ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL

SONIC SYMBIOSIS:
THE INTERPLAY OF SOUND AND SPATIALITY
IN INSTALLATION ART

M.A. THESIS

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İSTANBUL TEKNİK ÜNİVERSİTESİ ★ LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ

SONİK SİMBİYOZ:
ENSTALASYON SANATINDA SES VE MEKANSALLIĞIN ETKİLEŞİMİ

YÜKSEK LİSANS TEZİ
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Abdulfettah Salih GAFEROĞLU, a M.A. student of ITU Graduate School student ID 409201134, successfully defended the thesis entitled “SONIC SYMBIOSIS: THE INTERPLAY OF SOUND SPATIALITY IN INSTALLATION ART”, which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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To vibrations and waves

FORWORD

In his famous book Understanding Media, Marshall McLuhan says "*When IBM discovered that it was not in the business of making office equipment or business machines, but that it was in the business of processing information, then it began to navigate with clear vision."* Certainly, he was describing a moment of epiphany, the realization of a deeper meaning in a process. During the preliminary phases of my research, before I landed on this particular research topic, I was curious about the practical facets of spatial sound in virtual environments. I was trying to understand the three-dimensional perspective of hearing. Gradually, I started to recognize that in essence, space was the charming factor for me and I was searching for ways of meaningful communication with it. The way I found for this was mostly related to disturbing air molecules, pushing and pulling them back: Shaking the atmosphere nearby, and getting shaken by it. Then I started to read whatever I could find, and experiment. A myriad of questions and answers appeared, mysteries became solved one after the other. This would be quite difficult without the endless support of masterful, kind, and patient members of our institute. Hereby, I would like to give my sincere appreciation to all our researchers at the Centre for Advanced Studies in Music of Istanbul Technical University. It has been a great joy to share this time with you while thinking and working on sound in every aspect. In each semester, my vision of sound, aesthetics, and sonic arts got broader, and literally, everyone had a share in this change and development. This was a great journey and opportunity for me, and hopefully, I could contribute back to our community as well. Thank you.

Perhaps, I disturbed the most, one and only Dr. Cevdet Erek with my endless questions, and I am grateful for his patience and mastery in orienting my enthusiasm. Then my jury members Dr. Enis Gümüş and Dr. Sair Sinan Kestelli, the details that they pointed out both in my text and in my exemplary installation artwork definitely contributed to my processes. I also must thank Dr. Konstantinos Vasilakos, who made invaluable contributions at turning points of my research at our institute and who introduced me to the world of programming audio in a way that I can grasp it well. Also, although we were mostly apart during my studies, professors Dr. Tolga Bozkurt from Ankara University and Dr. Ufuk Önen from Bilkent University supported my dream of studying here at Istanbul Technical University at the very beginning and I am deeply grateful for their contribution.

Before I start to show my gratitude to friends, I must thank my dear mother Zeliha Gaferoğlu who was always there from start to end and her ever-lasting support was fundamental and empowering. I can not imagine how this journey came to this stage without her trust. Also, my dears from Ankara, Ali Bozkurt, Naciye Bozkurt, and Merve Gülgü, your sincerity, love and presence were essential. I also would like to thank all my friends who live in Istanbul and supported me with their ideas, love, and homes when I came to Istanbul from Ankara, very often. I would like to mention them name by name with the order of days I accommodated: Emine Arslan, Ogulcan Akca, Semih Düz, Ulaş Kuduban, Utku Temel, Damla Temel, Elif Soyer… You and many other friends whom I encountered during the different phases of my journey, I am glad that we have shared this time, thank you very much. I am looking forward to sharing more time with you all in the future.

I also feel the necessity to thank my virtual assistants, and their developers; ChatGPT, Google Translate, and Grammarly. Since my undergraduate education was in my native language and not English, I had difficulties from time to time but these tools helped me a lot. The assistance I got was more on etymological and grammatical and as of November 2023, they are moving forward each day. I wonder what they will become and how they will be a part of our lives.

Hereby, I can say that considering the circumstances over the past months, albeit the shaking events both public and personal, I did whatever I could do passionately. Perhaps in an environment that is more stable, I might able to take things a bit further but this is not a statement of “I wish”. I know there will be always some percentage for more. In the given timeframe this happened and I am glad it did. Now I have the necessary toolset and experience to take it further in the next chapters of my life, this is invaluable. Once again, a million thanks that all my peers and mentors both in and out of academia helped me land here.

I dedicate this work to you all.

November, 2023

A. Salih GAFEROĞLU
Music Industry Professional

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ABBREVIATIONS

3D	**:** 3 Dimensional
BEAST	**:** Birmingham Electroacoustic Sound Theatre
CHARM	**:** Research Centre for the History and Analysis of Recorded Music
DAW	**:** Digital Audio Workstation
dB	**:** Decibel
HRTF	**:** Head-related transfer function
Hz	**:** Hertz in short, after its founder physicist Heinrich Rudolph Hertz
IRCAM	**:** Institute for Research and Coordination in Acoustics/Music
IFCA	**:** Istanbul Foundation for Culture and Arts
ITU	**:** Istanbul Technical University
KCL	**:** King's College London
kHz	**:** Kilohertz
MIAM	**:** Dr. Erol Üçer Müzik İleri Araştırmaları Merkezi
MIDI	**:** Musical Instrument Digital Interface
n.d.	: No date
PC	**:** Personal Computer
SC	**:** SuperCollider
VR	**:** Virtual reality
WW2	**:** Second World War

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SONIC SYMBIOSIS:

THE INTERPLAY OF SOUND AND SPATIALITY IN INSTALLATION ART

SUMMARY

The primal need to discern the direction and proximity of sound sources for survival has greatly affected humankind's relationship with sound and its spatial properties. Cultivating this capability has significantly influenced cognition and spatial behavior, shaping how to prioritize auditory stimuli, and figuring out possible sources of sounds through it. To illustrate, consider early humans who relied on the accuracy of identifying the rustling of leaves to detect potential threats in a dense forest. This instinctual skill continues to resonate within the modern auditory perception. With this observation in mind, this research examines the broader context of the role of sound and its symbiotic bond with spatiality, in particular, its aesthetic interpretation within sound-related arts. It offers a detailed examination of sound spatialization techniques throughout history and their impact on human society at large. It explores historical milestones as well as their social context and the implications of burgeoning technologies while critically analyzing cognitive and societal evolution behind spatiality in sonic arts, the technological resources developed for sound representation, and the aesthetics of contemporary paradigms respectively. In the discussion chapter following this detailed context setting, two major issues are centered. The importance of linguistic tools to depict and evaluate a sonic artwork, and an examination of sound installations in the light of contemporary examples. This examination includes an assessment of distinctive qualities, what is diffusion and what does it mean to have a strategy regarding it in the context of sound installations, and the notion of focus in this context.

At last, this investigation is enriched with a multi-channel sound installation named *CLSR* as an empirical dimension to the study. It challenges the perception of space as a transparent container for sound and art exemplifying the research's philosophical facet. Leveraging the real-time generative capacities of the SuperCollider audio programming language, *CLSR* employs reference tones for interactive spatial exploration and invites the audience into a dialogue between sound, environment, and perception. By probing the role of space and its influence on sound creation, the project fosters new ways of appreciation for soundscape.

SONİK SİMBİYOZ:
ENSTALASYON SANATINDA SES VE MEKANSALLIĞIN ETKİLEŞİMİ

ÖZET

Hayatta kalmak için ses kaynaklarının yönünü ve yakınlığını ayırt etmeye yönelik temel ihtiyaç, insanlığın sesle ve onun mekansal özellikleriyle ilişkisini özünden etkilemiştir. Bu ihtiyaca verilecek cevabın bir yetenek olarak geliştirilmesi, işitsel uyaranlara nasıl öncelik verileceğini şekillendirmiş ve bunun aracılığıyla seslerin olası kaynaklarının belirlenmesini sağlamış, dolayısıyla bilişsel ve mekansal davranışı önemli ölçüde etkilemiştir. Örnek vermek gerekirse, bir ormanda etrafındaki potansiyel tehditleri tespit etmek için yaprakların hışırtısını dinleyerek ne duyduğunu anlamaya çalışan ve bu bilginin doğruluğuna güvenerek hayatta kalmaya çalışan ilk insanları düşünelim. Bu durumun önemi neticesinde duyuma dair kazanılan beceriler içgüdüselleşmiş ve modern işitsel algıda yankılanmaya devam etmektedir. Bu araştırma, bu gözlemi akılda tutarak sesin rolünün daha geniş bağlamını ve mekansallıkla olan simbiyotik bağını, evrimsel köklerden başlayarak güncel anlamlarına ulaşmasını, ve sesle ilgili sanatlardaki estetik yorumunu incelemektedir. Özellikle ses enstalasyonu sanatını merkeze alan bu araştırma, ses ve mekan arasındaki bu özsel ilişkinin ses sanatının bu özel veçhesindeki çalışmalara etkisini tartışır. Sese dair bilişsel ve fizyolojik evrimi çıkış noktası kabul ederek, mekânsal ses algısı etrafındaki doğal farkındalığı incelemekle başlayan araştırma metni, zaman içerisinde sesin mekânsallığına dair geliştirtirilen teknolojik kontrol yöntemlerinin ayrıntılı bir incelemesine doğru ilerlemekte ve bu ilişkinin tarihsel, toplumsal ve sanatsal etkilerini metin boyunca kademeli olarak değerlendirmektedir.

Araştırmanın genel amacı uzayın ve mekanın bizi sarmalayan pasif bir etmen olduğu intibasının yeniden değerlendirilmesini teşvik etmektir. Bu çalışma ses çevremizin, sesin etkileştiği, bulunduğu alana özel tınladığı ve bir anlamda kendisini bulduğu durumun aktif karakteri hatırlatılmakta, sesin yaratılması ve algılanmasında oynadığı rol tartışılmaktadır. Bu amacı gerçekleştirmek için öncelikli olarak takdim bölümünde mekan, ses, psikoakustik ve mekansallığın ses sanatında kullanımına dair bir temel oluşturmak amacıyla okuyucuya bu konulara dair referans kaynaklara yönlendirmelerle birlikte kapsamlı bir terminolojik zemin çalışması yürütülmekte, ardından meselenin bilişsel evrimini merkeze alan ikinci bölümde de burada takdim edilen bilgilerin tarih öncesi dönemlerden başlayarak bugüne kadar olan yolculuğu detaylı bir şekilde işlenmektedir. Ardından tamamlayıcı niteliği ile tartışmayı etrafında şekillendiren örnek çalışmaya ilerlerken “Tartışma” isimli bölümde çağdaş yöntemler, sorular ve sorunlara dair bir bilimsel aktarım yürütülmektedir. Bölümlerin ihtiva ettiği detaylara konunun özütünü aktarmak amacıyla biraz daha yakından bakmak gerekirse, ilk bölüm olan takdim bölümünde anlatım mekan kavramı ile başlar. Mekanı biyolog Jakob von Uexküll’ün öne sürdüğü *Umwelt* kavramının işaret ettiği çerçevede inceleyen bu bölüm, özünde her canlının hem kendine has hem de evrimsel bir geçmişi olduğunu göz önünde bulundurarak, bu zeminin algılarımızı nasıl şekillendiğirdiğini, her birimizin aynı araçları kullanarak aslında ne kadar farklı duyusal deneyimler yaşadığını tartışır.

