this experiment. The sound clips were taken from Anne Guthrie's study of New York sound-

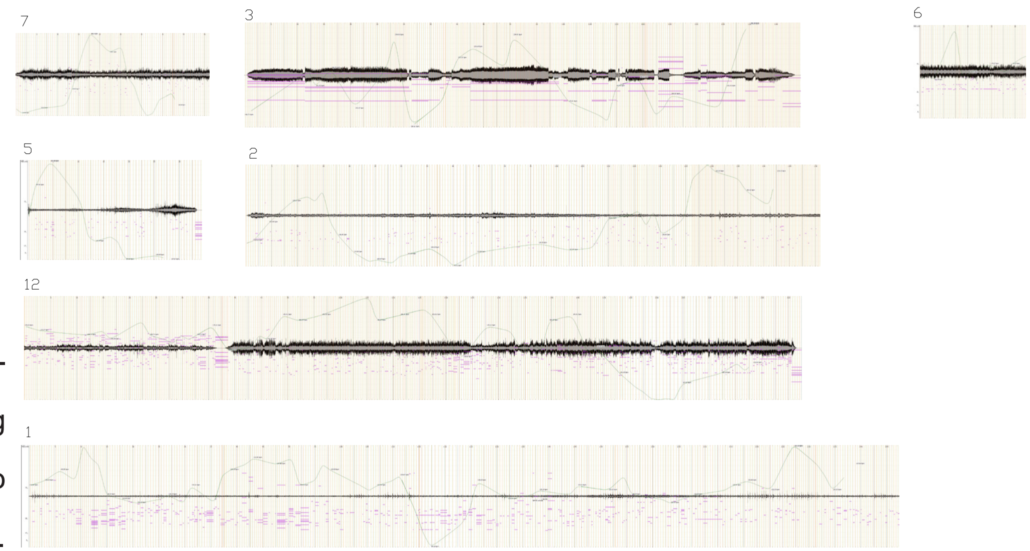
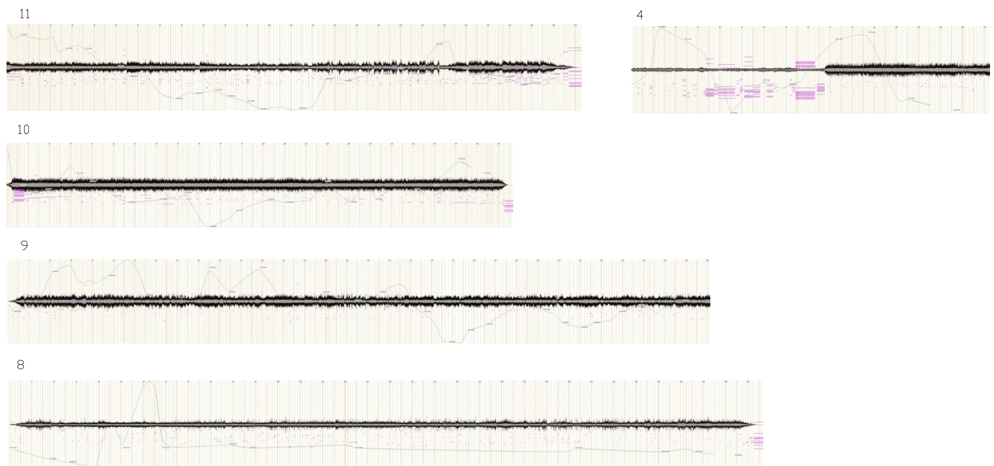


Figure 63 - *Soundclips from the urban soundscape of Manhattan, retrieved from Anne Guthrie's soundwalk study (left and right).*



scapes, for which she collected unique sounds from around New York on one of her soundwalks. The following twelve clips were used.

1) Sheepshead Bay, Brooklyn,

2) Flatbush Avenue, Brooklyn,

3) Pratt Institute, Brooklyn,

4) Arverne, Queens,

5) Seven Train Overpass, Queens,

6) Grand Concourse, The Bronx,

7) Joseph Yancey Field, The Bronx,

8) Tompkins Square Park, Manhattan,

9) Columbus Park, Manhattan,

10) Pier 66, Manhattan,

11) Midtown East, Manhattan and

12) Adam Clayton Powell, Jr. Boulevard, Harlem.

Results

The results of running the sound analysis algorithms on all twelve sound clips yielded important insights. The ‘rhythm’ relationship between sound, landscape and the urban environment of the twelve sound clips lead to the exploration of Anne Guthrie’s soundwalk project. This exploration led to the focus of listening and researching the perception of sound. The idea of a soundwalk, inspired by Guthrie’s work, led to the next lab, where a relationship began to develop between the concept of a sound-walk and a path.

Lab 5

4.6 Lab Five - A Tool for Architectural Intervention

Introduction

This experiment had an acoustic and mathematical approach. The inverse square law was used to try to generate a path through the site that would act as the landscape.

Method

The same sound sources were used in the previous two experiments and analyzed for their data. Once the data was collected the mathematics were applied. The two laws that were applied were the formulas for the Spherical Spreading of a Point Source and the Falloff from a Point Source as previously studied.

The centre points of each existing program of Washington Square Park were located, including those of the fountain, kids playground, toddlers playground, chess plaza, dog run, and bocce courts. These centre points of these programs then acted as the source points.

The decibel level of each program was determined using the field recordings. For example, the fountain is considered a program in the park. This sound clip of the fountain was analyzed, and its average decibel

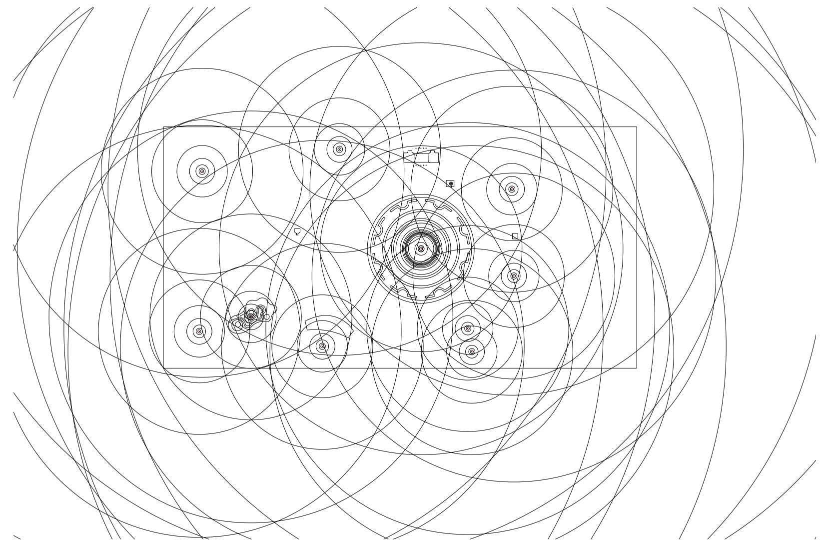


Figure 64 - *The result of using 'Spherical Spreading of a point source' in analys ing the sites existing program.*

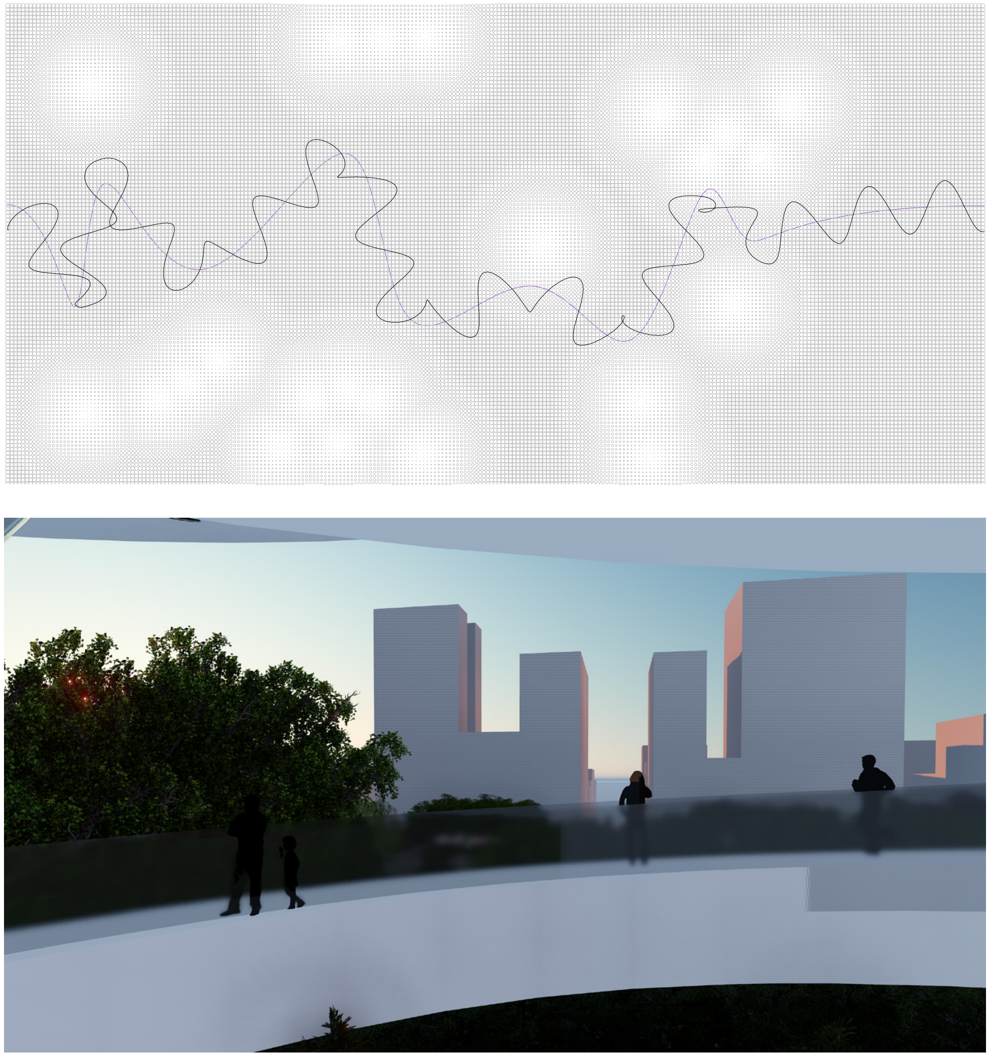


Figure 65 - *The 'Path' derived from the spherical fall off of a point source.(upper)*
A view from the 'Path' above the tree tops. (lower)

level was found.

Next, the Inverse Square Law was used to create a circular grid from each point source of the existing programs of the site.

Then the circular grid was used to sketch and define a path with particular decibel levels as it meanders through the park. The calculations did not take into account any obstacles.

Results

In the end, a path was derived but was based on simple acoustic calculations and did not take into account any obstacles in the way. The path was imagined as a continuously built form that would transform into benches, bridges, walkways and eventually terminate at the centre of the park (where the existing fountain is located) and turn into the landmark component.

From the visualisation to the discrete listening experiments these labs all had a part in developing not only the concept of the sonic effect but also developing the ability to identify them as part of a general auditory therapy. The auditory therapy that arose from the labs is a technique similar to that used by composers and musicians to train the ear to listen discriminately. This compositional aspect of the urban sound environment is explored further in the final chapter through one of the most famous architects and composers of all time, Iannis Xenakis, using a method of composition he used for a piece of his music. His methodology of composition, coupled with the discovered instruments of Washington Square Park studied in Part Three, is applied to the urban sound environment of Washington Square Park.

Composition
Part 5

5.1 The Methodology

This thesis encompasses analysis from urban soundscape studies and musical compositional methods. Thus far the urban sound environment has been studied for its physical contextual elements by employing theory and definitions from a wide range of composers, architects and theorists highlighting the urban soundscape studies of R. Murray Schafer and Augoyard's and Torgue's sonic effects, by identifying and experimenting with the contextual elements of the urban sound environment from an architectural point of view. Through the experiments it was discovered that there is a relationship between composing a piece of music and the composition of the urban sound environment. With the study of the existing park's contextual elements it is now time to compose the urban sound environment as if it were an instrumentation. The architectural composition uses a methodology derived from Iannis Xenakis stochastic mathematically-driven approach to music composition.

In order to develop a better understanding of his mathematical approach to composition it is necessary to understand his methodology for constructing a piece of music. As stated, in his book titled, *For-*

malized Music, his methodology for composition is an eight phase process:

1. Initial conceptions. This phase is where the composer decides on any initial intuitions, and decides on the data that is going to be used within the composition.

2. Definition of the sonic entities. In this phase the composer decides on either musical instruments or electronic sounds and how they will be defined.

3. Definition of the transformation process. During this phase the composer transforms the sonic entities decided on in previous steps and applies an algebraic framework at both a macro-compositional level and on the time axis of the composition.

4. Micro-composition. This phase is where the mathematical principle or principles are defined which can include but not limited to, Boolean algebra, Stochastic laws, Arborescence method, Markov chains and Game theory.

5. Sequential programming of phase three and four. The musical piece is sculpted in this phase.

6. Implementation of calculations. This is when the composer fine tunes, verifies and modifies the piece. This phase does not require mathematical principles but rather is fine-tuned by the composer's ear.

7. Final symbolic result. This phase is where the musical graphics are converted into standard western musical notation.

8. Sonic realisation. This phase is where the piece of music is performed live or is played by computer synthesis.

The discovery of Xenakis's stochastic mathematical process for composing music promised to be the ideal next step of exploration in the search for the instrumentation of the urban sound environment because the sound environment itself is stochastic, in that it cannot be predicted precisely and is random, whether it is manmade or natural.

At first glance, it may seem counterintuitive to place the work of Schafer, Augoyard and Torgue and Xenakis in the same line of inquiry. However, there are significant relations between the work of these thinkers. They all have contributed to the field of soundscapes thorugh research, theories, musical compositions and built works of architec-

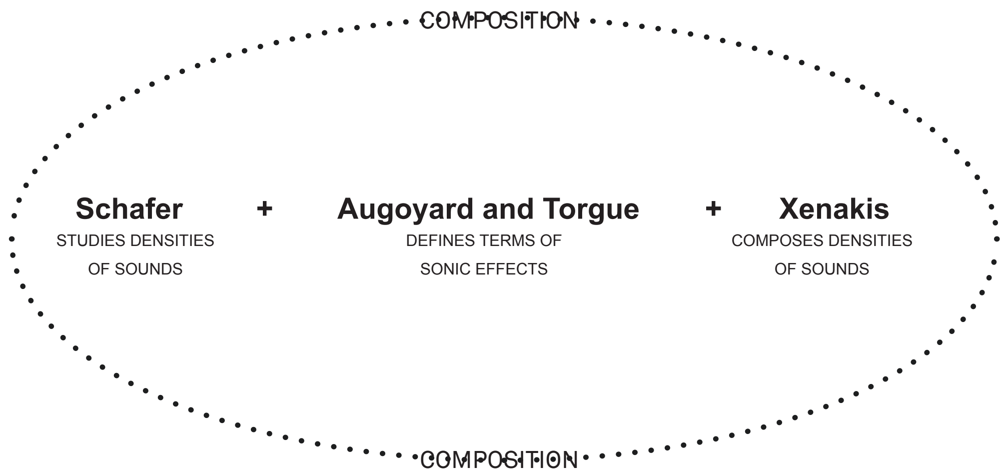


Figure 66 - Schafer versus Xenakis - relationship flow diagram for Part 5 'The Composition'.

ture. The urban soundscape is made up of densities of sounds; these sounds interact with the built environment to produce sonic effects. Schafer studied the urban soundscape, which is made up of densities of sounds; Xenakis is the composer of the densities of sounds; and Augoyard and Torgue are credited with further defining these densities of sounds with sonic effects. Although Shafer, Xenakis, Augoyard and Torgue were not necessarily working together or even at the same times they were all, in one way or another, enriching our knowledge of the urban sound environment. Discovering this relation between the three inquires of theories and methods an experimental composition is produced enriching the social cultural sound milieu of Washington Square Park.

Through its previously conducted studies, this thesis explored the urban sound environment as a rich reservoir of sound possibilities shaped by the forms in the city. Understanding and further defining how these physical contextual elements manipulate the soundscape is an ongoing area of exploration. The composition involves a stochastic methodology that forces the designer to think like a composer.

Through this cross-disciplinary pollination, the project aims to produce a graphical illustration of Washington Square Park that invites readers to look at sound more closely and encourage an individual to listen when they are amongst the urban environment by using a recognizable place such as Washington Square Park. The chosen stochastic methodology for producing the final result is derived from Xenakis's piece titled "Achorripsis." Achorripsis is a Greek word meaning 'jets of sound'. Xenakis's piece is a stochastic composition of sounds that employs aspects of his eight phase process and mathematical formulas to score the music.