Hakikaten de, mekanı duyularımız bize alan açtığı ölçüde hissedebilir, kavrayabilir, ve dolayısıla anlamlandırabiliriz. Bu duyuların yetkinliği, keskinliği ve kapasitesi her yaş grubunda grubunda insanda büyük farklılıklar gösterir. Buna bir de öğrenilmiş duyumlama şeklinde tanımlayabileceğimiz anlamlandırma örüntülerini dahil ettiğimizde ortaya çıkan tablo birçok noktada ortaklaşırken aynı zamanda bambaşka diye de tabir edebileceğimiz iki uçta ortak bir mekan deneyimi yaşadığımız sonucuna varır. Metin daha sonra sesin doğasını ve mekan ile ilişkilendirildiğinde ortaya çıkanları derinlemesine araştıran akustik bilim dalından bulgularla sesi fiziksel bir mefhum olarak incelemekle seyrine devam eder. Akabinde işitme duyusunun nüansları üzerine nöro-bilim, psikoloji, sesin fiziği ve mekanla ilişkisinden beslenerek birden çok akademik disiplinin kesişim alanında araştırmalar yürüten psikoakustik biliminden gözlemler paylaşarak ve bu meselelerden dolaylı veya direkt olarak etkilenen sanat eserlerinin ontolojik sorgulamasını yürütür.

Evrim isimli bir sonraki bölüm ise bu detaylı bağlamsal takdim üzerine ses sanatlarındaki uzamsallığın arkasındaki bilişsel evrimi, ses temsili için günümüze değin geliştirilen ve günümüzde de geliştirilmekte olan bilimsel ve teknolojik kaynakları inceler. Çağdaş paradigmaların estetiğini eleştirel bir dilde analiz ederken, tarihsel dönüm noktalarını ve gelişen teknolojilerin sonuçlarını varlık bilimsel bir felsefe ile inceler. Araştırmanın bu bölümü, başlangıcını tarih öncesi dönemlere dayandırır, ve tarım devrimi öncesi dönemin şartlarından başlamak suretiyle bu dönüşümün süreçlerini kademeleri bir bir inceleme altına alır. Akustik biliminin milattan önceki ufuk açıcı deneylerinden, akustik olarak etkileyici mimari doğru gelişen yetkinlik ve bu yetkinliği genel anlamda yönlendirdiğimiz dini bina mimarisinin aslında nasıl ses mekan ilişkisine nasıl yüzlerce yıl ev sahipliği yaptığını tarihsel örneklerle ortaya koyar. Bilişsel ve tarihi evrimin kesişiminde süren analizler endüstriyel çağın getirdiği teknolojik imkan patlamasına doğru ilerler. Araştırma metni, bu dönem ve sonrasında ortaya çıkan toplumsal dönüşümlerin ve ortaya çıkan buluşların nasıl bir toplumsal etki yarattığı, ses sanatına bu etkinin nasıl nüfuz ettiğini inceler. Ses mefhumunun bir olgu olarak müzikle iç içeliğinin bu dönemde ayrışmaya başlamasını bu bağlamda inceler. Bu ayrışma aynı zamanda ses sanatının ortaya çıkışının habercisi olacaktır. Bu dönüşümde öncü rol oynayan Edgard Varese, Eric Satie, John Cage, Igor Stravinsky gibi ikonik isimlerin 1. ve 2. Dünya Savaşı arasında kalan dönemde çok derin toplumsal değişim dönemlerinde çalıştıklarını biliyoruz. Bu tez çalışması, bu dönüşüme mümkün olduğunca alan tanımaya çalışmakta ve çağdaş ses sanatı algısının meydana gelişini tarihsel örneklerle ortaya koymaktadır.

Bu masif sosyolojik ve psikolojik dönüşümlerin işlenmesi akabinde, tezi tamamlayıcı nitelikte hazırlanmış örnek çalışmanın (kendi özel ismi ile *CLSR*) analizine geçmeden önce hem bu işi ve ifade ettiklerinin anlaşılabilmesi için hem de genel anlamıyla entelasyon sanatının önemi ve inceliklerinin anlaşılması için hazırlanmış bir tartışma bölümü mevcuttur. Bu bölüm geldiğimiz çağdaş noktanın detaylarına eğilen ve okuyucuyu örnek çalışmaya doğru yönlendirirken estetik ve teknik olarak ses enstalasyonunun tartışılması ile meydana gelir. Metnin devamı sesin mekansallığını estetik olarak idrak ve ifade edebilme, bu meselelerin öznelliği ve bir hiyerarşik tartımdan bahsedemeyeceğimize dair yapılan gözlemler neticesinde ses enstalasyonları nedir, türsel bir ayrışımdan ya da tanımlama sisteminden söz edilebilir mi ve ses sanatının bu nişini hangi nüanslar eşliğinde anlamak ve düşünmek gerekir ve benzeri soruları tartışmaktadır. Bu bölümü bir ses sanatı eseri mekanla nasıl ilişkilendirilir, bir ses enstalasyonunu mekan bağlamı içerisinde ele alırken ne gibi inceliklere dikkat edilmelidir sorularını merkeze alan “difüzyon stratejileri” bölümü takip eder. Ses entelasyonu bağlamında odak konsepti nedir ve bu tip sanat eserleri başka bağlamlara uyarlanabilir mi bunların sorgulandığı alt bölümlerle tartışma sekansı tamamlanır.

Araştırma metni bu teknik, terminolojik, tarihsel ve estetik ve zemin üzerine *CLSR'*ın metodolojik olarak takip ettiği yol, estetik ve felsefik olarak işin kendini konumlandırışı ve de ayrıca ilhamlarını içeren final bölümüne ilerler. Bu 4. ve son bölüm örnek çalışmanın işleyişini ifade etmekte ve kurulumun yaratımı sürecinde ve neticesinde ortaya çıkan bulguları okuyucu ile paylaşmaktadır. *CLSR*, bu tez çalışmasının sona erdirilmesinden önce İstanbul Teknik Üniversitesi'nin Maçka Kampüsü Binası içerisinde Doç. Dr. Cevdet Erek danışmanlığında iki kez kurulmuş, test edilmiş ve geliştirilmek üzere raporlanmıştır. Üçüncü ve son bir gösterim de bu tezin sunum ve savunma günü gerçekleştirilmiş, pratik edinimler tez metni içerisinde raporlanmıştır. Bir çok-kanallı enstalasyon çalışması örneği olan bu örnek, mekanın saydam bir arkaplan olduğu yönündeki düşünceyi tartışmak için tasarlanmış ve uygulanmış gerçek zamanlı bir iştir. Ses sitemlerinin kalibrasyonunda kullanılan referans tonlarını SuperCollider ses programlama dilinin algoritmik olarak ses üretme kapasitesini merkeze alarak faydalanır. İzleyiciyi, ses, çevre ve bunların algılanması arasındaji dinamik ilişkiyi keşfetmek üzere kurgulanmış bir diyalog daveti olarak düşünülmüştür. Ses ve çevresi arasındaki simbiyotik ilişkinin altını çizmeyi amaçlar. Özünde bu tez çalışması, enstalasyon sanatında mekanın rolünü ve yaratım üzerindeki etkisini araştırarak, ses ortamını değerlendirme biçimlerini sorgulamakta, sesin yaratılmasında ve algılanmasında aktif katılımının altını çizerken ses sanatlarında mekansallığa bir davette bulunmaktadır.

1. INTRODUCTION

Sound behaves according to its environment. This association is recognized as spatiality in sound studies. Whether incorporated in arts or in music, spatiality has a binding role. It is an aspect that connects the majority of sound-related arts. In fact, any act of sound design inevitably affects the spatial qualities. This implies that whether composers or sound artists are crafting harmonies or modulating synthesis methods, they are intrinsically leading to outcomes intertwined with space. Therefore, speaking in terms of aesthetics, in particular, this makes considering spatial qualities of sounds as pivotal as placing them in time. The relationship between a sound and its environment is a whole and studying the exact nature of a sound beyond this integrity can be handled only in sterile laboratory environments. However, for the purposes of this research, the focus will be on the usage of sound as a means of artistic expression in environments that are not particularly “sterilized”. The subsequent pages will delve deeper into this relationship between sound and its environment, exploring how it influences our perception within the realm of sonic arts.

Regardless that it is organized or not, sound doesn't possess a location. This information is synthesized in the brain based on the receiver's position in space. Due to the natural structures of its bodily parts, the human auditory experience has characteristics that evolved to recognize certain qualities of sound events. Thus, sound only has perceptual spatial counterparts that are based on the perceiving auditory system. The ear captures sound and translates it into electrical signals. The brain utilizes subtle differences in intensity, spectral, and timing cues to localize sources of sound and understand their direction, distance, and sizes in space. This is the process that creates the association between sound source, space, and listener. Hereby, when a sound artist prefers to work with a specific sound, their preference becomes a subject of this exchange. There are two arterial directions for the artist: Either accepting this nature to exploit its potential or trying to prevent deviations it may cause by determining what is interfering with the desired result(s). In any case, steps that are taken without recognizing this symbiotic, and delicacies of human perception would lack transmitting the information that is intended in essence.

The symbiosis between sonic art and its residing space is a multi-faceted interplay. The broader public tends to perceive the latter as static, a mere container for the former. This thesis challenges this widespread preconception by calling attention to the interactive role of space. Along with discussions regarding this starting point, a complementary sound installation project will be introduced in *Chapter 4*. While it is prepared uniquely for this research to gain empirical data, the exemplary work's philosophical foundation is rooted in the psychological theorem known as *gestalt*[1] where the whole is seen as different than the sum of its parts. Therefore, it highlights connections on seemingly separate entities, and how they create a larger, more entangled experience when they interact. From now on, to refer to the exemplary work, *CLSR* will be used in short.

Besides this root, *CLSR* draws inspiration from the pioneering works of Alvin Lucier and Ryoji Ikeda. In particular, Ikeda's interest in evaluating very precise materials like the sonification of pure data[2] in his compositions (Rugoff, 2021); and Lucier's explorations on the acoustic influence of a room over sound by exploiting resonant frequencies as he demonstrated in his seminal piece "I am sitting in a room" (Lucier, 1981). In essence, this research is primarily questioning the counterfeit transparency of space, examining how it affects artistic output and in which ways its nature can serve as tools of creativity. The following questions will guide this thesis and the associated exemplary work:

- What is sound, space and why their meanings vary, particular in the context of installation art?
- If space is not merely a transparent agent in the presentation of sonic arts, how does it influence sounds propagating within it?
- How does the diffusion strategy (the choices made regarding the placement of sound sources and absorber/reflective surfaces at a site) affect installation artworks, and what are the widely questioned practices regarding it?
- When evaluating auditory input, attention can be directed to focal details or used to grasp layers globally. Can these polarities co-exist harmoniously and how to address this dichotomy within an installation artwork?

[1] Originating from early 20th-century psychology, this theorem posits that humans perceive objects as organized patterns or wholes rather than merely as separate components. This holistic approach emphasizes that the whole is different from the sum of its parts, and our minds tend to simplify complex images or sounds into more easily understandable, unified forms (Koffka, 1935).

[2] For instance, in his album "Test Pattern," Ikeda uses specific waveforms, impulses, and burst data that are typically used to test loudspeakers and headphones (Ikeda, 2014). These types of sounds are commonly referred to as reference/test tones in sound engineering terminology.

1.1. Space

Space. A fundamental framework that describes the abstract or physical expanse in which objects and events occur, having relative position and direction. From the vast cosmos to the minuscule quantum realm, everything exists within and relates to it. As is the case with things that are omnipresent, it is often thought of as transparent. This is because it is easier to focus on other details within its context, after all, they are what is apparent on the surface. This study's approach is to acknowledge this reasonable tendency, but also remind us that as human beings we are actually living in the space, not in a city or in a building, in an art gallery, or simply, in a room. We live on a spinning space rock orbiting around a burning globe that is spinning around itself, and these two are orbiting around a galaxy (a cluster that has several hundred billion of these burning globes) center (Masetti, 2015). The beautiful weirdness of this combined with our limited ability to truly comprehend it, leads to this tendency to ignore where we actually are, and attempt to establish physical and/or psychological boundaries. As a mechanism to simplify living and enrich the survival tool-set, this indeed has immense importance. However, as a side-effect, it makes people become disconnected from each other, life, the realities of it, and the reality of being in space; we become aliens in our very nature.

Returning to earth, perception of space hinges on numerous factors, including sensory capacities, cognitive abilities, and a mosaic of past experiences that encompass biological and cultural facets. Fortunately, in the context of arts, space is a concept that is rarely seen as just an empty container or a passive agent that allows events and objects to merely exist within it. Particularly in sound art, there are a handful of tools known as spatialization techniques to shape sound and its relation with space, which are useful in manners like manipulating sound sources to convey impressions of movement or depth. These techniques view the spatial properties of sound as an interactive canvas, allowing artists to craft soundscapes that resonate and interact uniquely with their audiences. The influence of considerations on spatiality transcends mere auditory aesthetics and brings a transformative touch, redefining the meaning and essence of a sonic artwork. This emphasizes that our understanding of space isn't set in stone, instead, it is fluid, subjective, and perpetually evolving. Gaining access to the ability to shape this perception necessitates delving into these nuances, spatiality, and their respective layers.

The concept of spatiality traces its etymological roots to the Latin word *spatium*, signifying "room", "space", or "distance". When augmented with the suffix *-ality*, it denotes "the quality or state of being", leading to spatiality being understood as the essence or condition of occupying or relating to space (Alfirević and Simonović, 2019). This notion extends its influence across diverse fields, from architecture and design to geography and social sciences. In the realm of sound, it gains an added dimension, that not only encompasses the physical location of sounds but also pertains to the perception of their positions, accounting for a listener's ability to discern sound origins.

When considering how sounds can be differently perceived and how their interaction with space influences this, the concept of *umwelt*[3] draws attention. It dives deeper into the subjectivity of spatial perception and proposes that each organism has its own self-world that is shaped by its unique sensory and cognitive capacities. As will be discussed in the following pages, due to physical and psychological differences, the processing of sensory inputs varies significantly among listeners. Space thus transcends mere physical dimensions; it transforms into a stage for interaction, a component of an organism's experience and understanding. This recognition allows us to appreciate the multitude of perceptual spaces that coexist, each one tailored to the specific ways in which an organism perceives and navigates in the world. Thereby, spatialization can be viewed as the unique mapping of an environment by each organism, influenced by their distinct sensory perceptions and cognitive abilities.

It might seem intuitive to regard all sounds as spatial entities due to their existence in three-dimensional space; however, the term "spatial sound" in the sound art context extends beyond this intrinsic property. Sound, in its raw form, possesses physical properties that correlate with the intangible aspects of sensory recognition. As highlighted by a philosophical puzzle that Sethares points out, "*If a tree falls in a forest and no one is around to hear it, does it make a sound?*" (Sethares, 2010), without an auditory system to perceive and give it context, sound may remain undefined in spatial terms. Thus, defining a sound as "spatial" necessitates both perception and cognition. In sound art, "spatial" not merely refers to sound's inherent spatiality but to the specialized techniques that reproduce sound to convey a profound sense of three-dimensional space. By harnessing techniques such as sound localization and spatialization, sound artists aim to craft immersive auditory experiences that either mirror or enhance our natural engagement with sound in our surroundings.

[3] A term coined by biologist Jakob von Uexküll refers to the perceptual world in which an organism exists and interacts. (Uexküll, 1920).

1.2. Sound

Sound is a multifaceted phenomenon that can be defined in various ways. These definitions vary depending on the perspective from which the phenomenon is approached. Author and researcher William Sethares points out how different meanings are attributed to sound with the following words:

> One definition describes the wave nature of sound: "Vibrations transmitted through an elastic material or a solid, liquid, or gas, with frequencies in the approximate range of 20 to 20,000-hertz."[4] Thus, physicists and engineers use "sound" to mean a pressure wave propagating through the air, something that can be readily measured, digitized into a computer, and analyzed. A second definition focuses on perceptual aspects: "The sensation stimulated in the organs of hearing by such vibrations in the air or other medium." Physiologists (and others) use "sound" to refer to a perception that occurs inside the ear, something that is notoriously hard to quantify (Sethares, 2010).

For the purposes of this chapter, the meaning of the engineer/physicist definition will be elaborated. Throughout the broader text, however, the term's different meanings will be employed interchangeably based on related context, with explanations provided for when and why. Now, to put it very simply, sound is energy that travels in the form of waves through a medium, the auditory system picks it up and the brain interprets it as sound. Sound can propagate through various states of matter, including solids, liquids, and gases. To be able to grasp this propagation's relation with space, understanding its various physical and psychoacoustic properties is essential. The physical sound waves fluctuate through the medium they propagate, causing molecules to go high (compression) and low (rarefaction) density over time. Please check *Figure 1.1* to get familiar with this concept through a very particular waveshape named "sine wave".[5]

It is possible to characterize this oscillatory process of push and pull by three mathematically calculated quantities: Amplitude, frequency, and phase. The amplitude is the measurement of the distance between higher and lower peaks of the pressure wave. It is reported in decibels, dB in short. The dB represents a logarithmic ratio between two quantities. The frequency of the wave represents the number of oscillations that happen in one second. For instance, a sine wave that has a frequency of 100 Hertz (Hz in short), oscillates 100 times each second. Although it alters greatly based on factors like age, body type, and past experiences in life, the human auditory range typically spans from 20 to 20,000 hertz.

[4] According to Sethares's article, this is information from *"the American Heritage Dictionary*" (Sethares, 2010).
[5] A sine wave is a basic sound waveform named after the mathematical sine function. It represents a smooth and pure sound with a specific frequency and amplitude.

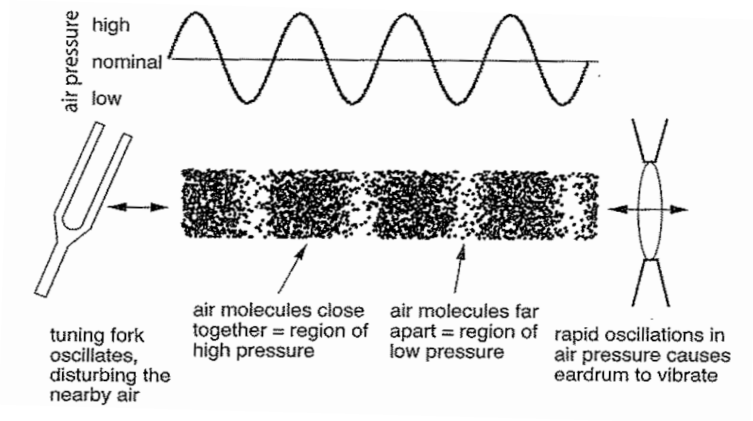

Figure 1.1 : Sound as pressure wave (Sethares, 2010).

The variation of amplitude in a transfer medium is perceived as “loudness”. Increased amplitude results in a greater tactile impact due to the energy of the sound wave, leading to heightened perceived loudness. However, the perception of loudness is not directly proportional to the amplitude only. Physical attributes of a signal like amplitude and frequency must be kept distinct from their perceptual correlates like loudness and pitch respectively. Physical attributes are quantifiable properties of the signal, while perceptual correlates arise in the listener's mind.

Among the three fundamental physical aspects of a sound wave, lastly, 'phase' denotes the relative position of a point in the cycle of a waveform to its reference position at a specific moment in time. The phase of a sound wave during a singular listening instance is not perceivable. However, it becomes important when multiple sounds are present in an environment. As the propagation of mechanical radiation in a medium proceeds, they exhibit points of points of push and pull on that medium each second. When two or more sound waves are present, depending on whether they are in-phase or out-of-phase, their phases can either reinforce each other amplifying the sound, or cancel each other out, leading to silence. The latter effect is known as phase cancellation and occurs when two sound waves with opposite phases combine, resulting in a disappearance of sound waves. Therefore, an understanding of phase is essential in situations where multiple sounds are present, as it can directly influence the perceived loudness and perception of space.

Multiple factors influence an auditory perception that evaluates sound design and music composition, especially ones employing techniques to manipulate spatiality. These factors encompass individual sound processing variations and listeners' prior experiences with sounds. Before delving into these aspects in the subsequent chapter on psychoacoustics, it is essential to first understand how a given space influences the propagation of sounds within it.

This specific area of research falls within the broader field of science known as acoustics. While commonly associated with architecture or music, acoustics encompasses a much broader scientific domain. It is the science that explores the production, transmission, and reception of mechanical waves as well as how they interact with different media. The term is derived from the Greek *akoustos*, meaning "heard" (Berg, 2019). Studies around it involve the physical properties of mechanical waves, as well as their interactions with various materials and structures. Refer to Lindsay's "Wheel of Acoustics" (Figure 1.2) for a visual representation, acoustics covers a broad range of topics from seismology to bioacoustics. The science of acoustics inherently addresses the spatiality of sound, as examining wave properties elucidates their behavior in varied environments. This research, in turn, transforms into the cumulative knowledge of what is known about the dynamics of three-dimensional space.