"Achorripsis" is a study in different densities of sounds, which relates directly to the densities of sounds that make up the urban soundscape and ties in neatly with Schafer's soundscape studies. These densities of sounds found in the urban soundscape are manipulated based on a number of factors, such as materiality, changing seasons, topography, landscape, social cultural community, and infrastructure to name a few. When factors such as these are coupled with a stochastic methodology a varied composition like Achorripsis will begin to shape the sound densities of the urban soundscape, and begin to break the dense urban soundscape down into smaller pockets of unique, less dense areas of sound, thus affecting people's aural experience and rendering the soundscape legible.

Why "Achorripsis"? Xenakis's approach to composition in "Achorripsis" centres on a culmination of a large number of sound events that produce a single composite and live sound, putting the listener in a situation where it is impossible to distinguish between the individual sounds. Significantly, this is the same phenomenon commonly experienced in the urban soundscape. As the urban soundscape is a field of sounds perceived as a single, whole sound, it can be difficult to distinguish pleasant sounds from unpleasant ones. This phenomenon was a critical part of Schafer's reasoning for why an in-depth study of the urban soundscape was such a valuable pursuit. Schafer believed that as our cities have become enveloped with human-made sounds, it has become nearly impossible to distinguish between pleasant and unpleasant sounds, and that this caused everyone to stop listening. The sound field engaged in "Achorripsis" relates directly to the urban sound field of our modern cities. The intended deployment of this process represents a possible methodology to view the urban sound environment as if it were a composition of instruments and techniques used by composers to produce an architectural composition of Washington Square Park. Given this, based on Xenakis's eight phase process and his composition of Achorripsis, the following methodology is proposed:

1. *Organisation of a Formal Structure:* At this stage initial conceptions are made. The matrix is defined and reveals the formal structure of the composition, in terms of the instruments used and the length of the work. Each of the rows represents a category of a sonic effect, while the columns represent a fixed unit of time.

2. *Allocation of the Sound Events:* This step includes direction on how to allocate each category of sonic effect on the cells of the matrix. The category of effects are distributed using the Poisson probability distribution formula. This will produce an estimated number of times a sound event will occur within the overall given time span.

3. *Allocation of the Sound Events Across the Columns:* Poisson probability distribution formula is re-applied to determine the number of times a sound event is distributed amongst the columns.

4. *Allocation of the Sound Events Across the Rows:* Poisson probabil-

ity distribution formula is re-applied to determine the number of times a sound event is distributed amongst the rows.

5. *Definition of the Sound Events - Material and Form:* At this stage, the form and materiality of each sound event are specified.

6.*Micro-composition - A Designers Touch:* This is where the designer's touch comes in to make fine adjustments or alterations.

7. *Final Compositional Result:* This is where the graphical notations are converted into the final architectural visualisation.

8. *Sonic Realisation - A Reflective Essay:* This is where a journey through the composition is explored through an essay and reflects on how working with sound during the thesis process and how sound research impacted the author's internal soundscape and social cultural sound milieu sociological view not only as a designer but as a listener.

5.2 Organisation of a Formal Structure

In Achorippsis, Xenakis scores twenty-one instruments and uses experimentation to determine the overall compositional form stochastically. Here nineteen phsical contextual elements are scored. The resultant form uses a chess-like board game. Xenakis called this the 'matrix.' Xenakis used Poisson's law of probability to produce the matrix of the music score. As Arsenault notes, "Xenakis refers to Poisson's formula only in the context of the rationale and of the process for manufacturing the template into which music is to be placed."[66] This same idea is employed in producing a template in which to place the score. Each of the rows represents a category of sonic effect, while the columns represent a fixed unit of time. Just as Xenakis defined seven timbres for the rows, here five categories of sonic effects are defined. As Augoyard and Torgue state, defining these categories of sonic effects help to specify different relations between the sound environment and the listener. The five categories are defined as follows:

Elementary Effects (Filtration, Resonance)

Elementary effects are quantifiable and associated with modern acoustic knowledge. They are associated with sound material itself such as pitch, intensity, attack and timbre.

Compositional Effects (Cut-out, Drone, Mask, Wave)

Composition effects are defined by complex sound arrangements that

66 Linda M, Arsenault, Innais Xenakis's "Achorripsis": The Matrix Game (MIT Press, 2002), 58.

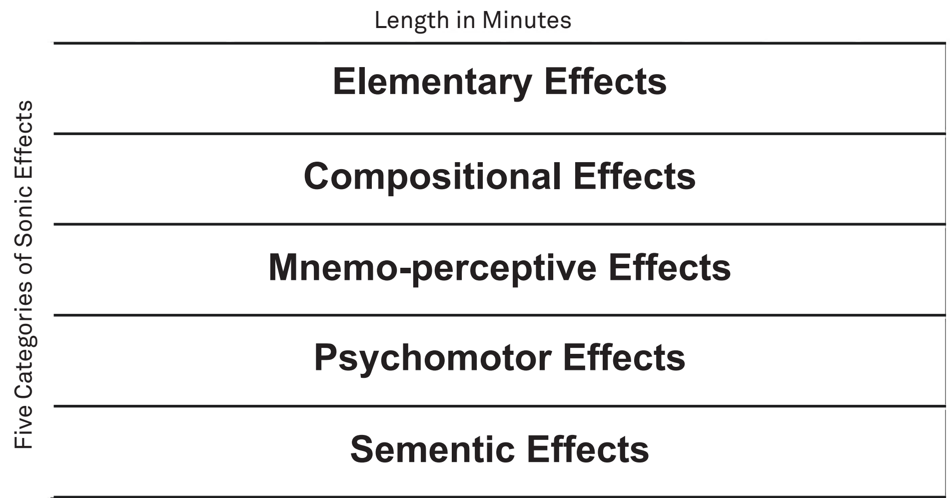


Figure 67 - The five categories of sonic effects.

are subjected to at least one physical object.

Mnemo-perceptive Effects (Metamorphosis)

Mnemo-perceptive effects are related to what is known as perceptive organisation in psychology which involves the individual listener's perception of grouping complex characters of the sound environment to understand it as a whole.

Psychomotor Effects (Niche)

Psychomotor effects are concerned with movement of the listener and cognitive functions.

Semantic Effects (Imitation)

Semantic effects are concerned with the meaning of a given context and the individuals perceptive significance. This is also known as de-contextualisation.

Xenakis subjectively determined that the length of his piece would be seven minutes in length. The twenty-eight columns therefore lasted fifteen seconds each. In the case of this matrix, the total length of the site and the average speed of a walking pedestrian are the factors that determine the length of the piece in minutes. The columns were calculated based on time and distance. The following formula was used to calculate the duration of each column.

Time = Distance

Speed

= 0.3 km

5.0 km/hr

= 0.06 hours

= 3.6 min

=216 sec

10 equal spaces

= 21.6 sec

Therefore, each column lasts 21.6seconds. The units of time are 21.6 seconds, which equals 10 columns over the 300meter distance. This resulted in five rows multiplied by ten columns equalling a total of fifty cells in the matrix.

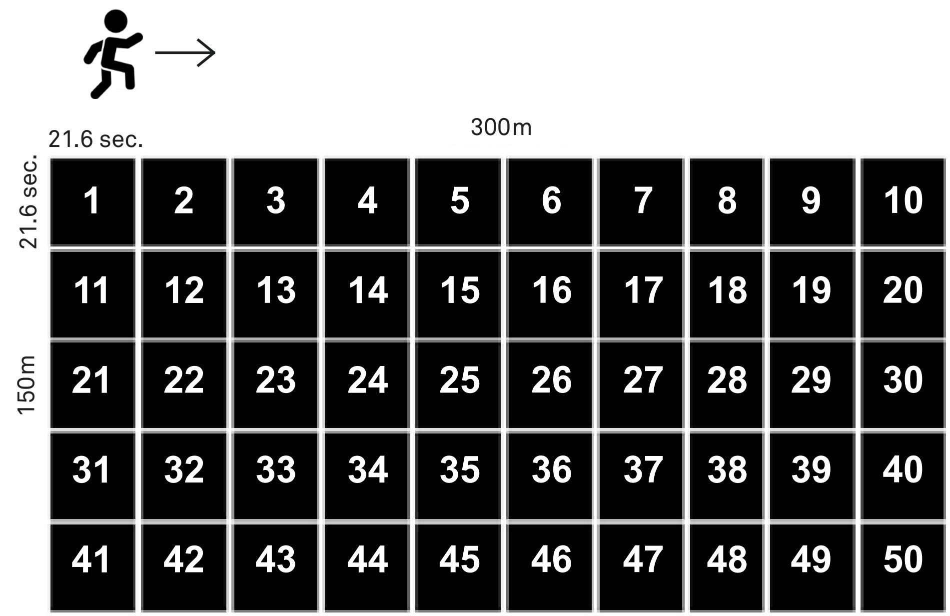


Figure 68 - The 50 cells of the matrix, made up of 5 rows and 10 columns..

POISSON'S DISTRIBUTION FORMULA

$$P(x;\lambda) = \frac{\lambda^x e^{-\lambda}}{x!}$$

DEFINED VALUES OF THE FORMULA

λ = mean number of successors in a given time period

x = number of successes we are interested in

e = Euler's constant (2.71828)

x! = product of all positive integers less than zero equal to x

Example:
x = 2
2! = 2x1 =2

Figure 69 - (upper) Poisson's Distribution Formula used for probability calculations. (lower) Defined values for Poisson's Distribution Formula.

5.3 Allocation of the Sound Events

Just as Xenakis used the probability theory of the Swiss mathematician Simeon Denis Poisson to furnish the musical structure of "Achorripsis," so does this thesis. As Arsenault explains, "The Poisson distribution may be used to describe a variety of applications, primarily those in which events are rare and involve both space and time, "[67] such as sound (time) and space (form). Xenakis for his part arbitrarily determined that 0.6 events would occur on average in each cell. It is said that he chose 0.6 because it made some of the calculations easier to compute by hand. Since Xenakis arbitrarily used 0.6 as the number of events per cell, so does this thesis. In allocating the types of sonic events, the Poisson distribution formula is used. This formula is used to estimate the number of times a specific event occurs within a given time period. In "Achorripsis" the formula was used to determine the probability ofP(0), P(1), P(2), P(3), P(4) or P(5) events occurring in any given cell. In this thesis, the formula is used to determine the number of P(0), P(1), P(2) or P(3) sonic event in the fifty cells of the matrix.

67 Linda M, Arsenault, Innais Xenakis's "Achorripsis": The Matrix Game (MIT Press, 2002), 58.

The probability that P(0) sound event occurs in the matrix is determined by Poisson's formula as seen in the example calculation. As seen in the example calculation the chance that P(0) sound event occur in a given cell is 54.88%. Continuing the calculations, it is also determined that:

P(1) = 0.329286982 x 100 = 32.93%

P(2) = 0.089786094 x 100 = 9.88%

P(3) = 0.019757219 x 100 = 1.98%

P(4) = 0.002963583 x 100 = 0.30%

Once the probabilities governing the occurrence of the sound events are determined, it is possible to calculate the number of cells that will contain each of the P(0),P(1),P(2),P(3) or P(4) sound event. This is arrived at simply by multiplying the number of cells in the matrix by each probability. The results can be seen as follows:

n(0) = P(0) x N = 0.548811636 x 50 = 27 (rounded up)

n(1) = P(1) x N = 0.329286982 x 50 = 16 (rounded up)

n(2) = P(2) x N = 0.089786094 x 50 = 5 (rounded up)

EXAMPLE CALCULATION

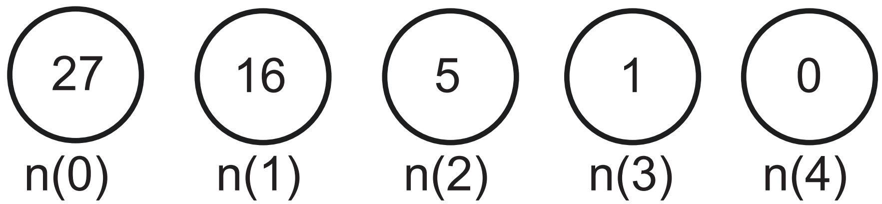
$$P(x) = \frac{\lambda^x e^{-\lambda}}{x!}$$

where;
x=0
lambda=0.6
e=2.71828
x!=1

$$P(0) = \frac{0.6^0 (2.71828)^{-0.6}}{1}$$

P(0) = 0.548811636

Figure 70 - (upper) Example calculation using Poisson's Distribution Formula. (lower) This chart shows the probability of each type of landscape typology occuring.



P0	0.548811636	50	27
P1	0.329286982	50	16
P2	0.098786094	50	5
P3	0.019757219	50	1
P4	0.002963583	50	0
	0.999605514		50

Figure 71 - The number of P(0), P(1), P(2), P(3) sound events to be distributed amongst the matrix.

n(3) = P(3) x N = 0.019757219 x 50 = 1 (rounded up)

n(4) = P(4) x N = 0.002963583 x 50 = 0

The sum of the number of cells in the matrix where (P0), (P1), (P2), (P3) or (P4) sound event occur is equal to fifty and the values are rounded up in the same way that Xenakis rounded his values up to equal a whole number of cells.

5.4 Allocation of the Sound Event Across the Columns

Once the matrix was laid out and the number of probabilities of distribution was determined using Poisson's calculation and the number of each type of sound event was figured out in the matrix, the next step was to decide how these events get distributed among the columns and the rows of the matrix. Xenakis asked the questions, should they merely be placed randomly? Alternatively, should there be rules to guide the placement of the events?[68] Xenakis's solution to the problem was to reapply Poisson's law for each kind of event in order to establish general rules to govern the distribution of the fifty cells.[69] The decision was to follow the same set of rules governed by Poisson's

68 Linda M, Arsenault, Innais Xenakis's "Achorripsis": The Matrix Game (MIT Press, 2002), 61.

69 Ibid.

formula to determine the distribution of the columns and rows. The example calculations and tables show the distribution for the columns of the matrix for the sound event a P(0), P(1), P(2), P(3) or P(4) event will be distributed.

First, within the ten columns, new lambda values needed to be calculated. Consider, for example, the number of P(0) events, which was found to be twenty-seven. In order to get the lambda value of P(0) events per column twenty-seven needs to be divided by ten, using the formula for calculating lambda. This formula is applied to P(1), P(2), P(3) sound event.

Next Poisson's equation is applied to compute the probability of the P(0) events using the new calculated lambda values. The number of columns in which there will be P(0) events is equal to 0.067206 x 10 = 1 (rounded up). If the same process using Poisson's formula is followed, we end up with the results seen in the table. The same procedure is followed applying Poisson's formula for the remaining P(1), P(2), P(3) and P(4) events.

NEW LAMBDA VALUES FORMULA

$$\lambda = \frac{x}{n}$$

(COLUMNS)

$$\lambda = \frac{27}{10}$$

$$\lambda = 2.7$$

P0	
Lambda = 2.7 (columns)	Probab
0	0.067
1	0.181

P1	
Lambda = 1.6 (columns)	Probab
0	0.201
1	0.323

P2	
Lambda = 0.5 (columns)	Probab
0	0.606
1	0.303

P3	
Lambda = 0.1 (columns)	Probab
0	0.904
1	0.090

POISSON'S DISTRIBUTION FORMULA

$$P(x;\lambda) = \frac{\lambda^x e^{-\lambda}}{x!}$$

Figure 72 - *(upper) Formula for finding new lambda values.*
(lower) Example calculation for finding new lambda values for columns.

P0				
Frequency	Probability	Columns	Number of Columns	Placement on Matrix
0	0.067206	10	1	C4
1	0.181455	10	2	C10,C3
2	0.244964	10	2	C1,C2
3	0.220468	10	2	C8,C9
4	0.148816	10	2	C5,C7
5	0.08036	10	1	C6
6	0.036162	10	0	
7	0.013948	10	0	
8	0.004708	10	0	
9	0.001412	10	0	
10	0.000381	10	0	
	0.99988		10	

P1				
Frequency	Probability	Columns	Number of Columns	Placement on Matrix
0	0.201897	10	2	C8,C6
1	0.323034	10	3	C5,C1,C7
2	0.258428	10	3	C4,C9,C3
3	0.137828	10	1	C2
4	0.055131	10	1	C10
5	0.017642	10	0	
6	0.004705	10	0	
7	0.001075	10	0	
8	0.000215	10	0	
9	3.82E-05	10	0	
10	6.12E-06	10	0	
	0.999999		10	

P2				
Frequency	Probability	Columns	Number of Columns	Placement on Matrix
0	0.606531	10	6	C2,C5,C6,C7, C9,C10
1	0.303265	10	3	C1,C4,C8
2	0.075816	10	1	C3
3	0.012636	10	0	
4	0.00158	10	0	
5	0.000158	10	0	
	0.999986		10	

P3				
Frequency	Probability	Columns	Number of Columns	Placement on Matrix
0	0.904837	10	9	C1,C2,C3,C5, C6,C7,C8,C9, C10
1	0.090484	10	1	C4
2	0.004524	10	0	
3	0.000151	10	0	
4	3.77E-06	10	0	
5	7.54E-08	10	0	
	1		10	

Figure 73 - *Values for total events distributed for columns.*

5.5 Allocation of the Sound Events Across the Rows

Using the Poisson distribution formula, the distribution of P(0), P(1), P(2), P(3) and P(4) events across the rows is determined. This distribution is calculated in the exact same way as for the columns. However, the events are divided by the number of rows, which is five.

5.6 Definition of the Sound Events - Material and Form

Thus far the number of P(0), P(1), P(2), P(3), and P(4) events have been predicted, as has the manner in which the events are going to be distributed amongst the columns and rows. The next step is to define what each of these sonic events is going to be.

As Xenakis chose to define the sonic events in *Achorripsis* with properties such as glissandi of certain instruments, pitch intervals, duration and speed, this thesis defines the sonic events based on architectural forms and materials to create a place that encourages the production of sonic effects, as listed in the book titled *Sonic Experience: A Guide to Everyday Sounds*. The composition of materials and forms aims to create a varied soundscape to invite people to explore and study the aural aspect of the urban sound environment. These architectural forms and materials were chosen and interpreted based on research by Jean-Francois Augoyard and Henry Torgue's team of urban planners, composers, sociologists, psychologists and acousticians at CRESSON and Max Neuhaus's ideas of sound shaping with vegetation. Some of these properties include pockets of low-density sounds using natural materials as filters, such as the density and type of vegetation, the diverse materiality of the hard and softscapes, and the programmatic physical structures introduced. The approach to the materiality was kept simple, and it was broken down into three main categories: hardscapes, softscapes, and vegetation.

Materiality

The hardscapes used include concrete and wood, while the softscapes are grass and sand. The various types of vegetation used are pine trees, maple trees, deciduous shrubs, black-eyed susans, Karl Forester grass, cherry trees, bamboo, Royal Empress trees, wind whisperer feathered grass and various ground covers. These materials were picked based on various sonic factors such as how they

NEW LAMBDA VALUES FORMULA

$$\lambda = \frac{x}{n}$$

(ROWS)

$$\lambda = \frac{27}{5}$$

$$\lambda = 5.4$$

P0	
Lambda = 5.4 (rows)	Proba
0	0.00
1	0.0

P1	
Lambda = 3.2 (rows)	Probab
0	0.040
1	0.130
2	0.208

P2	
Lambda = 1 (rows)	Probabi
0	0.3678
1	0.3678
2	0.183
3	0.0613

P3	
Lambda = 0.2 (rows)	Probab
0	0.818
1	0.163
2	0.016

POISSON'S DISTRIBUTION FORMULA

$$P(x;\lambda) = \frac{\lambda^x e^{-\lambda}}{x!}$$

Figure 74 - *(upper) Formula for finding new lambda values.*
(lower) Example calculation for finding new lambda values for rows.

reflect sound, absorb sound, produce sound with changing seasons, and produce sound with environmental factors such as wind.

The hardscape of concrete was chosen for its reflective properties of sound. Wood on the other hand has properties of absorbing sound. The reverberant and absorbent elements of these sonic events is an open cell with either an absorbent material like grass, sand or wood or a hard reverberant material like stone or concrete. As stated by Augoyard and Torgue, “the natural environment also features reverberant (cave, water, rocks, forest) and absorbent (grass, snow) milieus and elements.”[70] An example would be pedestrian footsteps on concrete produces a much different sound than on wood. The same concept can be applied to the softscapes chosen such as grass and sand. Although both are absorptive sound properties they have the ability to produce different sounds when coupled with pedestrian footsteps.

The various types of vegetation introduced were included based on these different abilities of manipulating and producing sound. Pine trees in particular are one type of tree, as Max Neuhaus has pointed out, that have the ability to produce a unique sound by dropping their pine needles. As the pine needles drop they rub together and create

P0				
Frequency	Probability	Rows	Number of Rows	Placement on Matrix
0	0.0045166	5	0	
1	0.0243895	5	0	
2	0.0658518	5	0	
3	0.1185332	5	1	R3
4	0.1600198	5	1	R4
5	0.1728213	5	1	R2
6	0.1555392	5	1	R5
7	0.1199874	5	1	R1
8	0.0809915	5	0	
9	0.0485949	5	0	
10	0.0262412	5	0	
11	0.0128821	5	0	
12	0.0057969	5	0	
13	0.002408	5	0	
	0.9985732		5	

P1				
Frequency	Probability	Rows	Number of Rows	Placement on Matrix
0	0.0407622	5	0	
1	0.1304391	5	1	R1
2	0.2087025	5	1	R2
3	0.222616	5	1	R3
4	0.1780928	5	1	R5
5	0.1139794	5	1	R4
6	0.060789	5	0	
7	0.0277893	5	0	
8	0.0111157	5	0	
9	0.0039523	5	0	
10	0.0012647	5	0	
11	0.0003679	5	0	
			5	

P2				
Frequency	Probability	Rows	Number of Rows	Placement on Matrix
0	0.3678794	5	2	R4,R5
1	0.3678794	5	2	R1,R2
2	0.1839397	5	1	R3
3	0.0613132	5	0	
4	0.0153283	5	0	
5	0.0030657	5	0	
			5	

P3				
Frequency	Probability	Rows	Number of Rows	Placement on Matrix
0	0.8187308	5	4	R1,R3,R4,R5
1	0.1637462	5	1	R2
2	0.0163746	5	0	
3	0.0010916	5	0	
4	5.458E-05	5	0	
5	2.183E-06	5	0	
			5	

Figure 75 - *Values for total events distributed for rows.*

70 Jean-Francois Augoyard, Henry Torgue. Sonic Experience: A Guide to Eeryday Sounds (McGill Queens Press, 2006), 114.

a continuous whimsical sound. The dropped pine needles cover the ground create a layer of acoustical insulation, adding an absorbent quality to the area under the trees.

Other trees such as maple, oak and cherry create unique sounds when compiled with natural elements such as wind. When the wind blows through the trees and rustles the branches a continuous sound is formed. Their sound properties also change with the seasons making them a good choice of material for the final composition. Although these materials have their own sound producing capabilities and sound properties when material is combined with form it again creates the potential for creating unique sound properties. As stated by Augoyard and Torgue, the sound designer attempts to create, or at least signify, a countryside atmosphere in the city.[71] The attempt to create micro-environments of rural space within the city is attempted by placing dense pockets of vegetation. These pockets of dense varying types of vegetation are placed throughout the park. Examples are a densely packed bamboo forest, which creates the distinctive clanking of bamboo stalks, or a forest of a local species of trees with the sound of wind rustling the leaves. Natural sounds such as the leaves rustling in the wind coupled with amplification imitates a rural setting, adding

71 Jean-Francois Augoyard, Henry Torgue. Sonic Experience: A Guide to Eeryday Sounds (McGill Queens Press, 2006), 64.

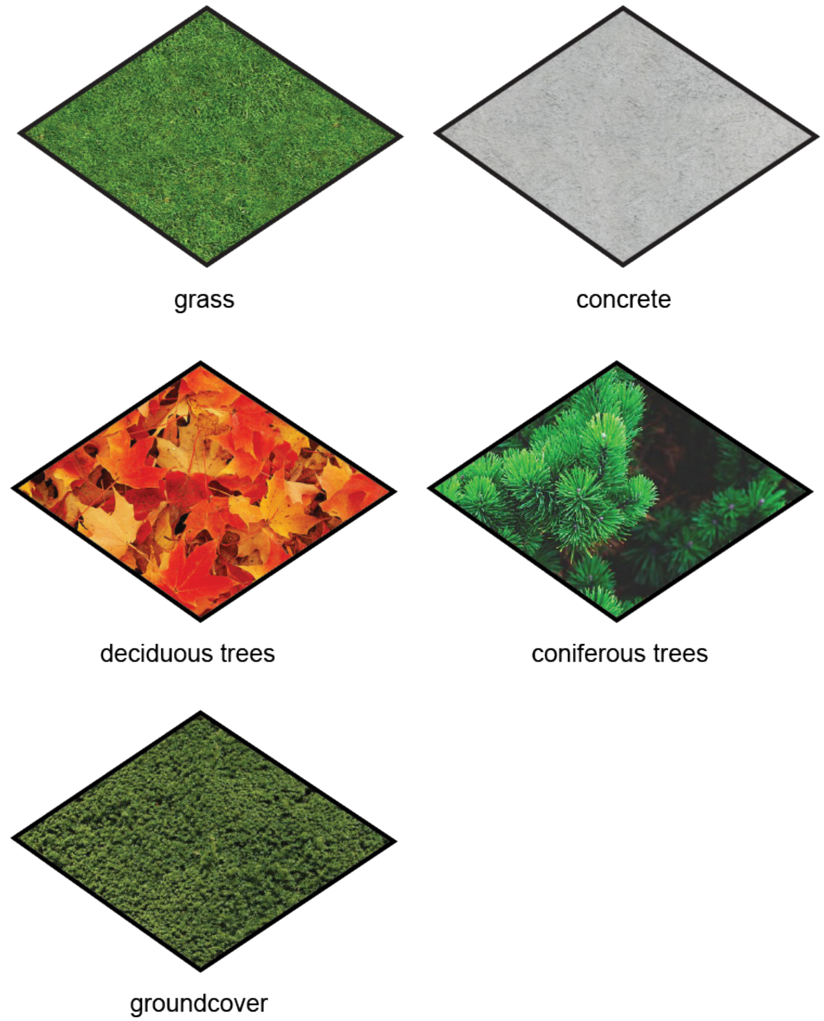
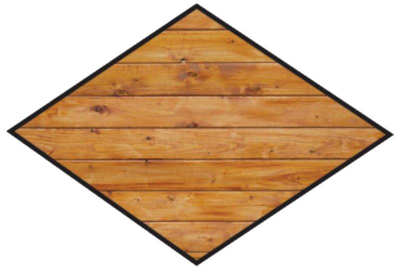


Figure 76 - Materials used in the composition.

sand



wood

tall grasses

flowers

to the composition, and bringing a new sonic element to Washington Square Park.

Sound Objects

The forms and objects introduced to the composition are moving walkways, rentable segways, outdoor rooms, amplification using speakers, dense vegetation, grade changes, acoustical screens, outdoor rooms, stairways, curved and parallel walls. These objects were picked based on their ability to manipulate sound.

The objects such as the moving walkways and the Segways introduce pedestrian movement that is faster than walking but also increases the chances of passing a stationary sound source at a speed faster than walking. Outdoor rooms provide a passage for pedestrians to walk through or occupy to cut out sounds.

The outdoor rooms create a micro urban plaza space within the park. As people walk by the paths that are cut out of the blocks they will pass sound sources being emitted inside the plaza. As one walks or stands on the moving walkway or rides by on a Segway around the perimeter, one will experience the sound being cut-out, but while inside the structure, one will experience a plaza space much like a plaza found in the city. As Augoyard and Torgue state, the appearance of the effect is based on the relative position of the listener to the sound source. In the first example, the listener is moving. For example, the listener is walking through a door. The sound door is made by positioning constructed elements to be used as acoustical screens in relation to induced progressions.[72]

Amplification of both natural and human-made sounds creates the opportunity for pedestrians to listen to or listen for sounds they have not noticed before. Walls are introduced at various curved radii and heights to initiate reflection of sounds and filtering of sounds. Much like the walls, acoustical screens are introduced to act as filters for the passerby to sit behind. Curved reverberant walls are introduced for their ability to concentrate sound in a focal point to encourage musical performances. As Augoyard and Torgue state, “street singers and musicians always place themselves at points where the architecture will reinforce the propagation of their music: in a large square, facing

72 Jean-Francois Augoyard, Henry Torgue. Sonic Experience: A Guide to Eeryday Sounds (McGill Queens Press, 2006), 33.

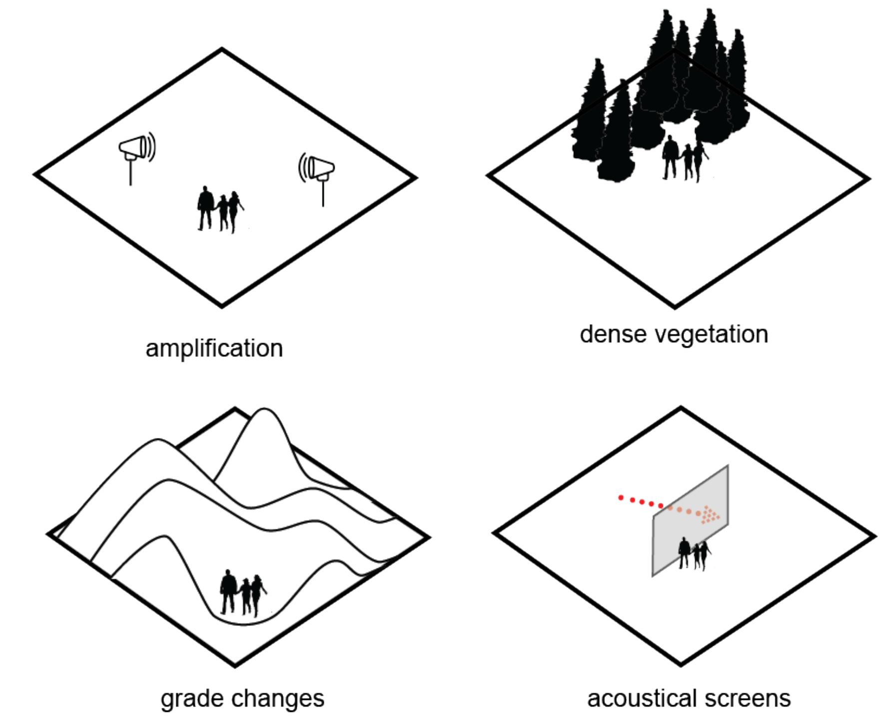
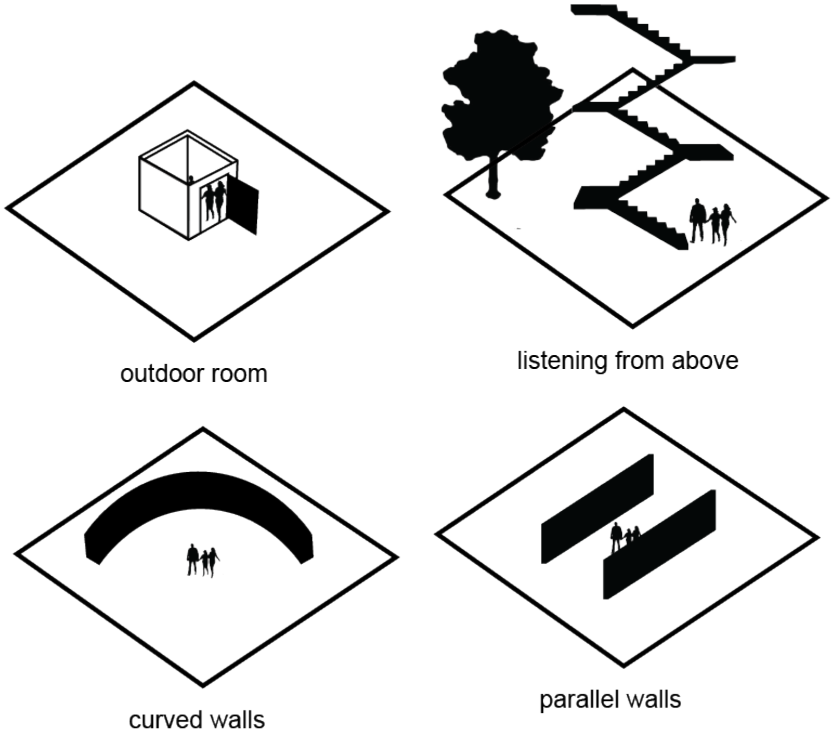


Figure 77 - Objects used in the composition.



a reflecting wall, at the meeting point of several galleries, or in subway corridors”.[73]

The curved shape of the walls is optimal for acoustics, producing reverberation and echoing that adds a sonic dimension to both artists’ performances and protesters’ messages. When not occupied by musicians or performers, these curved walls provide private spaces for individuals to retreat to for listening.

Stairways are added to encourage listening both amongst the tree tops and above the tree tops, at the same time offering expansive views of the park.

As Augoyard and Torgue state, “finally the same effect can occur when we listen from an elevated location because the height ‘equalizes’ sound sources in terms of frequencies, by a loss in the high range and makes the distinction of isolated sound shapes more difficult. The simple experiment of listening to outside sounds from the top of a high building provides an excellent illustration of the function of height in the transformation of a sound ambience through different perceptions.”[74] This is brought to the park in architectural staircases. The stairs, in turn, create an elevated space for listening within the park.

73 Jean-Francois Augoyard, Henry Torgue. Sonic Experience: A Guide to Eeryday Sounds (McGill Queens Press, 2006), 81.

74 Jean-Francois Augoyard, Henry Torgue. Sonic Experience: A Guide to Eeryday Sounds (McGill Queens Press, 2006), 76.

Although materials and forms were chosen separately the combination of these materials and forms add another layer to the possibilities of unique sound generation within the composition. Each one of these materials and forms were distributed and placed amongst the columns and rows using phase three and four of the above proposed methodology.