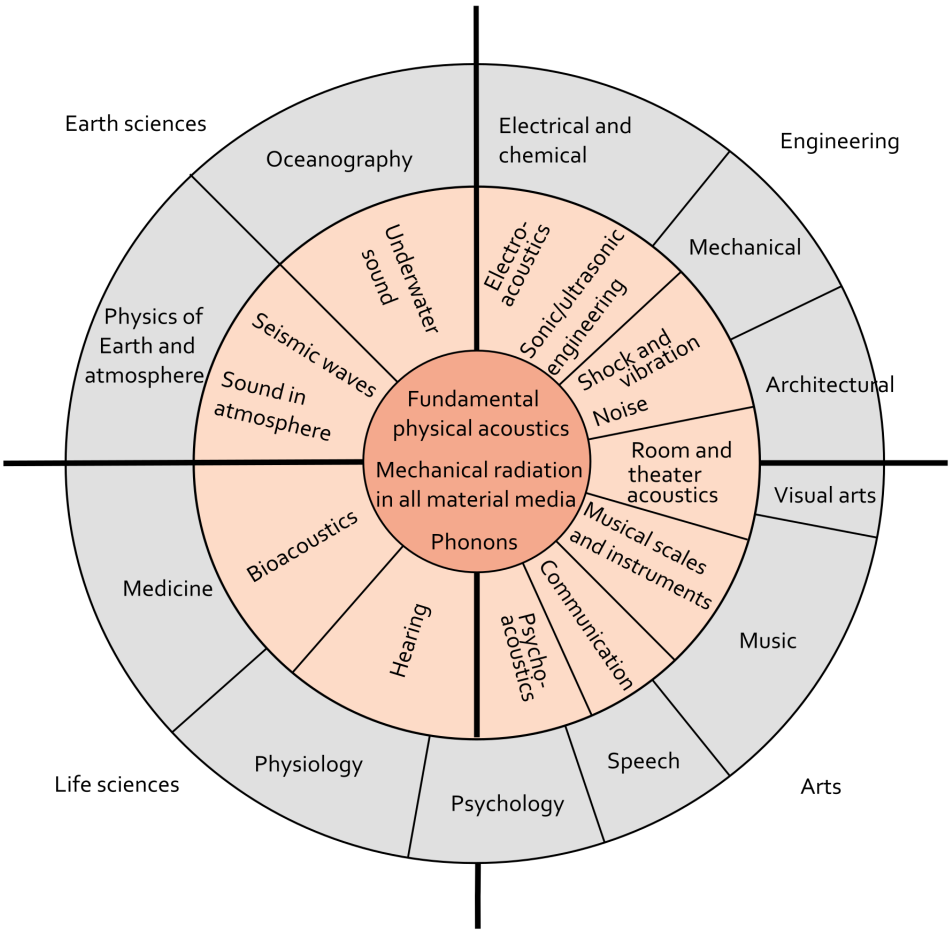

Figure 1.2 : Lindsay's Wheel of Acoustics (Wikimedia Commons, 2022).

Acousticians employ mathematical models to analyze sound wave behaviors and their consequent influences across various environments. Commonly addressed concepts in acoustics include amplitude, frequency, phase, spectral properties[6], resonance, delay, and reverberation. These concepts can interact with each other in complex ways and the auditory system infers information from combinations of them to derive a consistent and unique auditory perception. In simpler terms, reverberation is the persistence of sound after the source ceases, a phenomenon resulting from sound reflections within enclosed spaces. This interaction of sound waves with reflective surfaces, such as in cathedrals or classrooms, leads to a perception of "immersion" due to phase-shifted, reflected, layered multi-directional sound with slight temporal discrepancies (Wilson, 2021). It significantly influences the comprehension of speech, identification of individual sounds, and spatial perception. Reverberation and its attributes are parameters to think for acousticians in sculpting an audience's experience. While reverberation comprises a series of closely spaced echoes termed 'reverberants', a delay is characterized by a singular echo. When a sound wave travels through a medium, it gets affected by various factors that can cause delays in the sound. For example, when sound travels through a room, it can bounce off walls, floors, and ceilings, creating echoes and delaying the arrival of the sound in your ear. Very similar to a reverberant, the only difference being the timing of the reflection. Whereas reverberants emerge almost immediately after the initial sound wave, delays exhibit a more extended temporal gap between the initial, secondary, and subsequent waves. Modern sound recording and reinforcement systems offer techniques to precisely control and manipulate sound delays tailored to specific applications.

In acoustics, resonance describes a phenomenon where an object or system oscillates at its natural frequency due to an external stimulus with a matching frequency. This matched oscillation, termed as 'resonant', increases the system's amplitude, which in turn influences the sound's timbre, producing pronounced resonances. Resonant frequencies are dictated by a room’s size, shape, and construction materials, shaping unique acoustic characteristics. Because resonant frequencies shape sound waves, the reverberation of these frequencies also changes. An illustrative example of this principle is Alvin Lucier's 1981 recording, “I am sitting in a room”, demonstrating how resonant frequencies of an environment interact with sound, exemplifying the principles of acoustic resonance (Lucier, 1981).

[6] It states to how energy is distributed across various frequency components within a sound. Excluding instances like "pure sounds", every sound event possesses a distinctive array of frequencies. When such an event occurs, it is composed of a blend of frequencies, which collectively establish a unique "timbre".

1.3. Psychoacoustics

In nature, the ability to locate sounds is crucial for survival, leading numerous species, from dolphins to humans, to evolve sophisticated auditory systems. Due to the physical dependencies of being in a bodily structure, a sonic experience always incorporates multiple sounds at once, yet the auditory system can extract detailed information about its surroundings. Individuals can pinpoint the direction of a sound source with minimal deviation in degrees. They possess the capability to discern, or at the very least, surmise hundreds of sounds effortlessly. To achieve such precision, the human brain continuously performs calculations and formulates assumptions. Decoding air pressure waves that consist of layered information to determine the association between sounds and their sources is a quite remarkable skill, and it is one of the critical abilities for us to survive through evolution. While our auditory abilities have played a critical role in our evolution and interaction with our environment, it is essential to acknowledge that the auditory system, while sophisticated, is not without its flaws and remains not fully understood.

Transitioning from the evolutionary roots and inherent complexities of natural auditory processes, one encounters psychoacoustics: a field dedicated to exploring the relationship between sound's physical attributes and the perception it prompts. It ventures into the intersection of diverse disciplines like biology, neuroscience, physics, and psychology, to investigate the intricacies of how the human auditory system processes acoustic stimuli and how this input is interpreted subjectively. Psychoacoustics research provides essential insights into phenomena such as the hearing thresholds across varying frequencies and intensities, the interpretation of layered sounds and musical tones, and the impact of disparate acoustic environments on our perception of sound.

The practical significance of psychoacoustics spans across a multitude of domains. It guides the design of aids in creating devices for improved hearing, assists in assessing the implications of environmental noise pollution on human well-being, and audio systems utilized in live performances. Researchers in psychoacoustics leverage an array of techniques to explore the perceptual facets of sound. Their study encompasses exploring the audible threshold, understanding location cues, the influence of space on sounds, perceptual biases, and meaning listeners attribute in response to sound events and beyond. All in all, psychoacoustics research plays a pivotal role in enhancing auditory experiences in both artistic and medical domains.

The human auditory system is a set of sophisticated biological tools. All steps during the process of making sense of sound are critical. The outer ear collects sonorous vibrations from the air and sends them to the eardrum's membrane to make bones in the middle ear move. The middle ear amplifies and transmits this movement to the inner ear where sound waves stimulate hair cells in the cochlea. These hair cells undergo a process called transduction, where they convert the mechanical energy from sound waves into electrical signals, and then direct them to the brain through the auditory nerve system. Then the brain interprets them as sounds, allowing the listener to make sense of what they hear. In essence, the auditory system serves as a translator, enabling the brain to decipher acoustic information.

Building upon the distinctions drawn in the preceding chapter, the auditory translation process has perceptual counterparts that warrant distinct analyses. For instance, while amplitude is the primary metric to follow for perceived loudness, there is more than a mere direct proportionality. Because loudness doesn't merely depend on amplitude alone; other parameters, such as frequency, context, and the individual's sensitivity also play crucial roles in shaping its perception. While physical attributes can be empirically measured, their perceptual counterparts, exist within the listener's cognitive realm. As temporal beings, sounds only appear and disappear. Meanings like distance and location are attributed to them based on evolutional conditionings and one's previous experiences in life. Ville Pulkki[7], explains a part of this process, "the perception of direction" as the following:

> The perception of direction is formed in signal analysis by our brains. While signal characteristics in one ear are important to understand what type of sound we hear, to localize it we need two ears. Our brains calculate the differences between two ears and find out what to do. Its accuracy is developed over time because all humans have different pinna cavities and differences in perceptual precision. Hearing mechanisms most of the time estimate the most probable direction for the sound source. These calculations are open to perceptual misunderstandings (Pulkki, 2016).

Remarkably, the act of listening is not purely innate; it can be cultivated and learned. A frequently referred example of this phenomenon is as follows: In 1801, Dr. Jean-Marc Gaspard Itard performed various auditory tests on a young boy that he discovered living without any known parents and "untamed" in the wilderness. According to him, he did tests like abruptly closing doors or rattling keys, to gauge the boy's reactions. These common sounds, which would intrigue a "typical" individual of that time, had no effect on this boy. This situation led Dr. Itard to assert that auditory perception is an acquired ability (Newman, 2006).

[7] The founder of a sound spatialization method known as Vector-Base Amplitude Panning (VBAP).

Determining if the boy had developmental delays or autism may never be possible. However, this renowned example raises attention to the very issue being addressed here: One of the most significant flaws in aural rhetoric is the assumption that hearing is synonymous with listening. Hearing is a sensory process that does not require an activation, ears hear sounds even when sleeping. Listening necessitates hearing, but it can't be solely boiled down to hearing. It is an active behavior that necessitates focus and emerges in the conscious side of the evaluation of sensory inputs. It is an active practice that can be learned and is often shaped by cultural influences. Therefore, attempting to describe the act of listening in isolation, without considering its evolutionary and cultural contexts, leads to an incomplete or misleading understanding. Structures of human experience, consciousness, and even phenomenologies are susceptible to transformation.

Coming back to the auditory system, on the “learnable” side, there are a variety of “higher-level” cues that involve complex cognitive processes, such as spatial hearing templates. These templates are created through experience, and they reflect the listener's knowledge of the typical spatial properties of different types of sounds. For example, a listener may learn to associate certain characteristics, such as the reverberation time or the frequency content of a sound, with specific locations in space. As a result, when encountering a novel sound, the listener can use their knowledge of these spatial templates to extract information from the sound source. Additionally, the auditory system also uses contextual cues, such as visual information, to improve sound localization accuracy.

In sound localization, there are two primary branches in psychoacoustics: monaural and binaural cues. Monaural cues are based on the characteristics of the sound that arrive at a single ear. They play a pivotal role in localizing sounds in the vertical plane. These cues include spectral cues, such as the head-related transfer function (HRTF) that is related to the filtering effects of the head, torso, and outer ears on the sound waves. It is affected by factors such as head shape, age, gender, and ear canal length. HRTF is one of the defining aspects that makes all listeners unique. This variability makes it difficult to create a spatial sound experience that is consistently accurate for everyone. In contrast to monaural cues, binaural cues involve both ears. As human ears are on opposite sides of the head, they capture sounds from different directions at slightly varying times. These differences in timing, loudness, and frequency content are what the brain's processing of binaural cues relies on.