5.7 Micro-composition - A Designer's Touch

The result of Phase one to Phase five is a machine like process. Materials and forms decided on by the architect or designer follow the process of the proposed methodology and a corresponding stochastic matrix produced. However, Poisson's formula can only take us so far, and the artistic hand of the architect or designer helps shape the urban sound environment. The architect acts in much the same way as a composer, when a composer uses his or her ears to make final compositional decisions on a piece of music. It is phase six of the proposed methodology, where decisions are made such as what is to be kept on the existing site and what is to be added to the existing site. These decisions do not take a mathematical approach but instead

	C1	C2	C3	C4	C5
R5	GRASS	CONCRETE	GRASS	GRASS	CONCRETE
	MAPLE	PINE	MAPLE	MAPLE	PINE
	SHRUBS	BES	SHRUBS	SHRUBS	BES
	KF	BAMBOO	KF	KF	BAMBOO
R4	CONCRETE	GRASS	CONCRETE	GRASS	GRASS
	PINE	MAPLE	PINE	MAPLE	MAPLE
	BES	SHRUBS	BES	SHRUBS	SHRUBS
	BAMBOO	KF	BAMBOO	KF	KF
R3	WOOD	GRASS	GRASS	WOOD	CONCRETE
	CHERRY	MAPLE	MAPLE	CHERRY	PINE
	GROUNDCOVER	SHRUBS	SHRUBS	GROUNDCOVER	BES
	WWFG	KF	KF	WWFG	BAMBOO
R2	CONCRETE	GRASS	WOOD	WOOD	CONCRETE
	PINE	MAPLE	CHERRY	CHERRY	PINE
	BES	SHRUBS	GROUNDCOVER	GROUNDCOVER	BES
	BAMBOO	KF	WWFG	WWFG	BAMBOO
R1	CONCRETE	CONCRETE	WOOD	CONCRETE	CONCRETE
	PINE	PINE	CHERRY	PINE	PINE
	BES	BES	GROUNDCOVER	BES	BES
	BAMBOO	BAMBOO	WWFG	BAMBOO	BAMBOO

Figure 78- *Resultant matrix - materials.*

CONCRETE	CONCRETE	CONCRETE	GRASS	CONCRETE
PINE	PINE	PINE	MAPLE	PINE
BES	BES	BES	SHRUBS	BES
BAMBOO	BAMBOO	BAMBOO	KF	BAMBOO
CONCRETE	GRASS	WOOD	CONCRETE	GRASS
PINE	MAPLE	CHERRY	PINE	MAPLE
BES	SHRUBS	GROUNDCOVER	BES	SHRUBS
BAMBOO	KF	WWFG	BAMBOO	KF
CONCRETE	CONCRETE	SAND	GRASS	GRASS
PINE	PINE	ROYAL EMPRES	MAPLE	MAPLE
BES	BES	SHRUBS	SHRUBS	SHRUBS
BAMBOO	BAMBOO	LAVENDER	KF	KF
CONCRETE	CONCRETE	CONCRETE	CONCRETE	GRASS
PINE	PINE	PINE	PINE	MAPLE
BES	BES	BES	BES	SHRUBS
BAMBOO	BAMBOO	BAMBOO	BAMBOO	KF
CONCRETE	CONCRETE	CONCRETE	CONCRETE	GRASS
PINE	PINE	PINE	PINE	MAPLE
BES	BES	BES	BES	SHRUBS
BAMBOO	BAMBOO	BAMBOO	BAMBOO	KF
C6	**C7**	**C8**	**C9**	**C10**

use a more conventional way of making design decisions used by architects and designers. These decisions are based on things such as, urban design best practices, research, visual aesthetics, historic significance, existing conditions and functional programmatic uses, to name a few. As the designer for this composition of Washington Square Park, my decisions were based on studying the park's history, the factors that make it such an iconic destination. Two questions were posed, What should be kept to preserve its diversity and iconic status? What could be added to make it a destination for listening? As suggested in the historical overview of the site, it is clear that Washington Square Park was and is an important factor in the planning and evolution of Greenwich Village. As the park evolved from a potter's field to a parade ground and into a park, the neighbourhood grew around it and the park in turn has become enveloped into the pulse of Greenwich Village. The political and social impact this park has had on Greenwich Village is a testimony to the importance of preserving some aspects of the existing park.

Studying Schafer's methodologies for classifying a soundscape and Anne Guthrie's techniques for ear cleaning not only reinforced the preservation of the arch and fountain but inspired the addition of a soundwalk and wayfinding. The auxiliary layers of soundwalk and wayfinding engage with the idea of pulse and path to sculpt and deploy new programmatic series. The proposition for the micro-composition of Washington Square Park is that the two auxiliary layers, soundwalk and wayfinding, will respond to the layers being preserved adding to the composition of the park through the synthesis of layering, preserving and using existing programs, and introducing new layers. These new layers will blend with the existing layers and bring a new dimension to Washington Square Park.

The Layers Preserved - Landmark

While conducting early investigations into soundscapes, it soon became clear that Schafer was one of the leading and most significant researchers working within this area. He was a pioneer in investigating and experimenting with urban soundscapes. After studying his theories and reading a number of his books, a strategy was developed for the final proposal based on his methodologies for investigating soundscapes. The relationship between the existing park and

R5	DENSE VEGETATION	DENSE VEGETATION	CURVED WALLS	CURVED WALLS	DENSE VEGETATION
	ACOUSTICAL SCREENS	AMPLIFICATION	ACOUSTICAL SCREENS	ACOUSTICAL SCREENS	AMPLIFICATION
	PARALLEL WALLS		PARALLEL WALLS	PARALLEL WALLS	
R4	DENSE VEGETATION	CURVED WALLS	DENSE VEGETATION	CURVED WALLS	CURVED WALLS
	AMPLIFICATION	ACOUSTICAL SCREENS	AMPLIFICATION	ACOUSTICAL SCREENS	ACOUSTICAL SCREENS
		PARALLEL WALLS		PARALLEL WALLS	PARALLEL WALLS
R3	STAIRWAYS	CURVED WALLS	CURVED WALLS	STAIRWAYS	DENSE VEGETATION
	GRADE CHANGES	ACOUSTICAL SCREENS	ACOUSTICAL SCREENS	GRADE CHANGES	AMPLIFICATION
	MOVING WALKWAYS	PARALLEL WALLS	PARALLEL WALLS	MOVING WALKWAYS	
R2	DENSE VEGETATION	CURVED WALLS	STAIRWAYS	STAIRWAYS	DENSE VEGETATION
	AMPLIFICATION	ACOUSTICAL SCREENS	GRADE CHANGES	GRADE CHANGES	AMPLIFICATION
		PARALLEL WALLS	MOVING WALKWAYS	MOVING WALKWAYS	
R1	DENSE VEGETATION	DENSE VEGETATION	STAIRWAYS	DENSE VEGETATION	DENSE VEGETATION
	AMPLIFICATION	AMPLIFICATION	GRADE CHANGES	AMPLIFICATION	AMPLIFICATION
			MOVING WALKWAYS		
	C1	C2	C3	C4	C5

Figure 79- *Resultant matrix - sound objects.*

C6	C7	C8	C9	C10
DENSE VEGETATION	DENSE VEGETATION	DENSE VEGETATION	CURVED WALLS	DENSE VEGETATION
AMPLIFICATION	AMPLIFICATION	AMPLIFICATION	ACOUSTICAL SCREENS	AMPLIFICATION
			PARALLEL WALLS	
DENSE VEGETATION	CURVED WALLS	STAIRWAYS	DENSE VEGETATION	CURVED WALLS
AMPLIFICATION	ACOUSTICAL SCREENS	GRADE CHANGES	AMPLIFICATION	ACOUSTICAL SCREENS
	PARALLEL WALLS	MOVING WALKWAYS		PARALLEL WALLS
DENSE VEGETATION	DENSE VEGETATION	RENTABLE SEGWAYS	CURVED WALLS	CURVED WALLS
AMPLIFICATION	AMPLIFICATION	OUTDOOR ROOM	ACOUSTICAL SCREENS	ACOUSTICAL SCREENS
		PARALLEL WALLS	PARALLEL WALLS	PARALLEL WALLS
DENSE VEGETATION	DENSE VEGETATION	DENSE VEGETATION	DENSE VEGETATION	CURVED WALLS
AMPLIFICATION	AMPLIFICATION	AMPLIFICATION	AMPLIFICATION	ACOUSTICAL SCREENS
				PARALLEL WALLS
DENSE VEGETATION	DENSE VEGETATION	DENSE VEGETATION	DENSE VEGETATION	CURVED WALLS
AMPLIFICATION	AMPLIFICATION	AMPLIFICATION	AMPLIFICATION	ACOUSTICAL SCREENS
				PARALLEL WALLS

his theories was derived from one of his definitions for classifying a soundscape: soundmarks. The study of Schafer's methodologies for classifying a soundscape led to the preservation of a key element of the existing park. This element is the Washington Square Arch. Not only does the arch represent a significant element in the history of America but also has the potential to play an important role in the sound environment of the park.

The term soundmark is derived from the term landmark. According to Schafer, soundmarks deserve to be protected in the same way landmarks are because they make the acoustic life of a community unique. In architecture, the term 'landmark' is usually used to refer to a primary visual aspect of a city. Landmarks are also used as markers for navigation: many buildings become landmarks as people navigate through busy urban cores. Since Schafer made soundmarks a significant element of his soundscape studies it was determined that a landmark would be necessary as another architectonic layer of the new urban park. Since Washington Square Park already has a prominent landmark—the Washington Square Arch—it was decided that adding an aural component to the existing landmark would make the most sense. The aural component selected was an anechoic chamber within the existing arch; and access to the roof where listening to the urban environment from above could take place. These aural elements would introduce what Schafer would call an ‘ear-cleaning’ component to the final proposal.

The famous seventy-two foot six inch tall arch, standing at the most popular entrance of the new urban park, rises prominently within the urban context of New York. The result is a tourists destination and an attention-catching element of the cityscape that can be seen from blocks away down Fifth Avenue and several other streets intersecting Washing Square Park. Through the repurposing of the existing stairs , it is hoped that people from the nearby art schools and theatres, people on break from work, or students from New York University will stop and experience the arch not only from a visual perspective but also from the interior anechoic chamber and from atop the roof as they are passing through the new urban park.

At the base of the arch, visitors would have the option of using the stairs in the right column to make their way up to a silent chamber that spans the arch. This chamber acts as a sonic palate cleanser. As

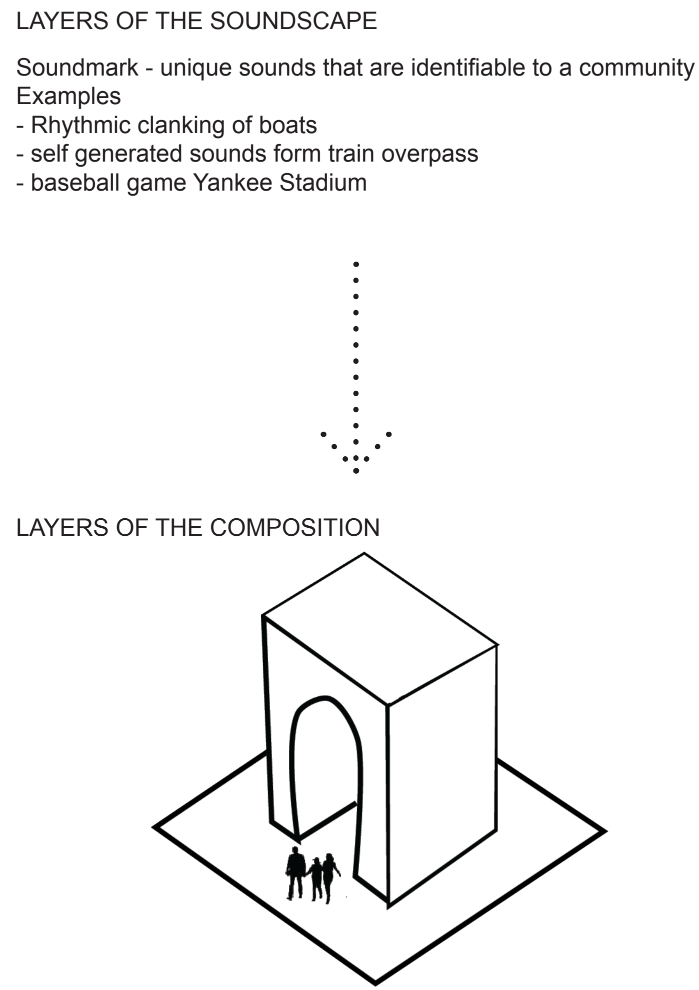


Figure 80 - *The first layer of the exisiting park being preserved is the Washington Square Arch.*

people wind up and down the arch they encounter the closest thing to silence available in public in the city and an opportunity to listen from above to the park and the city once atop the arch. At this point the arch is acting as an aural cleanser that prepares people for their encounter with the new urban park. The architectural interventions introduced in the new urban park design emphasize and isolate elements of the urban soundscape, promoting people's deeper appreciation of how architecture affects the sounds of the city, and bringing isolated attention to sounds in the city that are usually ignored or go unnoticed.

The space at the first level acts as an anechoic chamber. Darkness was selected as a component of this experience in order to enable people to focus on the aural. This space contains sixty-centimeter-deep fiberglass wedges that diffuse and absorb sound from within the space. People often become disorientated in anechoic chambers due to the lack of auditory spatial awareness that they create. This causes people to realize and appreciate their habitual dependency on the aural for wayfinding, and simultaneously acts as an aural palate cleanser. The space is fairly small so people's tolerance level for this disorientation should not be a problem as they pass through the

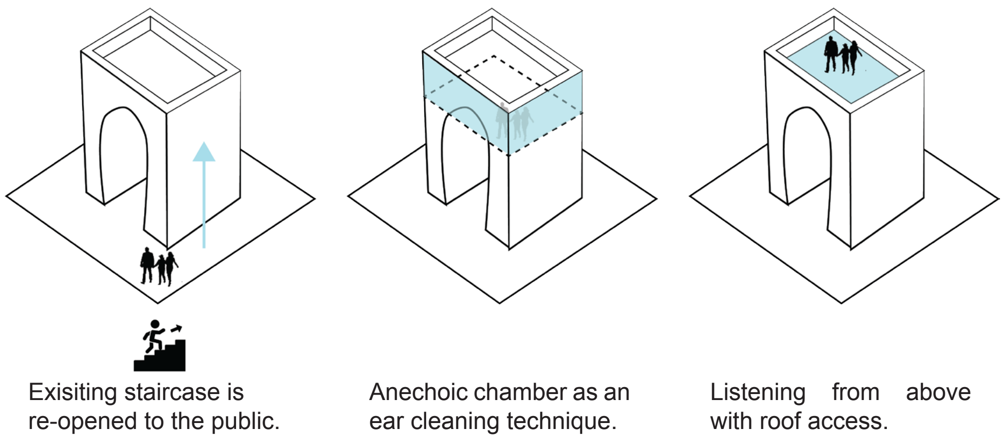


Figure 81 - *The new program of the Landmark.*

space on their way up to the roof.

Once the visitor reaches the roof, they hear the city and the park from above. One purpose of a trip through the arch is to remind people of the critical importance of sound to any understanding of the environment.

The Layers Preserved - Main Plaza

One other fundamental urban park characteristic Washington Square Park possesses is the diverse neighbourhood surrounding it. Washington Square Park, for its part, is surrounded by an area characterized by its mixed uses. A large centre serves as the climax of the park— the fountain, where most of the park's many performers set up and put on live shows, attracting a wide range of people from all over the world throughout different times of the day and year.