Monaural and binaural cues employ differences in arrival time between sounds at each ear (namely interaural time differences, ITDs), and differences in sound intensity between ears (namely interaural level differences, ILDs). ITDs are particularly important for perceiving the location of sounds that vibrate in lower frequencies, while ILDs are more important for higher frequencies. Binaural cues are employed primarily to determine the horizontal position of a sound source.

The mechanisms of localization examined thus far primarily address directionality. In addition to directionality, when assessing a sound's spatial qualities, distance cues are also significant. While seemingly similar, distance and localization cues serve distinct purposes. As the name suggests, distance cues, refer to the cues that the auditory system uses to determine the distance between a listener and a source. A primary example is the temporal changes in sound level, namely attenuation. It refers to the decrease in sound intensity as a source moves away from the listener. As sound travels through a medium, it encounters molecules that absorb and scatter its energy, resulting in a decrease in intensity. Another cue in the calculation of distance is changes in the spectrum. This involves changes in the frequency content of sounds as they move through space. High-frequency sounds are attenuated more quickly than low-frequency sounds due to the absorption and scattering of sound energy affecting them more. Distance recognition takes this phenomenon into consideration. Lastly, the changes in reverberation and echoes: The persistence of sound in space after the sound source has stopped can provide information about the size and shape of the sound source and space, which in turn help to determine the distance. These cues vary based on the acoustic environment and the properties of the sound source. They interact with localization cues and shape the perception of sound.

Last but not least, another significant topic in psychoacoustic studies is auditory illusions. This concept refers to a perceptual phenomenon in which the brain perceives qualities of sound different from the actuality. Although it is tempting to claim the auditory system works inaccurately, this is not always the case. Sometimes the perceptual input is accurate but the interpretation of it is unusual. Such deviations may occur due to various factors, including the spectral and temporal characteristics of a sound, and/or the acoustic properties of the listening environment. As it is stated above, although there are facets in common, all auditory experiences are unique and personal. Researchers gain insight into the dynamics of sound perception by studying how auditory illusions arise from this juxtaposition. A few of the most influential examples are explained below.

Acoustic Shadowing: It is a phenomenon in which a sound wave is blocked or attenuated by an obstacle, resulting in a reduction in sound intensity on the other sides of that obstacle. Factors affecting the extent of shadowing include the size, shape, and material of the obstacle, as well as the sound's frequency properties and the distance between the sound source and the obstacle. It has practical applications in areas like acoustic design. Distant sounds are typically perceived as less "bright" than nearby sounds. This is due to both the effects of acoustic shadowing and the inherent tendency of high frequencies to dissipate in the air more swiftly than lower frequencies.

Auditory Masking: A phenomenon in which the perception of one sound is affected by the presence of another sound. The interfering sound can either completely mask the target sound, or reduce its audibility through partial masking. This is because the auditory system has a limited ability to decode sounds simultaneously, and the presence of one sound can make it more difficult to detect or perceive another sound. That being said, although it is affected by auditory masking, the auditory system can selectively attend to the sound of interest and "filter out" other sounds.

Doppler Effect: It is used to describe the change in frequency of sound in moving sound sources. It plays an influential role when composing the movement. An illustrative example often used to explain it is the car horn. The observer of this effect experiences three phases. When the sound source is approaching, the perception of pitch tends to be heard as if it is higher. This is because the sound source is moving towards the observer and so pressure waves move faster than they should be, therefore more frequent in a second, and thus higher in pitch. While sharing a very close area, the source is audible as it is and when it goes away from the observer, the pitch becomes lower because the movement that is just described affects the sound in reverse.

Franssen Effect: A phenomenon in psychoacoustics where a listener perceives a continuous sound as coming from its original location, even after the sound source is moved elsewhere, as long as there is no interruption in the sound. It demonstrates the importance of the onset of a sound in localizing its source and highlights the limitations of the auditory system in updating the perceived location of continuous sounds. The listener's perception remains ‘anchored’ to the original source location if the sound remains continuous. It is especially effective in spaces that have excessive reverberation.

Spectral Splitting Effect: This effect occurs when the spectral components of a sound are spatially separated, it is also known as spectral dispersion. This separation arises when sound waves interact with surfaces or objects, causing different frequency components to disperse unevenly and travel at varying speeds. Therefore, these components arrive at the listener's ears at different times or vary in phase, leading to the perception of spatial separation, and significantly influencing the perception of music and speech. Due to altering effects of acoustic resonance and phase cancellation, this effect can trigger a perceptual “virtual pitch” in the absence of a physical source, known as the "Dichotic Pitch" or "Binaural Pitch".

Precedence Effect: Also known as the law of the first wavefront or the Haas effect, in which the perception of a sound source's location is dominated by the first arriving sound wave, even if subsequent sound waves arrive from a different direction. When a particular sound event is followed by another sound with a fairly small delay in time, the listener tends to perceive these sounds as coming only from the direction of the first-arriving sound and perceive the successive one as fused or as the echo of the first. Therefore the spatial origin of the first event shadows the following event. The precedence effect is considered the reason why panning in stereo[8] doesn’t work unless the listener is in between loudspeakers (Wilson, 2021). This effect aids in sound localization in reverberant environments, allowing one to focus on the sound source rather than the reflections, and can lead to the localization of sounds.

While evolutionary processes favor information that could survive, this doesn't imply there is uniformity in what is heard or how it is interpreted. It is essential to recognize that approximations often serve us well, but there's always room for variation, much like evolution itself.[9] Employing psychophysical tests, brain imaging techniques, and more, psychoacousticians delve deeply into this variability to determine where the median is and in which ways things deviate. To reveal accuracy in designing and interacting with spatial sound, these departure points start to become matters of thought. By combining knowledge from the multi-faceted discipline of psychoacoustics professionals can craft new ways to interact with sounds and space that resonate coherently with human perception.

[8] In audio technology, "stereo" refers to a sound recording and playback method that uses two channels (left and right) to provide a more natural perception of sound with a sense of direction or depth, as opposed to "mono" which uses a single channel.
[9] Although it is often misinterpreted with dominancy, it is empowered by variation.

1.4. Sound Art

Sound art is an interdisciplinary field of study that explores creative and expressive possibilities with sound. It is an intriguing and multifaceted domain that extends beyond the traditional confines of music. It intersects a myriad of artistic expression forms including acoustic and electronic music, concrete poetry, installations, sound sculptures, and video art, among others (Collins et al., 2013). Practitioners in this field employ a diverse range of techniques and materials including live instrumentation, sound recordings, synthesized sounds, sound processing tools, software programming, et cetera. Thus, it escapes strict categorization, a characteristic that according to William Furlong has been "beneficial" (Furlong, 1994). The absence of such constraints allows sonic arts to thrive in diversity.

Sound art can be manifested in galleries or museums or transform public spaces into artistic landscapes. While some artworks might invite a more holistic listening experience, others might necessitate active participation from the audience. The acoustic characteristics of this art form are equally diverse. It can be experienced purely acoustically or delivered through sound reinforcement of a single loudspeaker or through hundreds of loudspeakers. The duration of this expressive practice can vary dramatically as well, from a fleeting moment to a span of several decades as in the case of *Dream House* (Figure 1.3).[10] In essence, the only constant in sound art is its variable nature, underlining the boundless possibilities within this field.

Figure 1.3 : Dream House by La Monte Young, New York, (Dia Art Foundation, 2015).

[10] La Monte Young's conceptual sound and light installation from the 1960s, Dream House, has been at its current home in NY since 1993, emitting high overtones on the harmonic series since then.

Sound art can be explored in detail through books and yet even this would be incomplete to cover its scope. Therefore, for the purposes of this text, rather than exploring its diversity in every direction, the focus will be on its relation with the notion of spatiality, in particular, in sound installations. The aim here is to bridge the introduction made until now to the emergence, evolution and future of the nuances of this artistic practice.

As shown, every sound has a life span and a specific spatial characteristic and the perception of sound is relative to each listener. Auditory systems make use of physically measurable properties of the spatiality of sound, but if there is no ear to collect it and attribute meanings like distance or location, then there is no one to evaluate it as neither sound[11] nor *spatial*. And yet, this concept named *spatiality* is apparent in varying practices including sound installations. It essentially refers to the perceptual and technical aspects of sound that convey a three-dimensional sense of space. By utilizing the nature of perception, spatial sound aims to create experiences that simulate the way sound is perceived. This concept has applications in various domains besides sound art, especially with the intention of enhancing realism and/or immersion for the listener or viewer. It refers to a group of techniques to manipulate sound to create a sense of space, depth, and dimensionality. This involves questioning the perception of distance, direction, and movement of sound events within the installation space.

Although it is not the only way to work with the spatiality of sound, and there is no obligation to work with electricity, reinforcement technologies are useful in the realm of spatial sound practices and installation art. Reinforcing sound is the process of amplifying and distributing sound using electronic equipment to ensure that it can be heard clearly and effectively. This process often involves capturing the sound with microphones, processing it through a mixing console to balance or distribute sound, power amplifiers to alter amplitude, and a strategy to place loudspeakers in the exhibition site. Also, as introduced previously, features such as delay, phase, reverb, and reflections have a direct influence on the perception of spatiality. From mimicking the behavior of these natural features to creating entirely novel behaviors for surreal soundscapes, as of today, especially with the dawn of digital processing tools, there are a myriad of techniques to sculpt the sound. The properties of sound examined so far, provide a broad palette to sound artists to craft versatile.

[11] Sethares discusses this topic by making use of a famous paradox: “If a tree falls in a forest and nobody is there, does it make a sound?” (Sethares, 2010).

At the heart of any artistic endeavor, lie the instruments and techniques that shape its creation. To truly comprehend the intricacies of these auditory landscapes, one must not only be attuned to the artistic expressions but also to the scientific and technological instruments that make them possible. Having explored the foundations of space, sound, and psychoacoustics, we will now delve deeper into the evolution of the art form. Before that, some of the key contemporary concepts on the spatialization of sound, frequently utilized by artists, will be introduced below briefly.

Microphone and loudspeaker: Since their early developments including the contributions of researchers by the likes of Alexander Graham Bell, Emile Berliner, they have been an essential tool in the capturing and the representation of sound waves. Within sound art, these devices transcend their primary functions, acting as the sensory organs of the installation, capturing, transmitting, and therefore altering the recognition of spatial nuances. They act as conduits that transmit aural complexities, often dictating the manner in which sound engages with space.

Sound recording and formats: From Edison's phonograph to contemporary digital formats, the history of audio capture has presented a myriad of ways to preserve and replay sound. While the global audio industry has given birth to numerous mediums and formats, in sound art, the choice can shape or even redefine the characteristics of an auditory experience. Each format has unique effects on the spatial and temporal properties of the sound. Thus, in sound art, the choice of format is beyond simply logical. Some of the most influential formats and their significance will be explored in the following chapter.

Loudspeaker placement and arrays: From Alan Blumlein's 1930s introduction of simple stereo setups, evolving to intricate multi-channel arrays of modern days, the spatial orientation of loudspeakers has transitioned from a basic left-right sound field to a full 360-degree soundscape. In the realm of sound installations, loudspeakers' role morphs into that of a spatial anchor. The configuration of loudspeakers can dramatically influence the experience and offer a tool for artists to sculpt spatiality. While using a pre-figured placement[12] or array is certainly not an obligation, the usage of configurations like quadraphony increases the adaptability, and replicability of an artwork, as long as the provided necessary equipment and settings are available.

[12] Even a single loudspeaker is a placement and therefore a system.

Panning: The term, derived from “panoramic”, involves the balance and distribution of a sound signal. Originally a staple in audio production to simulate aural movement, panning has found unique applications in sound art. Conventionally, it is a technique used to distribute a sound signal, into a sound field through a multi-channel sound diffusion system, such as stereo, which has two channels: left and right. The effect of panning creates the illusion of a sound source moving across space by adjusting the volume of each loudspeaker used in the process. Artists use it to guide the listener's spatial journey, simulating movement and directionality within an auditory canvas. It is known that starting from the 1940s and 50s, pioneers like Pierre Henry and Pierre Schaeffer explored techniques in spatial audio[13], including early forms of stereo panning, as part of their experimental work. (See: *Figure 1.4*)

Figure 1.4: Pierre Schaeffer at au pupitre d’espace, 1951 (Merlier, 2009).

Surround sound: Started to be developed in the 1970s, surround sound was initially a tool for cinema designed to envelop the listener in an immersive auditory experience by arranging multiple audio channels and loudspeakers around them. Unlike traditional stereo setups that present sound along a single axis, and an illusory depth, surround sound extends this field to create a more comprehensive spatial audio environment. In a surround sound setup, loudspeakers are strategically placed to deliver sound from various directions and distances, and the audio is split into separate audio channels. Each channel can produce a different sound simultaneously, allowing a richer, multi-directional sound field, allowing sounds to be treated as distinct spatial entities.

[13] Mostly at the French Radio institution, RTF, short for *Radiodiffusion-Télévision Française*.

Sound field reconstruction: It refers to the process of accurately reproducing or replicating the spatial characteristics and directionality of a sound, aiming to recreate the original sound field as closely as possible. This is often achieved using various recording, processing, and playback techniques to capture and reproduce sound from multiple directions and sources. The two commonly used techniques for sound field reconstruction are ambisonics[14] and wavefield synthesis. They offer the listener a semblance of being within a sound, surrounded by its spatial character. Despite being based on different theoretical premises, under certain conditions, they can produce similar effects. Both techniques work towards reconstructing the sound field in a way that provides a spatially coherent auditory experience.

Loudspeaker independent formats: Breaking free from the constraints of traditional fixed audio channels, methods like ambisonics, Dolby Atmos, vector base amplitude panning (VBAP), and wave-field synthesis (WFS) offer artists a more fluid, expansive canvas. These techniques associate sound with specific points or directions in space, rather than aligning them with predefined channels or loudspeakers, thereby enabling a more spatial, three-dimensional conceptualization of sound. Instead of fixed playback paths, these formats allow artists to associate sounds with precise spatial coordinates, creating fluid, expansive auditory canvases. Ambisonics depicts the sound field as a continuous distribution, capable of being decoded to any loudspeaker layout or binaural format, thus offering remarkable flexibility. VBAP creates a perceived position of a sound source theoretically in any loudspeaker setup by varying the amplitude of a sound source between a pair or a triplet of loudspeakers. Dolby Atmos is an “object-based” audio that leverages advanced algorithms to render audio “objects” in real-time, tailoring to the specific configuration and capabilities of the playback system. Lastly, Wave-field synthesis is a spatial audio rendering technique that aims to create virtual acoustic environments. It operates by producing "wave-fronts" synthesized by a large number of individually driven loudspeakers. These methods help facilitate immersive sound installations, often using multi-channel loudspeaker setups or spatial audio technologies, aiming to envelop the listener in a three-dimensional environment.

[14] Ambisonics is a method for representing and reproducing a sound field in full-sphere surround. Proposed by Michael Gerzon in the 1970s, the concept behind ambisonics is not just about recording and reproducing the sound from discrete loudspeakers, but about capturing and reconstructing an entire sound field.

Sound synthesis: It is the technique of generating sound, typically using electronic hardware or computer software, to create completely novel sounds or imitate musical instruments or other sounds. The core of synthesis involves oscillators to produce periodic waves, filters to modify spectral content, and amplifiers to control the dynamic changes over time. It constructs sound waves that are then shaped by manipulating various attributes such as pitch, timbre, and duration. It is foundational in music production, sound design for media and the development of new electronic instruments.

***"Sterile"* environments**: This is not a commonly preferred definition of the following concepts. However, this explanation is written to clarify what is meant by "sterile" in the introduction. In the context of sound studies and art, rooms that have minimized acoustic influence on sound can be considered as sterile environments. The theoretical end of this definition is rooms known as *anechoic chambers*. It is a space designed to completely absorb reflections of sound or electromagnetic waves. This makes the room effectively free of reverberation and external noise, thus the term *anechoic*, meaning 'without echo'. These rooms are lined with sound-absorbing material on all surfaces which traps sound waves and prevents them from bouncing back into the room (Martin, 2020). The *sterile* attribute refers to the acoustic purity of the environment; it doesn't color the sound with any additional acoustic properties, unlike typical rooms. In contrast, concert halls and galleries are designed with specific acoustical characteristics to enhance the sound of performances or to interact with sound art installations. They are not sterile in the same sense because they introduce their acoustic signature to the sounds they host, which can be reflections, reverberation, and other elements that help create a rich auditory experience. This deliberate shaping of sound through architectural design is intended to enhance the listening experience rather than provide neutral testing like an anechoic chamber. However, when compared with acoustically not organized spaces at all, they still can be considered as "sterile".

This terminological introduction to the concepts that are related to the context of this research was certainly only the tip of the iceberg. Also, they are examined in a quite superficial fashion here. Because the inention is not to give a comprehensive look on the subject, rather this was just to shed light on their presence and prepare the reader to the following chapters to some degree.

As of today, with the ever-growing resources and technological advancement, navigating the myriad possibilities these tools and techniques present, the creators find themselves both empowered and challenged. It is important to acknowledge that the effectiveness of these techniques can vary based on a combination of many factors, ranging from specifics regarding sound production to the design processes of an installation to psychoacoustic considerations and strategical approaches to the variables regarding this artform. Therefore the understanding of spatiality in sound art must accommodate its complexities and nuances, honoring its inherent diversity. It is these nuances and constraints that provide the fertile ground for innovation, solidifying sound art's distinctive voice in the broader spectrum of artistic expression. The next chapter will unveil how spatiality in sound art has evolved over time embracing these tools and methodologies' significance, and how contemporary debates are shaping the field’s future trajectory.

2. EVOLUTION

This chapter aims to examine the roots of the reciprocal relationship between spatiality and sonic arts, gradually focusing on sound installations. The primary inquiry guiding this chapter will be the following question: Regarding the evolution behind the perception of spatiality in arts that utilize sound as their medium, which stages were experienced through time and what are the historical artifacts? Additionally, the potential future directions, possibilities, and drawbacks of the spatiality's integration in the sonic arts will be discussed at 2.5 Post Scriptum.

Leveraging the mechanisms of spatial hearing for artistic expression opens up a wide array of potential applications in contemporary arenas, including music production, cinema, gaming, and virtual reality. However, utilizing it effectively as a creative tool remains a nuanced and sophisticated skill to cultivate. To state it colloquially, it is because there is a need to be a "Jack of all trades". This requirement for versatility comes with a bitter truth: It is so easy to become a "master of none". Fortunately, the extensive experimentation conducted in the field to date provides a substantial body of knowledge to inform and inspire the development of a unique artistic approach. As with any discipline, success lies in asking the right questions like "How to make a sound enveloping?", "How to control the perceived size of sound objects?", "By designing this automation, am I interfering with the law of first wave-front?"... and seeking effective solutions. While understanding different facets of the subject may seem daunting at first, the complexities of the subject become gradually clearer.

The naming of this chapter deliberately signals its purpose: By bridging historical perspectives with contemporary and prospective insights, crafting a scientific narrative that illuminates the evolution of spatiality in the studies of sound. The quest to trace these evolutionary markers takes us back to the echoes of prehistoric caves. Starting from these ancient settings, early humans developed a keen awareness of sound, reflections, and reverberations, utilizing them as vital cues to determine danger or safety. The genesis of spatial hearing has its roots in this recognition, a survival instinct that has been refined over tens of thousands of years and continues to hold a lasting impact on how sound is interpreted.

2.1. BCE[15]

Whether it is conscious or subconscious, the human auditory system has a tendency to make assumptions about what it hears, showing innate interest in the auditory landscape around it. This inclination has shaped how we interact with our surroundings, ranging from basic survival actions like hunting and hiding to more complex community behaviors. According to archeological evidence, musical instruments like flutes have been around for at least 40-50,000 years (See: *Figure 2.1*). Crafted from bird bones and mammoth ivory, these flutes are among the earliest known musical instruments, demonstrating early humans' attempts at interacting with sound. Such evidence suggests that our ancestors were not just passive receivers of sound but were actively exploring ways to interact with it.

Figure 2.1 : Bird bone flute, 40,000 years old (Welsh, 2012).

In addition to early musical instruments, recent studies in the field of archaeoacoustics provide insights into the emerging interest in spatial properties (Gaona et al., 2014). These insights suggest that there might be a correlation between prehistoric cave paintings and the sections of cave systems that have more dense reverberation. This implies that early humans were not only aware of the properties of these spaces but might have deliberately chosen these locations for their sound-enhancing qualities, potentially to amplify the impact of their ritualistic or communal events. The First Agricultural Revolution around 12-10,000 BCE brought these societal shifts to another level. As communities grew, the need to plan spaces suitable for habitation and collective experiences started to emerge. Humans were not the only species using this evolutionary technology,[16] but sound-based communication played a vital role in this transformation, serving as a method for information exchange.

[15] Before Common Era. Here it is used to reference the period from 50,000 to 1 BCE.
[16] One of the most interesting findings regarding this claim is Velvet monkeys. They have up to ten different vocalizations mostly used to warn other members of the group about approaching predators.

Building upon these prehistoric foundations, ancient societies explored the intricacies of sound and spatial design further. As societies evolved the ability to make rousing architectural structures improved too. What began in caves with natural acoustics evolved into making intentional architectural decisions. Experiments on how to handle sound within structures started. Among the relics of antiquity, ancient theaters stand out as a testament to this development, where the slightest nuances on stage could be heard at the furthest seat without any sound reinforcement. The birth of intentional acoustic consideration is in these grand examples of early architecture, a conscious application of knowledge on spatial sound experience to enhance communication and entertainment. Evidence of strategic acoustic design is visible in architecture are the incorporation of angles and usage of reflective materials in buildings like theaters, governmental (e.g. boulaterium), and religious sites. It indicates an emerging understanding regarding the interplay of sound, space, and arts. Traces of these advances are not limited to a specific region geographically, but instead across different cultures worldwide.