Finally, fountains are brought in for their ability to mask the regular drone of the urban environment and create a place where one on one conversation becomes comfortable. As Augoyard and Torgue state,

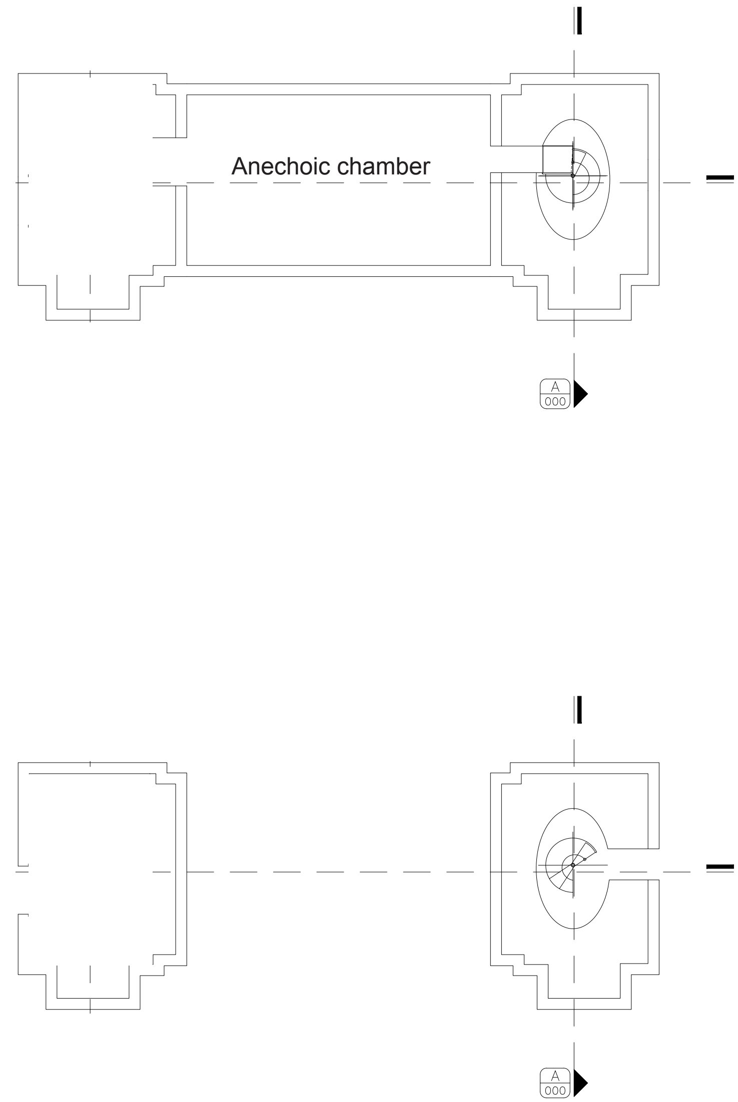


Figure 82 -*Plan of the Landmark at ground level and the second level.*

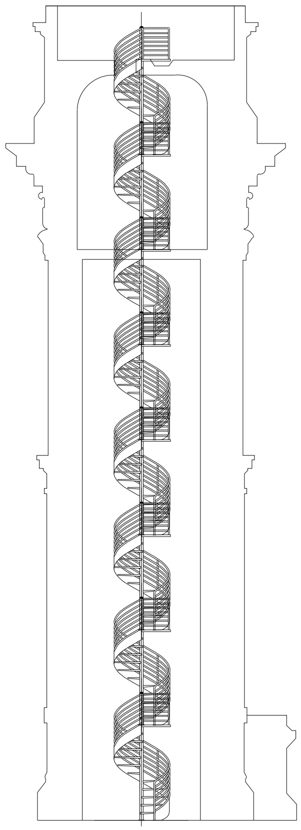


Figure 83 -*Section of the staircase in the Landmark.*

depending on the context, the same type of sound will produce different subjective perceptions. For instance, fountains create a broadband mask that makes it possible to avoid the perception of the urban drone in a city space.[75]

Not only does this fountain have a historical significance but it also plays a large role in the park's existing aural environment. The original placement of this fountain was offset from the arch. In a recent 2014 renovation of Washington Square Park the fountain was centred on the arch. This drove the community of Greenwich village to protest against the renovation of the park. The protest is a testament to the historical significance the fountain has not only to the neighbourhood of Greenwich Village but also to wider Manhattan. Based on the historical significance and the aural role the fountain plays in the park it was decided that this feature was a key element that would remain in the final composition. The placement of the fountain in the large centre plaza of the park acts as a positive background sound to mask the urban drone of Manhattan. This aural feature attracts performers and people to the main plaza for quieter intimate conversations. The foun-

75 Jean-Francois Augoyard, Henry Torgue. Sonic Experience: A Guide to Eeryday Sounds (McGill Queens Press, 2006), 68.

tain creates a micro aural space within the urban sound environment much like the cocktail party effect in a restaurant attracting people in small groups.

The Layers Auxiliary - Soundwalk

Although the preservation of the arch and the central plaza and fountain in the existing park were determined to be necessary as part of the composition it was also decided that additional layers could be added to the park to enhance the composition. The search began with Fredrick Law Olmsted's principles and characteristics employed in the design of Central Park. Although the original Washington Square Park was designed by William Tweed, the re-design of the original park was created by two of Olmsted's former colleagues, Igray Pilate and Montgomery Kellogg, who worked closely with Olmsted on Central Park. Given these shared origins, it was decided that Washington Square Park's intimate curving paths and emphasis on a natural rather than artificial feel were necessary to the newly derived matrix. The new matrix uses the design narrative of pulse to create intimate curving paths inviting entry but also a disorientating feeling while in-

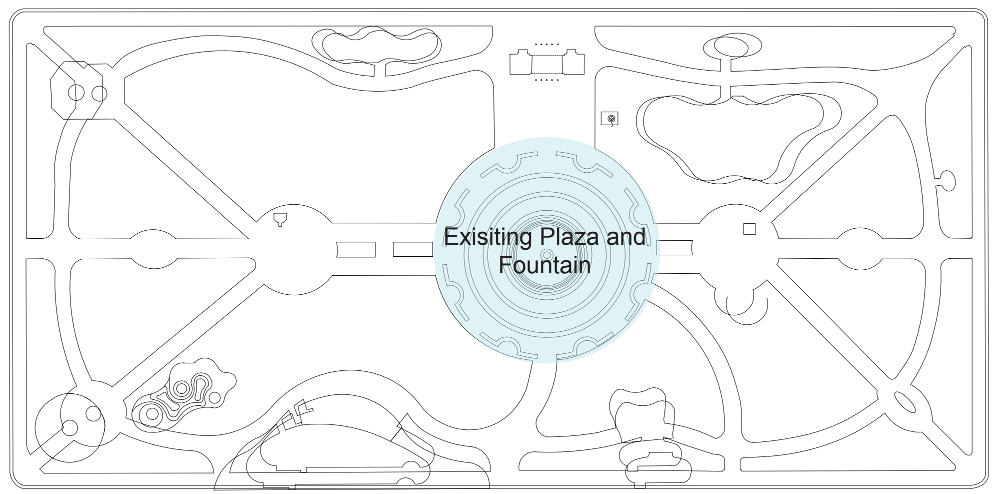


Figure 84 -*Plan of the exisiting plaza and fountain area.*

side, which works to keep people in the park, filtering them towards the fountain and the arch. The wider path that is added uses the same design narrative of pulse to create points of destination with the existing program of the park to attract more liveliness. As Jacobs states, “In cities, liveliness and variety **attract** more liveliness, deadness and monotony **repel** life.”[76] With that in mind, the design narrative of pulse and path was employed on the matrix.

A “pulse” can be defined as a single vibration or short burst of sound, electric current, light or other wave. An object that is throbbing rhythmically is said to be pulsating. The stereotypical sounds we hear as a culture when we think of New York are those sounds that make up the background noise of most urban cities: the flat continuous spectrum of cars, buses, sirens, airplanes and construction sites. Although these sounds can indeed commonly be found in New York and are the continual background and foreground spectrum of the many urban sites encountered when walking through New York’s Boroughs, one can also discover some interesting and unique sounds within the urban context, simply by listening. Anne Guthrie, a composer and acoustician, explores the technique of ear cleaning, a term invented by R. Murray Schafer. The ear cleaning technique Guthrie employs is that

76 Jane Jacobs. The Life and Death of Great American Cities. (Random House), 21.

of the soundwalk. Since the experiments were an exploration of both visualizing sound and experiencing sound through the ear, a research interest began to emerge in the final experiment that involved listening through one's ear, drawing on the idea of soundwalks. The final experiment began to explore a technique that involved deriving a path using the existing program of the park and the inverse square law. Through the study of Guthrie and Schafer's ear cleaning techniques it was decided that an additional layer to the park in the form of a soundwalk would be beneficial as an aural exercise. As Guthrie states, A form of active participation in the soundscape. "Though the variations are many, the essential purpose of the soundwalk is to encourage the participant to listen discriminatively, and moreover, to make critical judgments about the sounds heard and their contribution to the balance or imbalance of the sonic environment."[77] Although a soundwalk is usually on a pre-determined route assisted by a map, it was determined that this soundwalk would take the form of a pre-determined path, however, it would be laid by connecting existing programs of the park to create destination points passing through areas where unique moments of

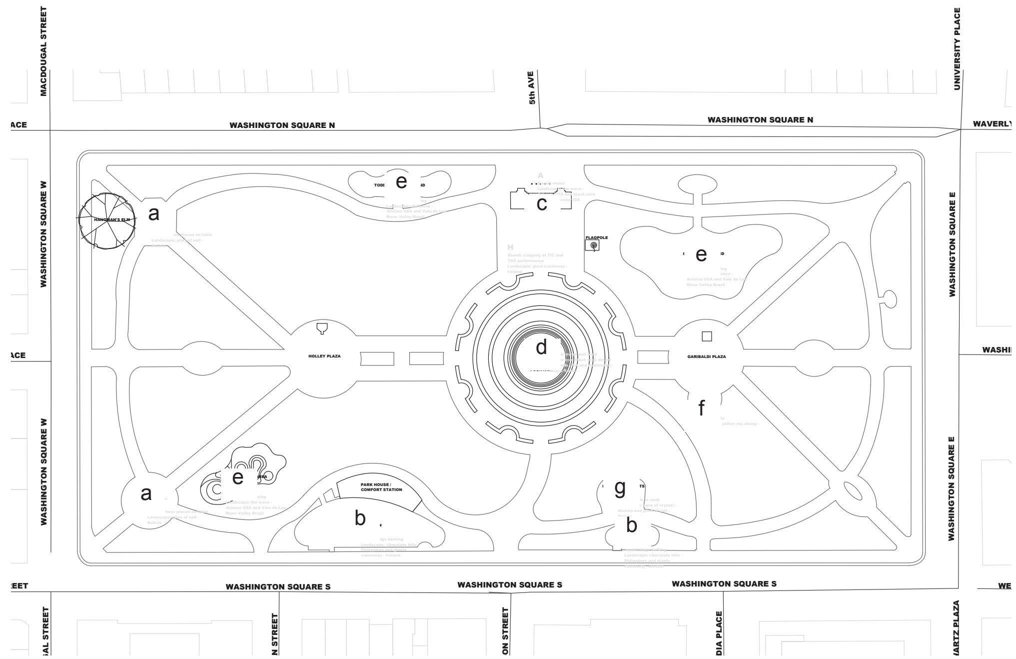


Figure 85 -*Plan of the exisiting program of Washington Square Park.*

77 https://urbanomnibus.net/2015/05/tune-in-soundscapes-of-new-york/.Retrieved 09/10/2016.

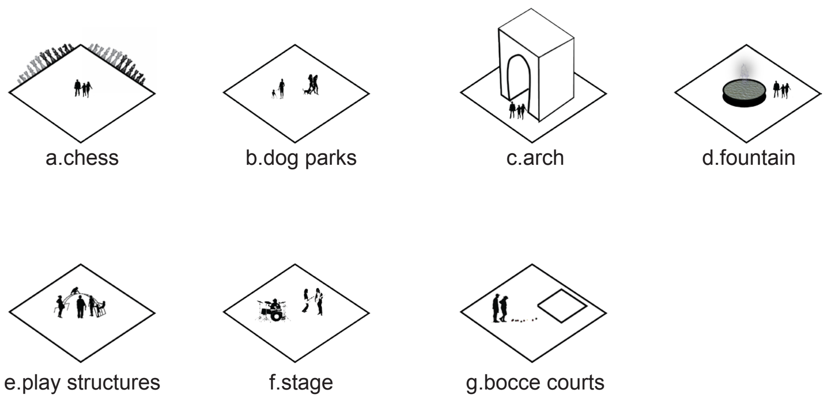


Figure 86 -*Existing Program of the Washington Square Park.*

sound could happen.

A "path" can be defined as a way or track that is laid down by walking or made by continual treading. In the context of sound and listening, the concept of the path is key to the phenomenon of the soundwalk. In a highly dynamic urban sound environment like Manhattan the concept of pulse can be found throughout the city. The city has many different patterns of pedestrian and vehicular movement across many different areas of the city. These movements of people and traffic at different times of the day give a city a pulse or rhythmic beat. For example, traffic lights are programmed to produce a rhythmic movement of vehicles. This concept of pulse can be seen at play in the existing Washington Square Park, as the existing sidewalk around the park acts as a natural jogging track creating a rhythmic pulse of people around and entering the park. The idea of rhythm of a city stems from the experiments as previously discussed and is a large part of the overall composition of an urban environment. The existing programs of the park create attractions and repulsions of people depending on the season, time of day or event taking place. These ideas of pulse and path are prominent, already-occurring forces in the existing park and they are picked up on here as the main driving narrative concepts that guide the auxiliary layers of the park.

The creative enactments of pulse and path in the proposal follow a particular set of design principles to meet objectives set for the site. Pulse takes cues from the existing programs of Washington Square Park to repel the matrix away from the existing programs. The new layers do not serve to break or interrupt the functional ability of the existing park. The notion of path uses pulse, but the existing programs now act to promote attraction to the path. This repulsion and attraction is also applied to the matrix to provide intermediate intimate curving paths. Thus, a journey is created between existing points through the new field conditions on the site.

The exercise of engaging with repulsion and attraction generated a series of digital models during the design process. The relationship of the generated curves to the existing context and programs of the park were questioned in plan and section. The questions in the plan provided an opportunity for the grid to respond to the existing programs. They also provided distinct sub-areas in the park within which different aural experiences

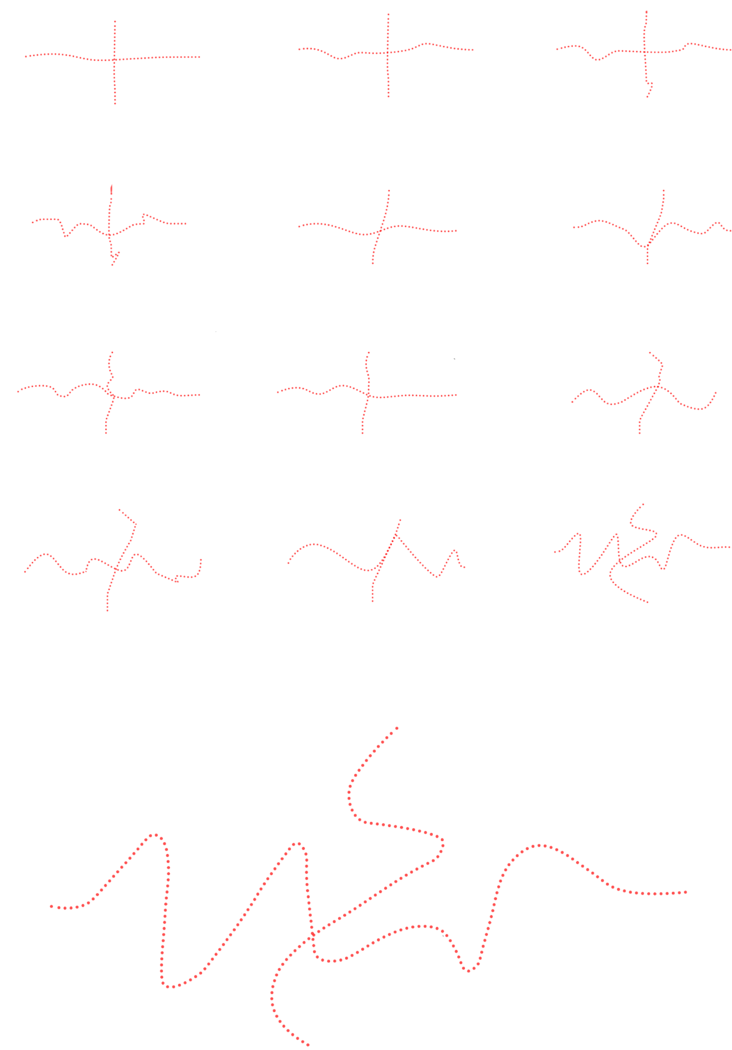


Figure 87 -*Resultant paths from Grasshopper Script.*

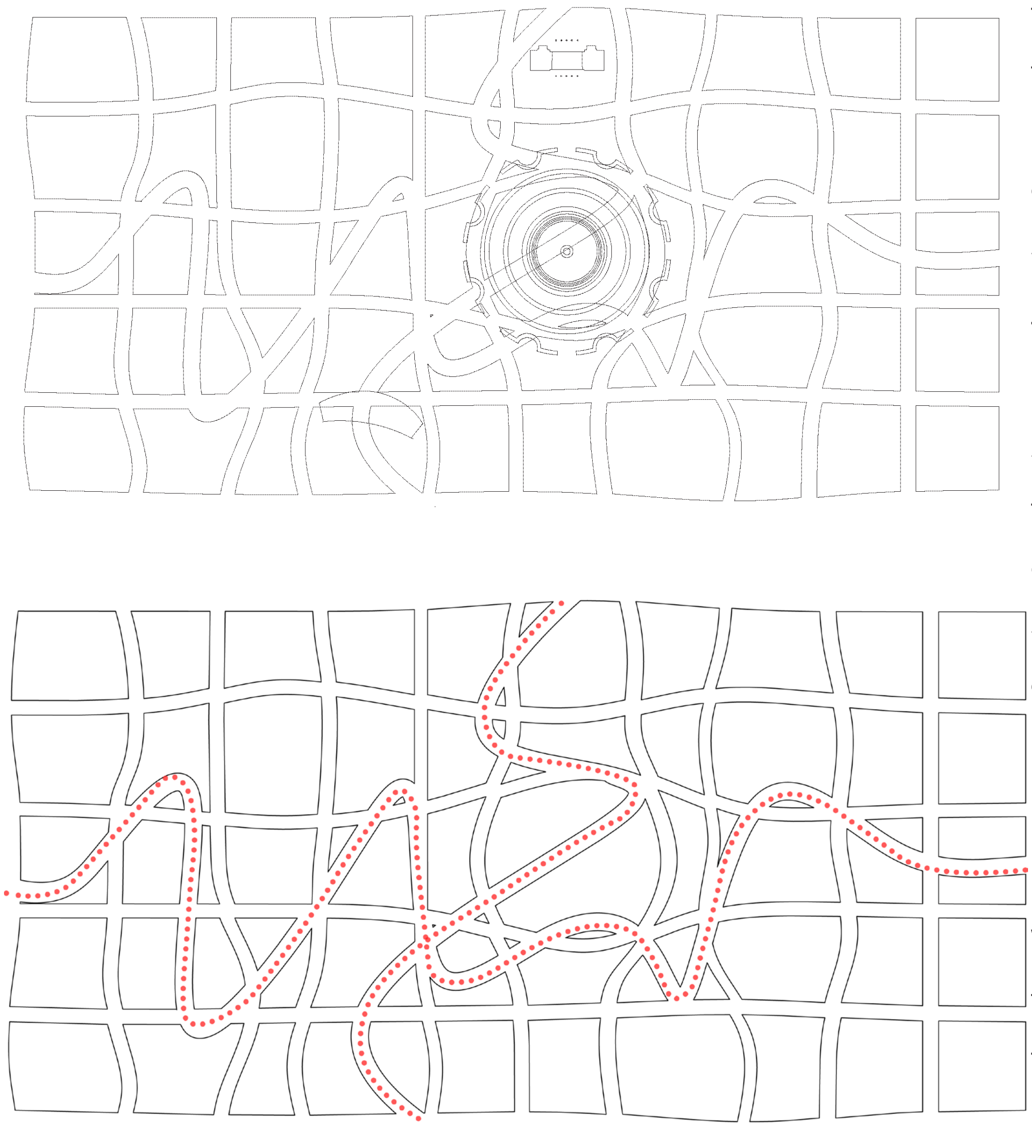


Figure 88 -*(upper) Plan of the resultant main paths and intermediate paths responding to the repulsion and attraction of the exisiting program.*
(lower) Seen in red the path used as the soundwalk.

could be deployed and achieved. The questions in section allowed the path to respond to existing site conditions and be repelled or attracted to the ground, resulting in a rhythmic path both in section and plan. This allows the proposal to participate as an added layer to the existing successful park, but also to act as a specialized, new dimension of the park where people can experience aural interventions.

The layers are distinguishable through the rhythmic path generated by the park's pulse. The architectural strategy of attraction and repulsion enables the path to oscillate between existing points of destination and points of passing. With a path defined there is still a missing component necessary to creating a soundwalk, which is a wayfinding system. to encourage listening along the newly derived path it was decided a wayfinding system was necessary.

The Layers Auxiliary - Wayfinding System

With a pre-determined path laid out it is necessary to have a navigational component along the path to act as a wayfinding system. Again, through the study of Schafer's terms for defining a soundscape, the term signal is derived from the theory of communication: a signal is a sound that atacts our attention, like message codes and information transmission.[78] Signals are the sounds that everyone can hear and understand; they catch the interest of the listener who belongs to a community which has a shared understanding of the significance of the signal. Examples of signals include bells, whistles and sirens.[79] For this proposal, signals were transcoded in the form of a wayfinding system. The signal layer of the urban park essentially consists of wayfinding system that guides visitors to places of unique aural experiences.

It was determined that perhaps using a traditional navigational system such as a map would not be best to accompany this path because the urban sound environment is ever changing and it is impossible to predict the sound events and how someone might interpret them at a certain point. Instead, navigational beacons would act as educators along the path to hold definitions of sonic effects and explain them in a visual form to pique the interest of the people and put them on alert to listen more discriminately throughout the sound environment, functioning almost like an

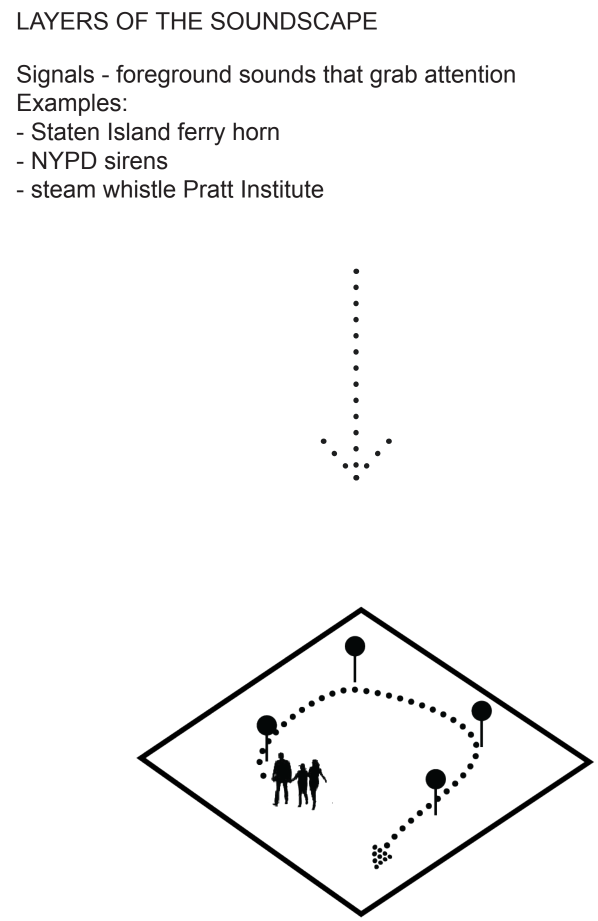


Figure 89 -*Schafers definition of a signal with examples.*

78 Ricciarda Belgiojoso. Constructing Urban Space with Sounds and Music.(Routledge). 14

79 Ibid.

aural scavenger hunt. For example one educational beacon would be placed by the fountain in the plaza explaining the mask effect. The beacons themselves contain visuals and definitions of defined sonic effects from Augoyard and Torgue's list of sixty six defined sonic effects. The sonic effects are visualized in their architectural and urban form and defined in their sociological, musical, psychological senses. The beacons are strategically placed where unique aural opportunities may occur. The strategic placement of the beacons create a path people can follow that acts as a soundwalk, to encourage discriminate listening throughout the park.

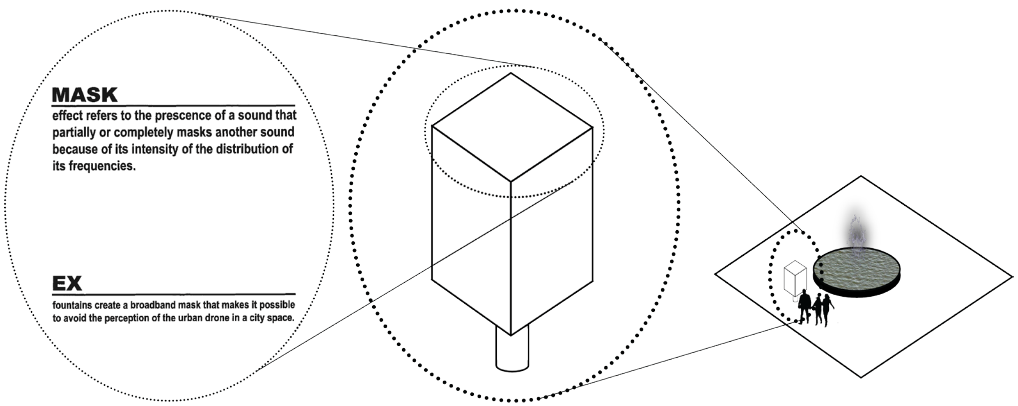


Figure 90 -*An eductional beacon, showing a definiton of a sonic effect.*

5.8 Final Compositional Result

The final architectural composition is not intended to be a direct graphical illustration of what is audible but rather is an invitation to rethink how sound can be shaped amongst the real-world orchestration of the urban environment and encourage the further study of listening.

The final compositional result is a layered synthesis. The existing park was deconstructed and examined from the ear's point of view in its existing layers and introduced new layers that involved information addressing, sound shaping, form, movement, vegetation and site. Existing built form and vegetation such as the Washington Square Arch, the large fountain, large trees, washroom building and programs such as the dog park, chess plaza, bocce courts, and playgrounds were preserved. New built form introduced such as moving walkways, rentable segways, amplification, dense vegetation, grade changes, acoustic screens, outdoor rooms, curved walls, parallel walls and stairways were added. New materials were applied to these built forms such as concrete, grass, sand and wood. New types of vegetation was introduced such as deciduous trees, coniferous trees, ground cover and tall grasses. All these forms and materials were not kept or introduced because of their visual qualities but rather for their aural qualities.

As an individual makes their way through the park and follows the newly defined path there are instances such as curved surfaces that will focus and project sound. By intersecting

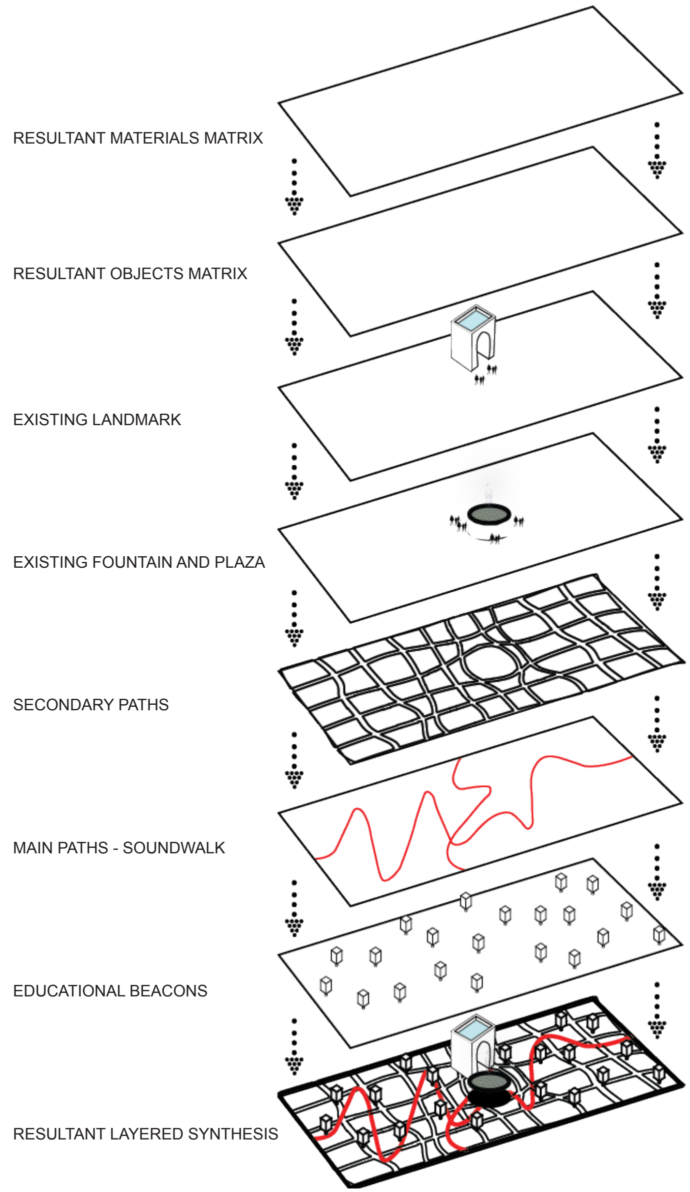


Figure 91 -*The synthesis of layering the, Marerials, Objects, re-invigorated Landmark, Plaza and Fountain, Secondary Paths, Soundwalk and Educational Beacons.*

Figure 92 -*The resultant composition of synthesising the layers and and applying the stochstic methodology.*

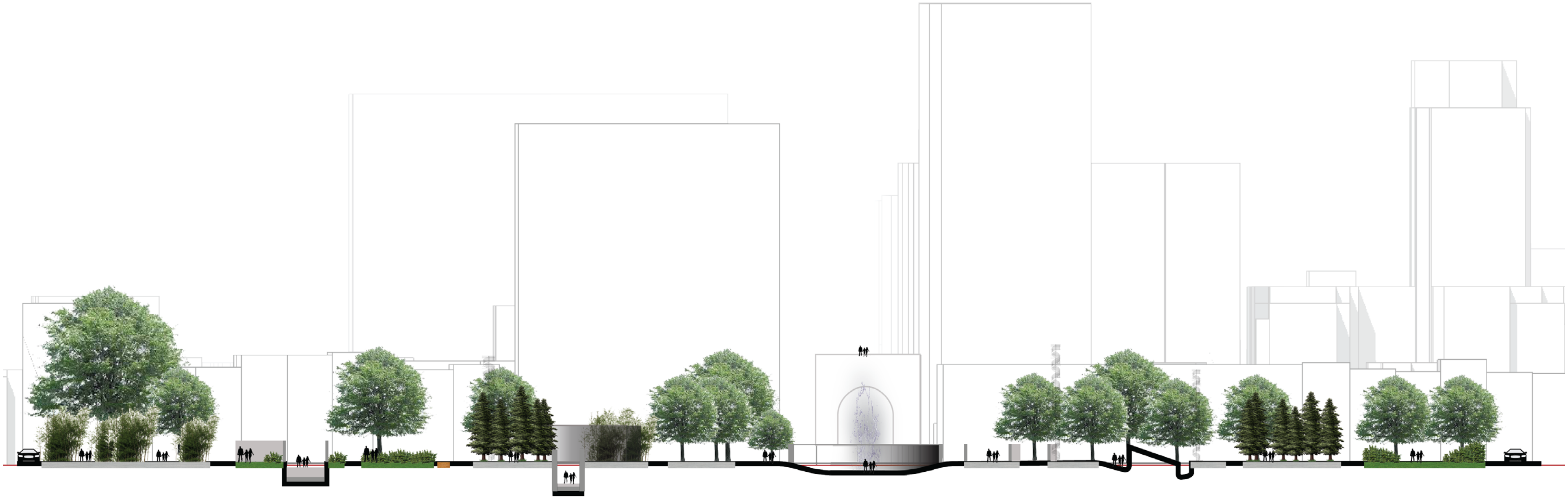


Figure 93 *-A section through the composition.*

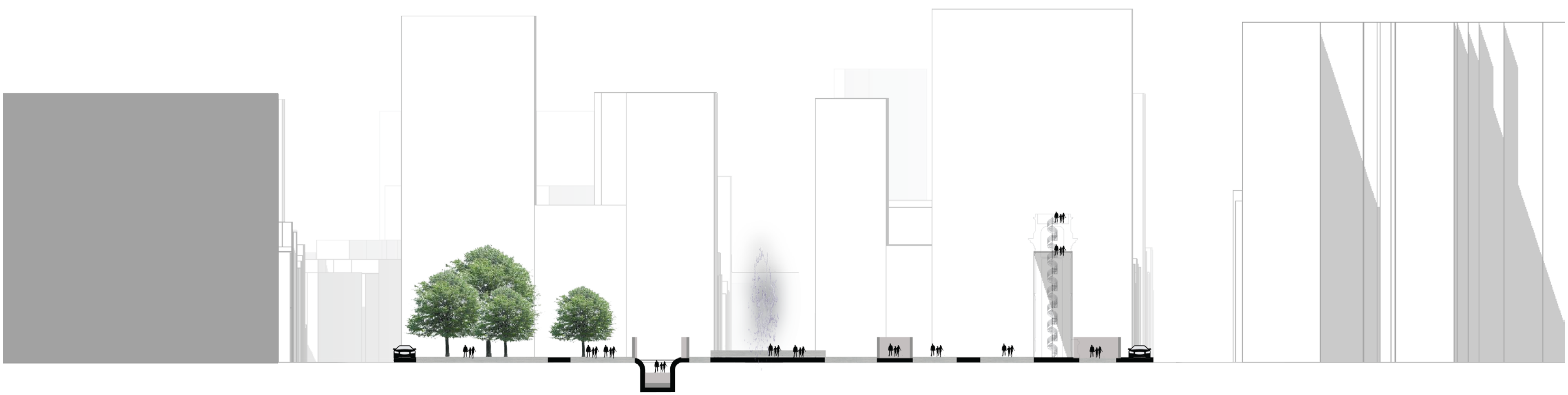
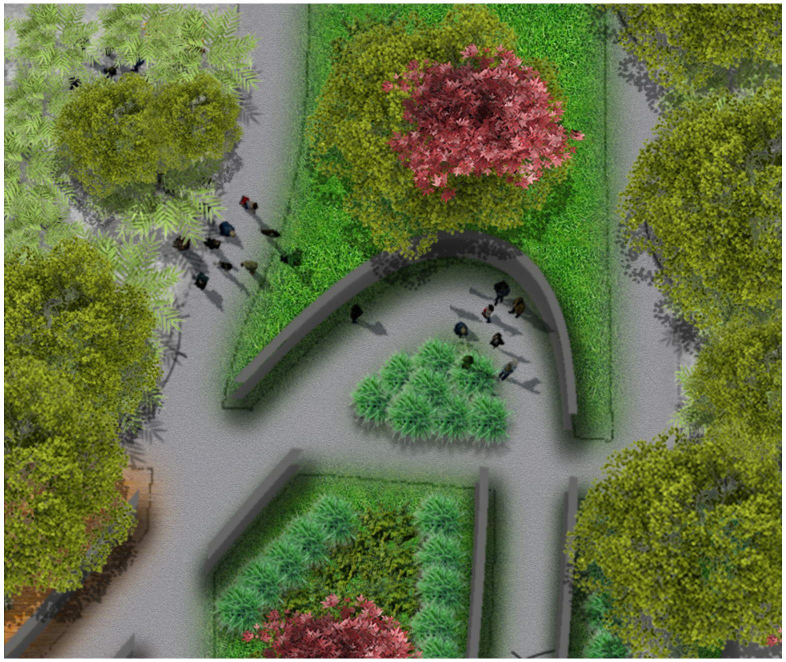