When pursuing all these traces, the appearance of research fields like acoustics may seem imminent. However, the birth of it as a discipline has been a gradual process and shaped by many figures throughout history. The formal study of mechanical waves, or in other words acoustics, can be traced at least back to Ancient Greece. Philosophers from this era were interested in mathematics, physics, and natural sciences and their discoveries became useful later on. An instance of this is Pythagoras of Samos, an Ionian Greek philosopher from the 6th century BCE. It is thought that his research where he is focusing on the properties of vibrating strings is credited with providing influential outcomes for the early research of acoustics. Another seminal observation was made by Aristotle in the 4th century BCE. He proposed a theory about how sound waves move through the air marking another important step in understanding of sound. However, it would be imprecise to claim he captured the process as the propagation of sound waves as we comprehend today. He hypothesized that air disturbed by a sound source, such as a vocal utterance or a plucked string, transfers this disturbance to adjacent air until it reaches the listener's ear. However, he did not conceive of this motion as the propagation of pressure waves through a medium, which is our modern understanding of sound. Instead, he posited that sound was related to motion or disturbance, which is why it could be blocked by barriers or attenuated by distance. While its principles had been intuitively applied by architects much earlier and questioned by philosophers for centuries, the modern scientific foundation of acoustics would only begin to solidify in the late 19th century.

2.2. Common Era

Advancing beyond the seminal examples of prehistory and antiquity, another notable example of this growing interest in spatial sound can be found back in the practices of the religious communities in early Byzantine. During the Medieval Era, the church served as a sanctuary for the preservation of scholarly knowledge and and fostering the creative arts. Churches built during this time, such as Istanbul's Hagia Sophia (Turkey, 6th century CE) and Ravenna's San Vitale (Italy) were typically massive stone structures with extraordinarily long reverberation times. While grand and immersive, this style of architecture often made speech difficult to understand due to excessive reverberation. It was in response to such acoustic environments that the era's distinctive slow-moving, monophonic chants evolved, a style profoundly shaped by the architectural features of the churches in which they resonated.

Another example of architectural acoustics is found in the 9th-century Saint Mark's Basilica in Italy (*Figure 2.2*). As the builders grew increasingly attuned to the importance of qualities of sound, so too did the users of these spaces. Here, the congregation of St Mark's separated their choirs, placed them in the galleries, and sang in an antiphonal[17] manner, alternately chanting by echoing with each other (Wilson, 2021). This spatialized music used the site to create more immersiveness. The dense reverberation of these cathedrals played a role in this, with the de-correlated sound coming from multiple directions, creating a sense of spaciousness.

Figure 2.2 : St Mark's Basilica, 9th century CE Venice (Wilson, 2021).

[17] Also known as the Venetian polychoral style, developed in the Renaissance. The choir separates sections of a chant or a song and sing it interchangeably instead of singing it in a unified single voicing.

By the 18th century, the observations made by musicians like flutist and composer Johann Joachim Quantz show that artists became increasingly conscious of the acoustics of their performance spaces and emphasized the importance of adjusting the choice of musical elements accordingly. Herr and Siebein (1998) note that Quantz's treatise offers profound insights into the interplay among the performer, the music, and the venue, discussing how the acoustic characteristics of large, resonant spaces versus small, intimate rooms demand distinct musical strategies. Moreover, he acknowledges the effect of the audience's physical presence, recognizing their bodies as additional acoustic factors:

> In the choice of the pieces in which he wishes to be heard in public, the flutist, like every other soloist, must adjust not only to himself, to his powers and capacity, but also to the place where he plays, to his accompaniment, to the circumstances in which he plays, and to the listeners before whom he wishes to be heard. In a large place, where there is much resonance, and where the accompanying body is numerous, great speed produces more confusion than pleasure. Thus on such occasions, he must choose concertos that are written in a majestic style, and in which passages in unison are interspersed, concertos in which the harmonic parts change only at whole or half bars. The echo that constantly arises in large places does not fade too quickly and only confuses the notes if they succeed one another too quickly, making both harmony and melody unintelligible. In a small room. On the other hand, where few instruments are at hand for the accompaniment, the player may use concertos that have gay and gallant melodies, and in which the harmony changes more quickly than at half and whole bars. These may be played more quickly than the former type. (Quantz, 1966)[18]

Musical patronage decreased in the Baroque period, and a significant rise in public concerts necessitated the creation of music that could fil larger spaces (therefore can be supported by larger audiences) and engage larger ensembles. As concert-going became more popular, demand for larger concert halls increased, catalyzing a shift towards scientific concert hall architecture aimed at optimizing the acoustic requirements of a larger audience and orchestra. In the 19th century, composers and conductors started to refer to the acoustic properties of their performance spaces more frequently. As Hector Berlioz and Richard Strauss observed, subjects such as the layout of the orchestra, the placement of acoustical reflectors in the room, and the creation of dramatic music suited to the acoustic properties of the space came into prominence (Herr and Siebein, 1998). The orchestra's development in Western music provides a clear framework to examine the parallel evolution of the concert hall and the orchestral music, highlighting the integral role of spatial sound perception in shaping human civilization. From this point of view, it is evident that throughout history, composers, performers, and architects have become aware of the interplay between sound and architecture over time.

[18] A translation from 1966, Quantz lived in between 1697- 1773. Source can be found in references.

Perhaps one of the top examples that can be pointed out how seriously composers were considering the effect of acoustics is Bayreuth Festspielhaus from 19th-century Germany (Figure 2.3). Supervised by composer Richard Wagner, this opera house stands out among many of its time. This opera house was designed with a novel, recessed orchestra pit, allowing the music to blend seamlessly with the on-stage actions, further heightening the immersive experience. Serving the utmost impact that the composer Wagner was looking for, a *Gesamtkunstwerk*, meaning a “total work of art”. Although he didn't coin the term himself, the word has become particularly associated with his aesthetic ideals. The essence of his work can be seen as a fusion of various artistic mediums, from music and visual arts to theater and architecture, creating a unified, cohesive immersive aesthetic.

Figure 2.3 : Bayreuth Festspielhaus, 1876 (Wikimedia Commons, 2008).

The birth of Bayreuth Festspielhaus, and buildings from that era, underline the growing interest from composers and musicians placed on acoustically enriching environments for their audience. This inclination also encompasses building and stage design and even delves into performer orientation on stage, organology, and, as Denis Smalley suggests, orchestration of composition itself (Smalley, 2014). As it is examined so far with examples, there has been a consistent interest in the correlation between architectural design and music that persisted throughout history. This tradition extends to opera houses, concert halls, and purpose-built structures explicitly designed for specific performances. Their emergence would only be growing more sophisticated as technological advancements have allowed.

The evolution of considerately designed spaces coupled with the increasing appreciation for their role in aesthetical decisions set a precedent for subsequent generations, echoing into the contemporary practices of sound art and spatial audio design. The transition from these foundations into an industrial society accentuated the importance of spatial consideration, as urban noise and electroacoustic technologies began to redefine sonic environments. This novel era was about to mark sound studies with - back then - emerging technologies such as recording, reproduction, and synthesis. These advancements were about to empower artists and researchers to control and manipulate sound in unprecedented ways leading to novel explorations and renewed interest in the field. From the echoing atriums of ancient Greece to the immersive designs of modern concert halls, the enduring fascination with sound and spatiality points out its profound influence on perceptual and emotional experiences. This highlights the ongoing dedication to craft engaging and immersive experiences and paves the way for the future of sonic arts in an increasingly interconnected world.

2.3. Industrial Era

The world societies underwent dramatic changes during and after the Industrial Revolution, spanning from the mid-18th to the end of the 19th century. With its rumbling factories and roaring trains, it was a period of transition from predominantly agrarian and rural societies to industrial and urban. Mechanization and the factory mindset transformed not just the economy, but also the social, and political landscape. Increased social mobility and urbanization can be named as significant features of this period. This era not only industrialized it but also revolutionized how society perceived and appreciated sound. Noises that were once distant and diffuse, began to localize and concentrate. In this mobilizing context, developing control over senses like hearing through technologies associated with it, became a marker of progress, human presence, and activity. The elements of this context were not designed with specifically sound in mind, but rather, the soundscape became an unintended consequence of this movement, a testament to humanity's growing influence on its environment and its sonic consequences. Moving forward to the late 19th to early 20th centuries, the world witnessed two World Wars and the Great Depression, which shaped societal constructs even further. The turbulent decades of The Second Industrial Revolution, also known as the Technological Revolution, further pushed the bounds of modernization, featuring the widespread implementation of steel, chemical, electric, and petroleum industries to daily life inch by inch.

To reflect the people of this era's society's shock and admiration of the massive transformation, Marx (2010) points out a ceremonial speech given by Senator Daniel Webster (Webster, 1903):

> It is an extraordinary era in which we live. It is altogether new. The world has seen nothing like it before. I will not pretend, no one can pretend, to discern the end; but everybody knows that the age is remarkable for scientific research into the heavens, the earth, and what is beneath the earth; and perhaps more remarkable still for the application of this scientific research to the pursuits of life. The ancients saw nothing like it. The moderns have seen nothing like it till the present generation. . .. We see the ocean navigated and the solid land traversed by steam power and intelligence communicated by electricity. Truly this is almost a miraculous era. What is before us no one can say, what is upon us no one can hardly realize. The progress of the age has almost outstripped human belief; the future is known only to Omniscience

Seismic societal shifts were present and this was frequently reflected in the arts. A major ideological change started to flourish in the art world's discourse, and music was no exception. The Italian Futurist movement, for example, explicitly embraced the noises of industry and technology as a new sonic palette for musical creation. Luigi Russolo, one of the leading members of this movement, wrote The Art of Noises in 1913 (Russolo, 1913). He argued that the human ear had become accustomed to the speed, energy, and noise of the urban industrial soundscape and that this new sonic palette should be incorporated into music. Russolo designed and constructed a variety of noise-generating devices named Intonarumori (Figure 2.4), reflecting this redefinition of what could be considered "musical" sounds. Surely, Russolo and Italian Futurists were not alone. People were seeking new ways of expression, and bells of change were ringing all over the globe.