Figure 94 -*A section through the composition.*

these areas of focus and projection with curved walls sound re-location becomes possible creating a unique moment of sound. Sunken corridors are also introduced which creates opportunity for shaping sound with resonance. By descending below ground level the individual enters a space where sounds made become resonance. The sunken concave bowls that are lined with ground cover vegetation have the opposite effect and create a feeling of tranquillity. Individuals also will have the opportunity to pass through dense areas of vegetation where they can sit on benches to experience sound generation by the wind passing through the trees. There are also opportunities where amplification has been placed to enhance the sound generation of the larger vegetation to have individuals focus on singular sounds. The existing arch becomes an opportunity to experience listening from above with the newly renovated stairs access and also poises the opportunity for people to experience the closest thing to total silence in the urban sound environment if they visit the anechoic chamber added to the second level of the arch. Finally the existing fountain at the centre plaza is a place where sound becomes masked by the sound of the water creating a space of where an individual's acoustic arena is brought into focus as the urban



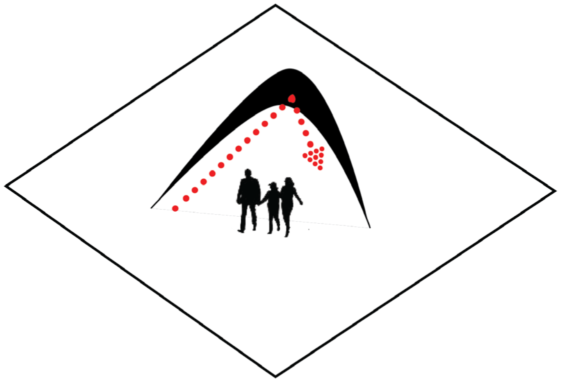
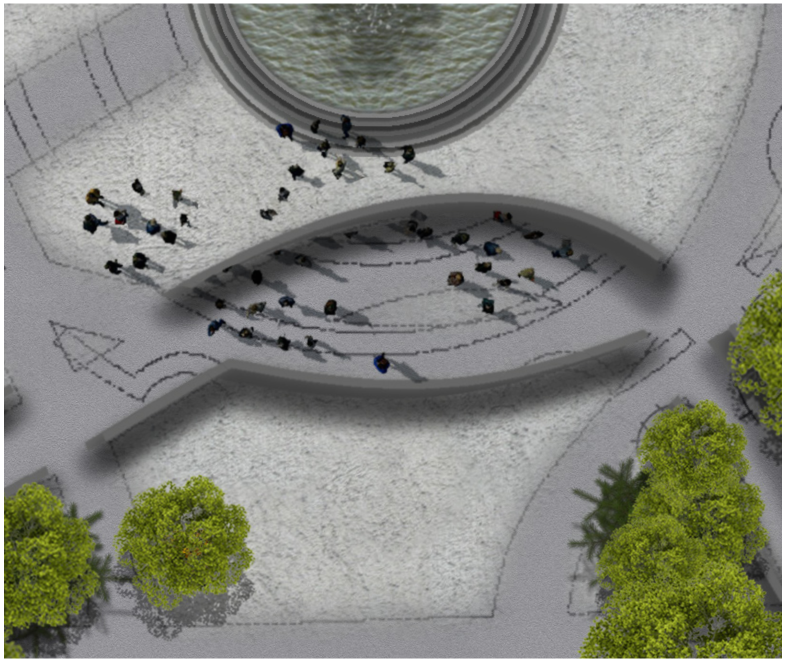


Figure 95 -*Curved surfaces for sound relocation.*



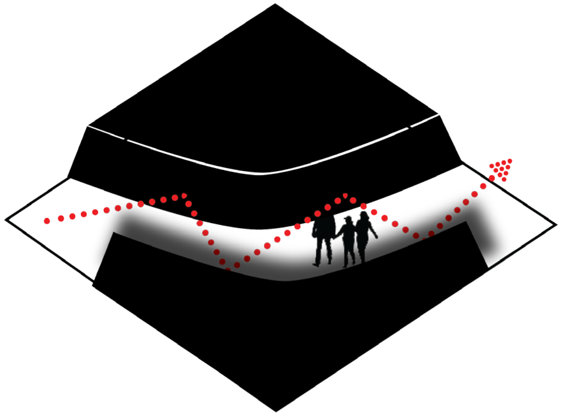


Figure 96 -*Sunken corridor sound shaping with resonance.*

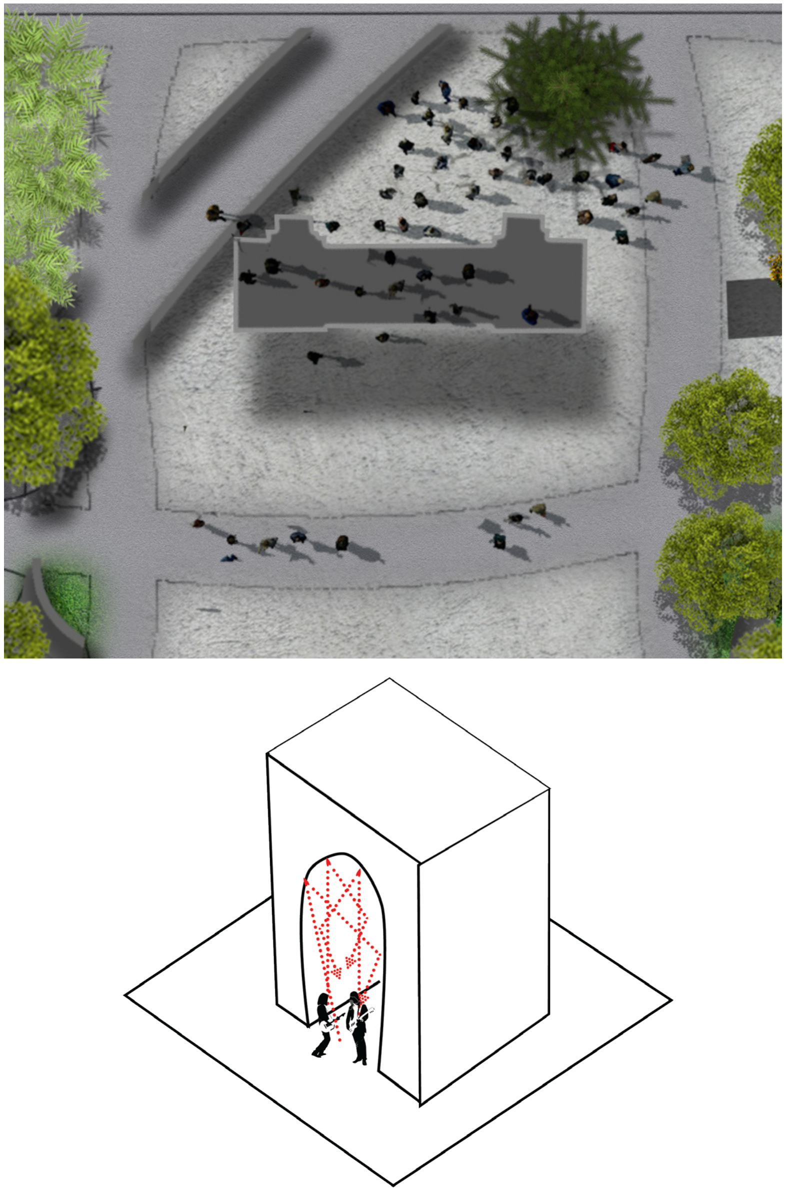


Figure 97 -*Shape of arch concentrates sound for the niche effect.*

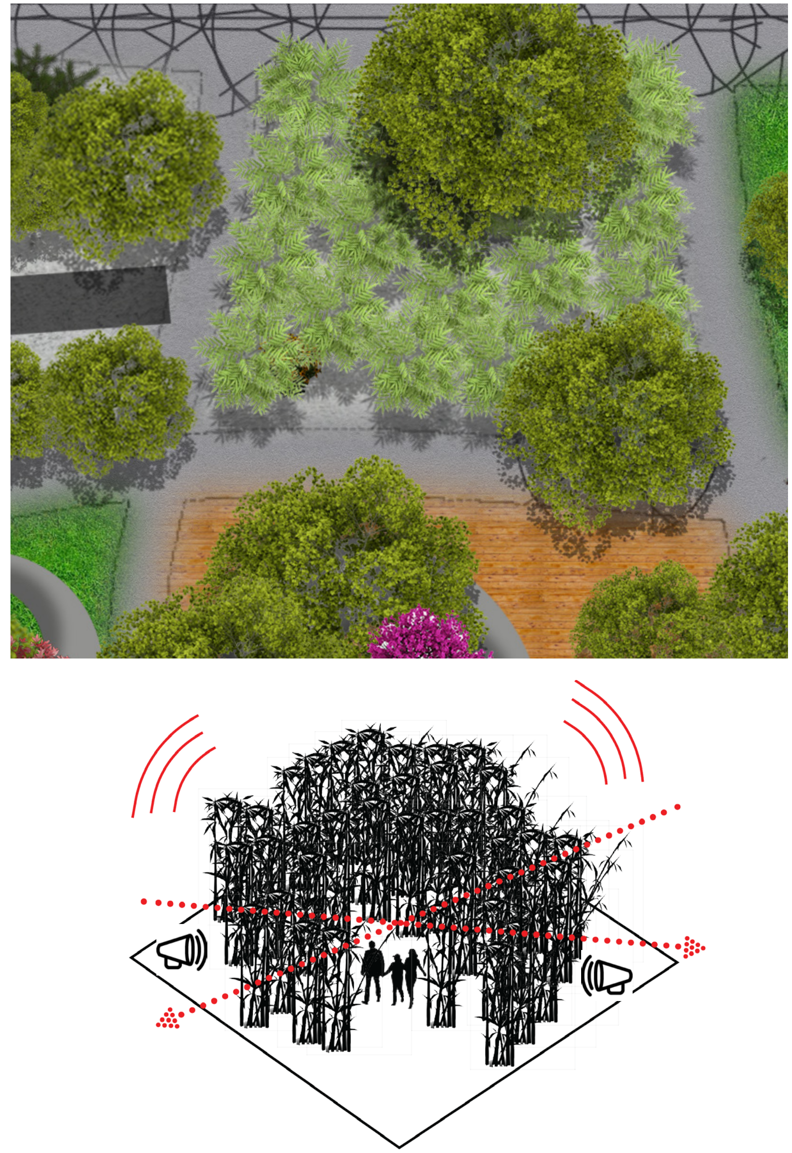


Figure 98 -*Dense vegetation for the imitation effect.*

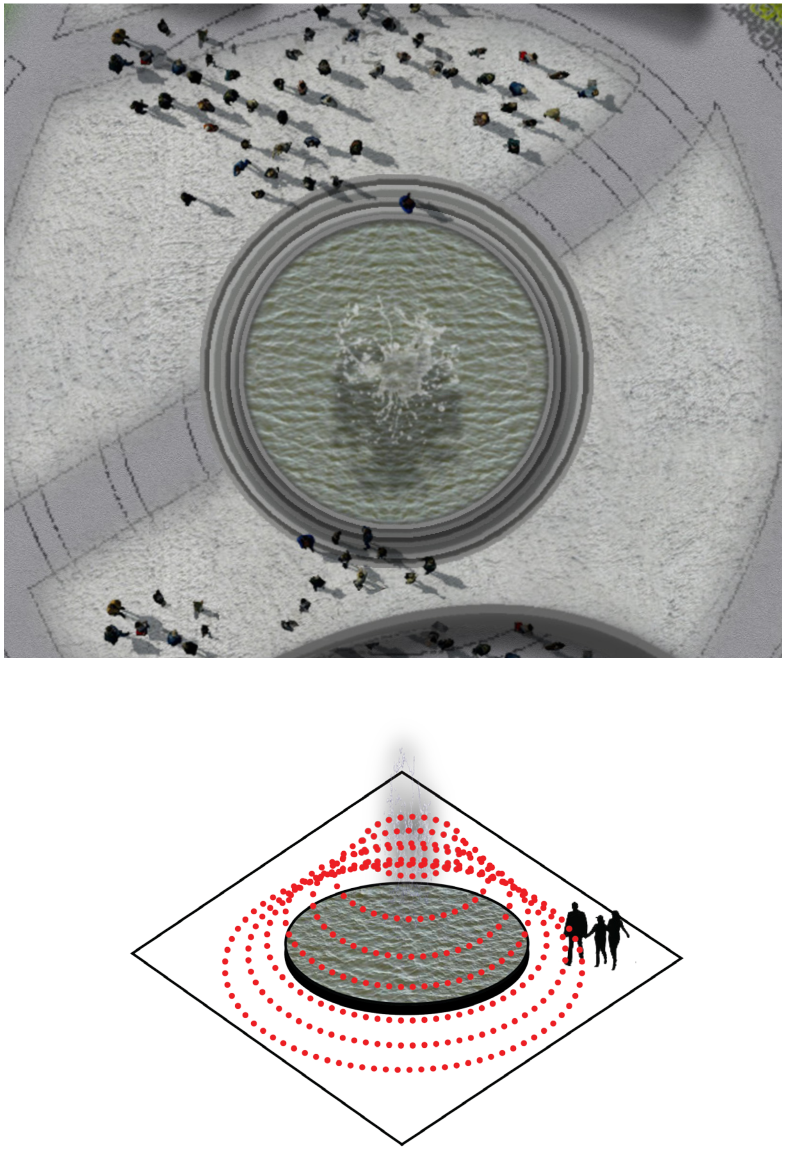


Figure 99 -*White noise for the mask effect.*

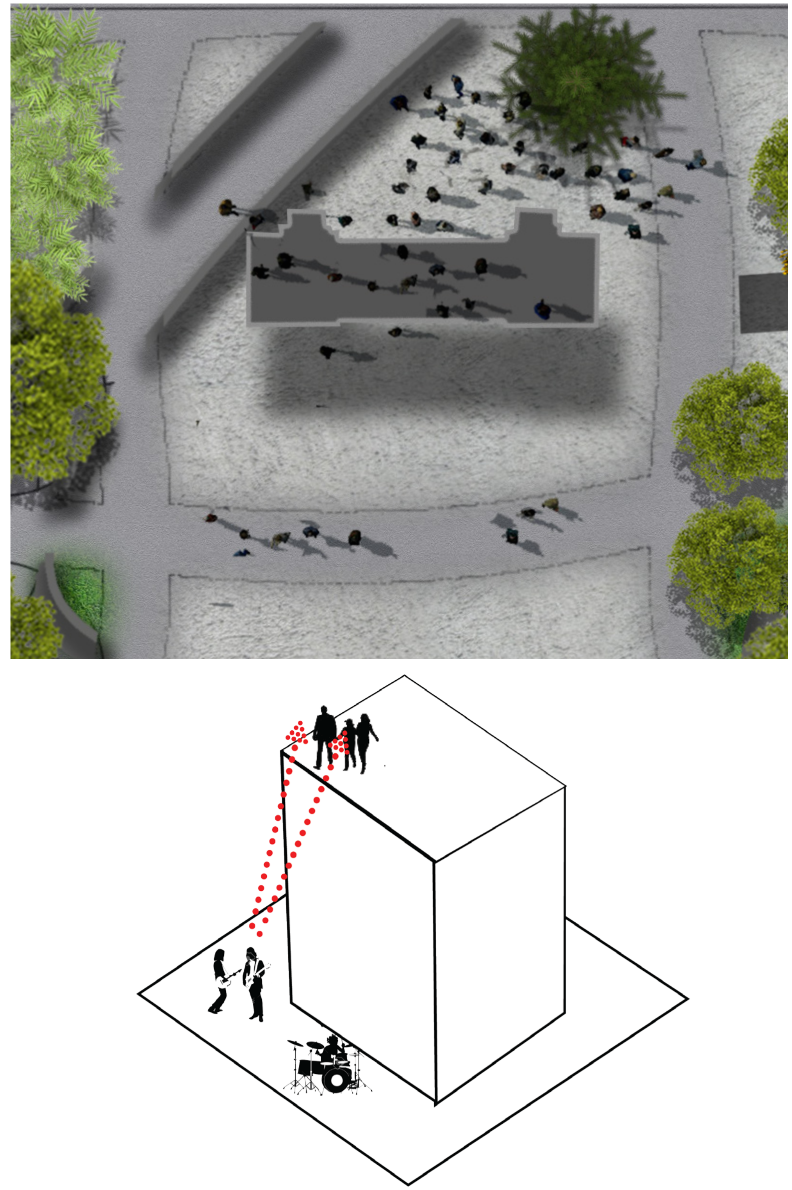
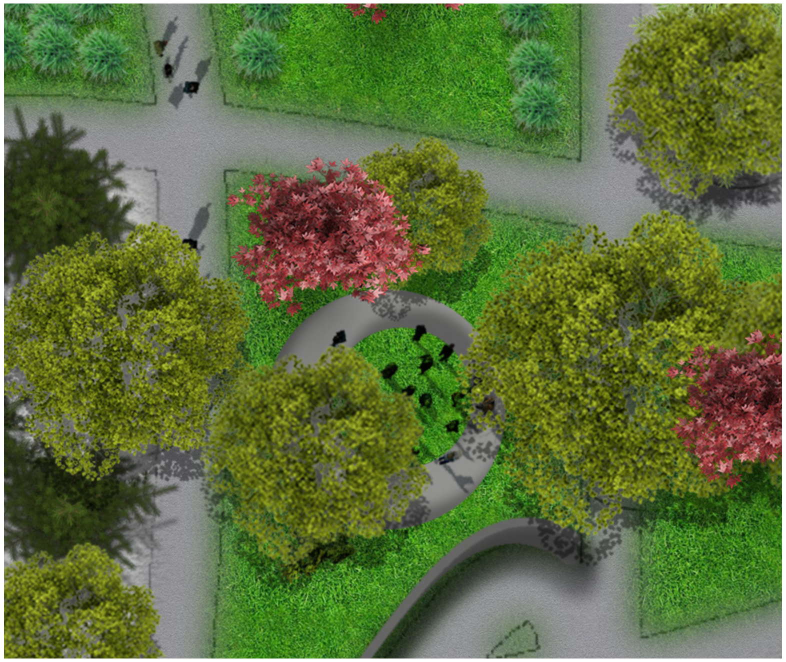


Figure 100 -*Listening from above for the metamorphosis effect.*



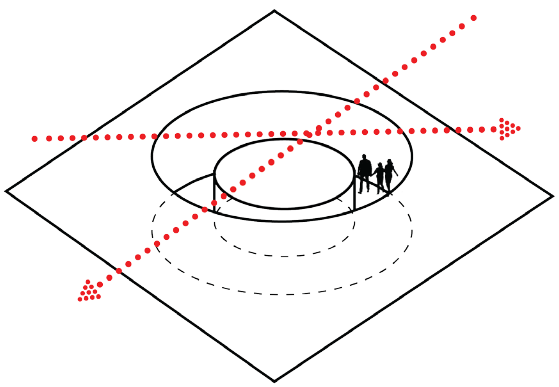
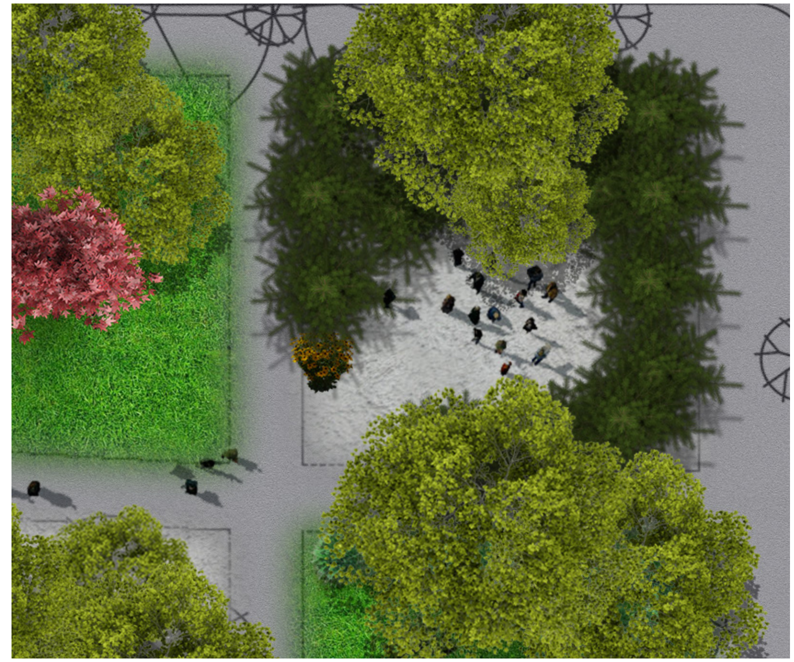


Figure 101 -*Sunken concave bowls with vegetation for sound shaping with shading and absorption.*



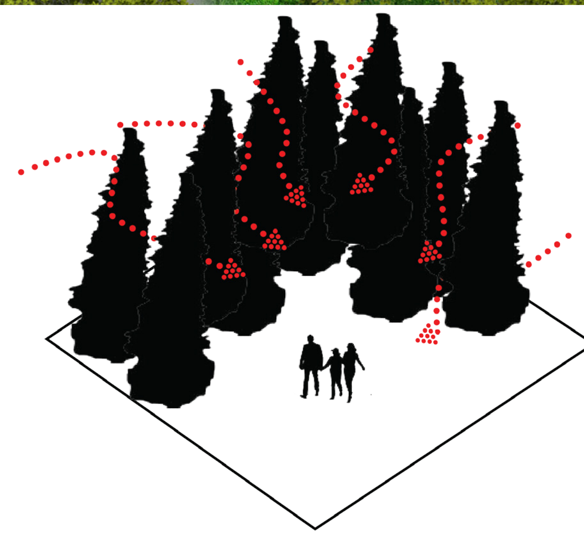


Figure 102 -*Pine groves, smooth sound texture from millions of pine needles rubbing together, sound generation with movement of air.*

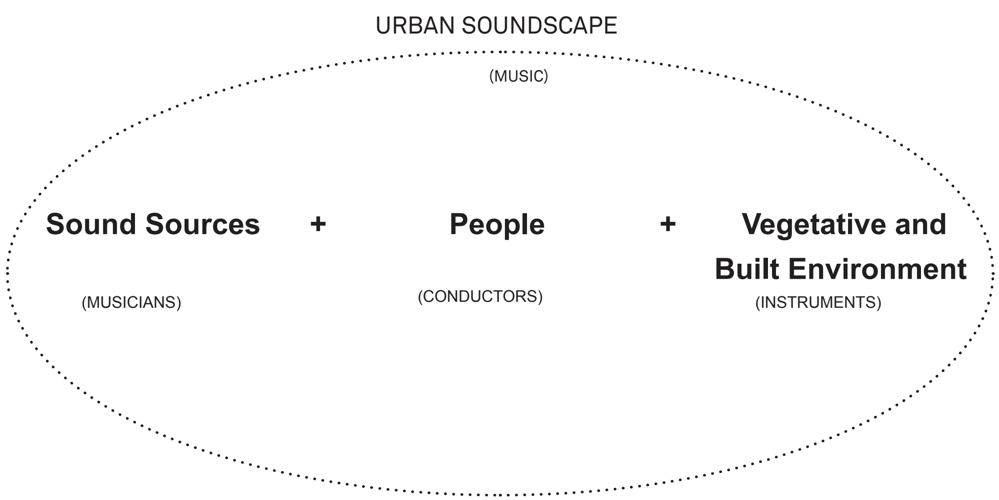


Figure 103 -*Graphic of the Urban Soundscape as an Orchestra..*

drone is weakened. In the end, the newly appointed elements in the park are designed from the ear's point of view rather than that of the eye. Creating infinite opportunity for individuals to experience the unexplained and mysterious sounds produced by the built forms and vegetation. Hoping to challenge their everyday belief of the Western cultures stigma's on urban noise.

The resultant overlapping of layers superimposed as a music composition blurs the line of the urban soundscape as a visual representation of a temporal experience. Exploring the urban environment as if it was an orchestra. In this context, the vegetative and built elements are the instruments, sound sources are the musicians, the people are the conductors and the urban soundscape is the music. As the designer acting as a composer of the urban sound environment it is impossible to predict sound sources and the perception of and individuals aural response. Therefore, the final design is a visual representation on what the designer can control as a composer of the urban soundscape and that is the built environment.

It is hoped that the experience of the composed urban park will encourage the park's many visitors that sound is critical to understanding the urban environment. The park reveals the capacity for the built environment to enhance aural architecture and be used as a tool to generate, mediate and control sounds of the urban environment and the world by proposing a new way to rethink urban places as aural spaces.

As Blesser has written, ”as a culture, we can create social and architectural opportunities to encourage our fellow citizens, especially our children, to listen discrimintely.”[80] The theory, methodology, and final design of this thesis provide an experimental process for thinking of the aural as a musical composition with the ability to break the background drone of the urban soundscape down into smaller zones of unique hi-fi soundscapes. Through the addition of new layers and the preservation of sonically rich existing layers, the landscape acts as a soundwalk and engages people in attentive listening. The potential for sonic effects provides a context and common sense for physical and human dimensions of sound.[81] As Blesser has described it, “in turn, a rich aural architecture is more likely to stimulate the development of that auditory spatial awareness.”[82]

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80 Barry Truax, Handbook of Acoustic Ecology (Cambridge Street Publishing, 1999), 48.

81 Ibid.

82 Jean-Francois, Sonic Experience: A Guide to Everyday Sounds (McGill-Queens University Press, 2006),76.

Personally, this thesis process has acted as an extended ear cleaning exercise from the research conducted, the experiments practiced, the knowledge gained, the sound clips listened to and the architectural compositions created. All of these exercises contributed to furthering my ability to listen. As a listener and designer, I believe working with sound over the past few years has changed my sociological view on urban noise, along with my definition of noise itself. My internal soundscape has evolved and I am far more attuned to the present sound environment. I find myself stopping and listening, trying to breakdown the sound environment as if it were a composition. I use a technique where I try to focus and listen past the background drone of the urban sound environment and pick out other sounds and attune to them. I also find myself trying to find beauty in the sound event, by trying to find the meaning behind the reason for which the noise is being created, or what is producing the noise. I find that imagining the bigger picture and understanding the source of the noise ultimately results in the understanding of the noise and potentially cancels out any annoyance it may have caused. Studying

Auyogard's and Torgue's list of sonic effects and creating visual vignettes enabled me to have a general understanding of the built environment's role in shaping the sound and its psychological and sociological effects. It goes without saying that this knowledge has greatly enriched my internal soundscape and has transformed my view of Western culture's stereotypical definition of noise. The advancement in my understanding of the sound environment was not just the result of research and experiments. Various people with diverse backgrounds influenced key moments in my research that ultimately led to a deeper understanding of the urban sound environment.

At the beginning of my thesis, I was focused on visualizing sound. I was using sound files as data and trying to directly translate the file into visible geometry. In my final critique of TRD1a visiting professor from the University of Michigan pointed out that this direct visualisation of a sound file into geometry was meaningless, and sound had many other dimensions to it. This was the first big shift in my thesis research and process. This led to the exploration of a wide area of soundscape research, ultimately leading me to R. Murray Schafer and The

World Soundscape Project. Schafer's studies influenced my thesis in that they caused me to shift my focus from the visual aspect of sound to the aural aspect of sound. Through this shift I conceptualised an understanding of Schafer's three-part classification of a soundscape that could be applied to architecture. I did this by relating his definitions to architectural elements of a landscape. This relationship would lead to my second big influence in my sound research process.

The second major influence in the development of my thesis research arose during my TRD2 final critique. It stemmed from Adrian Blackwell's statement that "I find the relationship between Schafer's three definitions of classifying a soundscape and the three layers very interesting; however, I would look into the shape of sound". This sparked the deeper dive into the actual geometry of sound, such as the geometry of vibrations, also known as cymatics. This led me to a brief dive into how matter is created using vibration and experiments using cymatics. After realising this was going back to visualising sound I began to rethink Adrian's term 'shape of sound' and what that could mean. At a standstill and researching day and night, I decided to enrol in Andrew Levitt's class, The Inner Studio.

Taking Andrew Levitt's class The Inner Studio led to the third big influence in my thesis process. The biggest thing I took from his class that related directly to my thesis is the difference between hearing and listening. In his studio we would do exercises that required listening. His studio also gave me a broad insight into psychology and listening. This class would inspire one the biggest shifts in my thesis process –the shift from visualising sound to begin to research the experience of sound. While researching the experience of sound and rethinking Adrian's Blackwell statement 'shape of sound' I began to research how the built environment can shape sound as well as the psychological and sociological sonic experience of individuals. This would eventually guide me to find the book titled, *Sonic Experience: A Guide to Everyday Sounds*. In was in this book that I found the true significance of the concept of shaping sound. This would eventually direct me to the fourth major influence in my thesis process.

The fourth influence came about during a thesis progress meeting with Ila Berman. It was Ila Berman's statement "Everything has Rhythm" that sparked my research into the rhythm of the city. This also led me to make the connection between rhythm and the city and studying Xenakis's methodology for musical composition. Ultimately, it led to viewing the urban sound environment as one large musical composition. The influences described above, combined with the research and experiments, led to the final composition in this thesis and ultimately to my deeper understanding of the urban sound environment.

To use a real-life example and examine the psychological and sociological perception of a sound event I will use an instance from this past summer. My fiancée and I were downtown sitting on a rooftop patio having dinner. The building was three stories in height, along a busy street with passing cars. In certain locations I then began to notice myself examining the built environment for potential based on the vignettes of sonic effects. The first thing I noticed was the metamorphosis effect, which is listening from above. This effect happens when a drop in the sound intensity occurs, simply as a result of being above the sound source. Secondly, I noticed an effect resembling the cut-out effect, which happens between a moving sound source and a stationary listener. In this case, the sound source I was focused on were the passing cars and we were the stationary listeners as we sat down at our table. And then in the midst of our conversation, a sound source arose that played a role in shaping our behaviour.

The cut-out effect occurred when a car went by with a very loud exhaust. The sound event of the loud pop of the exhaust made me and many other people turn around and focus our attention on that sound. The feeling of rupture from the high-intensity sound of the exhaust was pronounced. This rupture influences listeners' behaviour. Upon examining the situation, the behaviour was the abrupt turning of heads, which caught the attention of the listeners surprised and alerted by a spike in the intensity level of the sound environment. Secondly, because this rupture did not involve any of the listeners on the rooftop, it came as a sudden surprise to the listeners on the rooftop, including myself, thereby increasing the listeners' attention for a brief second and adding a level of anticipation to the moment. This increased attention and anticipation can play a role in the refinement of listening. My psychological perception of the sound event moved me from one state, which was one of relaxed conversation, to another state, which was surprised or startled by the loud sound of the exhaust. Learning to examine the urban sound environment from an architectural and psychological point of view has changed my personal sociological analysis of noise. I viewed the loud exhaust as another unique moment of the complex urban sound environment and its ever-changing composition.

Another example of my observation of my own increased attenuation to sound is when I listen to music in the car. I hear sounds and instruments that I have not recognized previously. It is almost as if working with sound over the last few years has unconsciously been training my ear, much like a musician trains their ear by doing listening exercises. I notice sounds such as background instruments or sirens. Hearing these background sirens, often used in hip hop music, frequently catches my attention even more to the point where I often find myself looking for emergency vehicles. This raises my awareness as I look around and check my mirrors to see if I can see an emergency vehicle coming, only to find out upon further listening that it is, in fact, a sound in the background of the song. Often riding with a passenger, I'll ask, do you hear that siren? Often the answer is, what siren? This has happened to me over the last six months more than once. I didn't experience this before I began closely studying sound during my thesis process.

As a result of studying sound, as a designer I have begun to view projects with the aural in mind. Using the visual vignettes produced in the study of the site of Washington Square Park I now, as an architect, use these sonic effects to influence the space I am designing.

In each example above there are many sonic effects which happen simultaneously; it is not possible to predict or subconsciously pinpoint a particular moment when an individual is experiencing one of them. However, the examples and vignettes produced are a broad way of gaining an understanding of how the built environment may be used for sound shaping. This thesis may not be the ideal example of specific sound experiences; nonetheless, it aims to act as an aid in stimulating the reader's memory of individual experiences and raise awareness of individuals' comprehension of sound in our urban environments in the same way it has impacted mine both as a listener and as a designer.

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