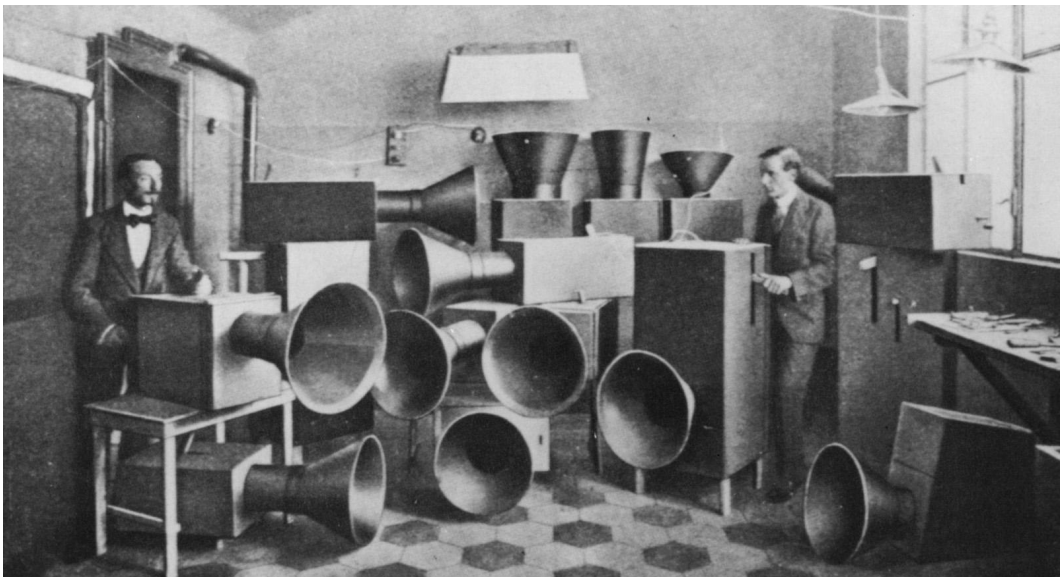

Figure 2.4 : Intonarumori by Luigi Russolo (Wikimedia Commons, 2008).

Moving towards another influential event: The birth of the ability to record, preserve, and reproduce sound. This is one of the most important milestones of how information is harvested and stored. The endeavor to document and transmit sound phenomena, such as writing[19] and musical notation, has been a long-standing aspiration for human civilization. This is quite remarkable because the relation with information is one of the foundations of a civilization. It is worth noting that the act of recording sound isn't merely preserving the physical propagation of sound waves. Early humans recognized this, which is why, following the invention of ways to document spoken words and sentences through language and writing, the quest for other mediums to encapsulate it began. Then, another method for registering sound events emerged; musical notation. Evidence lies in the clay tablets from Ancient Babylonia, showcasing that notation of musical events has been a tradition since 1400-1250 BCE (Kilmer and Civil, 1986). Coming back to contemporary times from antiquity, author and composer Semih Fırıncıoğlu elaborates more on this topic in 2021 (*Figure 2.5*).

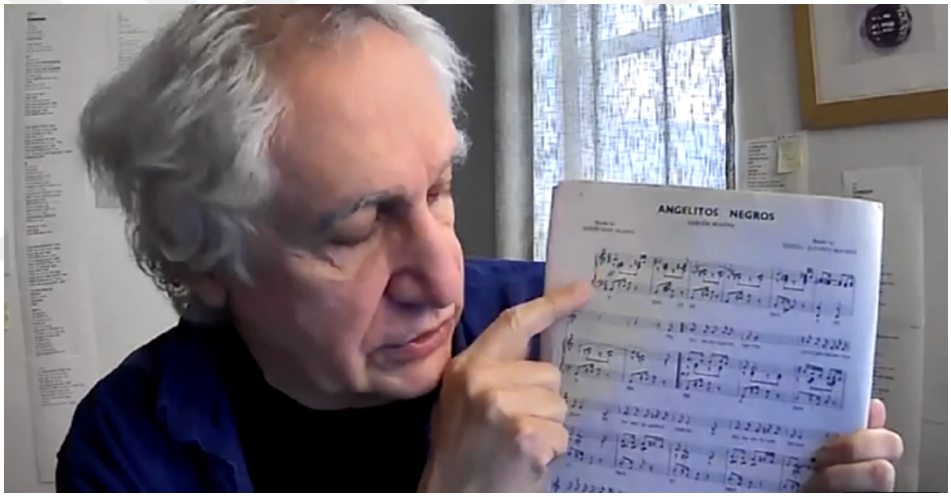

Figure 2.5 : Semih Fırıncıoğlu explains what notation represents (Fırıncıoğlu, 2021).

He points out how this advancement's initial intentions transformed by time: "*A notation is merely a record, a legal document… What you see here has nothing to do with sound or music. It is completely a record. This record has a name, composer, lyricist, copyright, permissions information… In other words, the concept of 'musical artwork' started to emerge because of this note. However, it is something that makes sound only if we hit it. This is another reality, but after all, this is a representation*" (Fırıncıoğlu, 2021). His insights lead to a deeper conversation about the evolution of music from a live art form to a documented artifact, a shift with significant implications for our understanding of music as both a creative and legal entity.

[19] It is a means of preserving syllables and words, hence, in a way, it is an attempt to preserve sound.

Capturing the actual physical sound events, and being able to record and reproduce them, is relatively new technology in comparison to these age-old methods. It can be argued that the theory and applications of these new technologies to arts, communication, and beyond is still in the preliminary phase. For instance, musicologist Jonathan Dunsby argues *"It remains true that any electronic reproduction of a sound recording is not in fact a reproduction but a mere simulacrum, an approximation*, *it is only in live performance offering 'real' sound, a balance of the expected with the unexpected, that the capacity for plenitude in human musical experience can be fully satisfied"* (Dunsby, 2001). Surely, his point is larger than only an electronic reproduction of a sound, in simple words he is comparing recorded sound, "*mere simulacrum*" in his words, with live circumstances. At first, Dunsby's claim may seem appealing. However, this discussion has multiple facets to evaluate, and not all of them leading to this inference. While Dunsby suggests a hierarchy with live performance at the top, philosopher and author Baudrillard offers a counterpoint that elevates the concept of reproduction to an original status: "*The simulacrum is never that which conceals the truth—it is the truth which conceals that there is none. The simulacrum is true*" (Baudrillard, 1994).[20] He points a different direction where a sound recording is not simply an approximation or a copy of an original that is more "real". Instead, simulacrum itself is a new version of reality that stands on its own and can be considered as valid as the live performance of a musical experience.

With simpler language, Baudrillard is arguing that a simulacrum is not necessarily inferior to the original. He argues "We live in a world where the distinction between reality and simulation has collapsed" and the idea of an "original" truth or reality is an illusion. Therefore the simulacrum has its own right to be considered as a valid reality. This means that a reproduction of a sound recording is not just a cheap imitation of a live performance, but a valid experience in itself. After addressing these two distinct interpretations of the subject, subsequent discussions will consider all represented sounds as an intrinsic part of the experience itself, regardless of their source, be it a score, vinyl, or tape. Over the past two centuries, artists, authors, and scholars from various disciplines have devised and studied discussions to grasp these emerging abilities and comprehend their societal implications; these perspectives are but two among many. Figures from fields including anthropology, sociology, physics, psychology, musicology, and many more shaped this period of time. Media theorist Jonathan Sterne characterizes this transformation as follows:

[20] Baudrillard makes a fake quotation here from *Ecclesiastes* when he is stating this. If the reader does not fact-check, then have to consider this information as it is real although it is not.

> Sound-reproduction technologies are artifacts of vast transformations in the fundamental nature of sound, the human ear, the faculty of hearing, and practices of listening that occurred over the long nineteenth century. Capitalism, rationalism, science, colonialism, and a host of other factors - the 'maelstrom' of modernity, to use Marshall Berman's phrase - all affected constructs and practices of sound, hearing, and listening. (Sterne, 2003).

To achieve the first piece of sound recording, people from all sorts of backgrounds made numerous attempts. At first, the focus was on trying to imitate the structure of the mouth and vocal cords. Researchers thought that if they could vibrate a mechanism in the same way, they may succeed in constructing a device to document sound, and interestingly, at first, being able to propagate back the recorded information was not the primary concern. Leon Scott, a typographer of manuscripts at a publishing house in Paris with a science focus, encountered an anatomical illustration of the human ear. He had an idea that changed the course of time: *a machine that would do for the ear what the camera did for the eye* (See Figure 2.6).

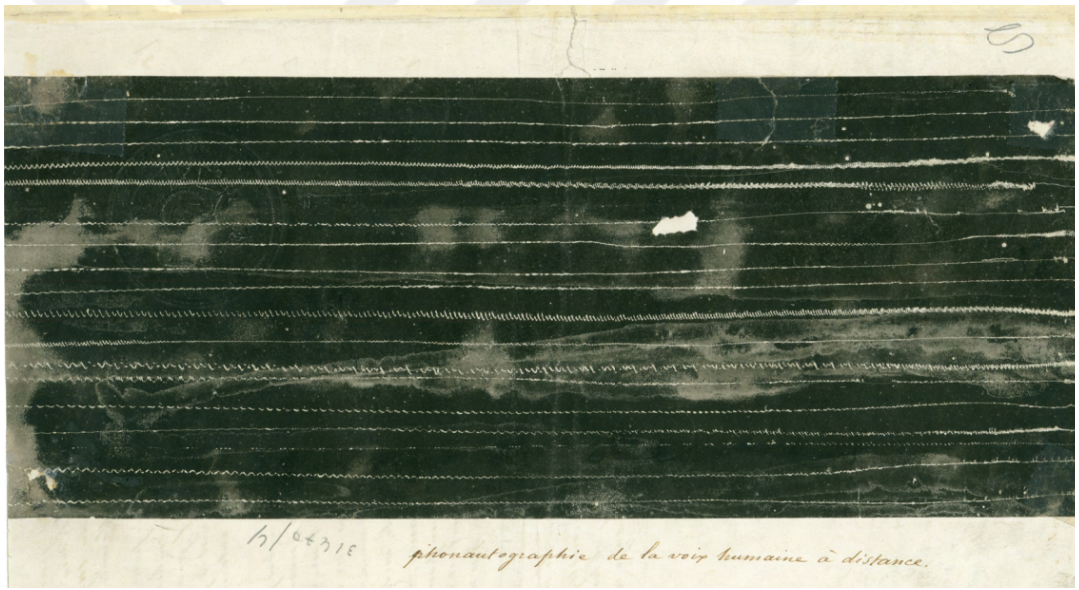

Figure 2.6 : Sound recordings from Leon Scott's phonautograph, 1857 (Camlot, 2015).

The aim was to be able to record spoken words in a way that photographs do for visual stimuli, and began working in 1853 on the idea, with an aim to construct a device that could replicate the functionality of the ear. He then finally invented the device and in 1857 patented it with the name *phonautograph* (Sterne, 2003). His phonautograph, part of 19th-century efforts to record sound, stood out from others as it was modeled after the middle ear. He succeeded in this by modeling the behavior of the membrane and tiny bones inside the human ear. Concisely, he created the first device for visually documenting sound waves, initiating a paradigm shift in both communication and the arts.

The fundamental detail missing in Scott's invention was the reproduction of sound. It was primarily designed to visually record sound waves. It consisted of a diaphragm and stylus attached to a barrel-shaped horn, which traced the vibrations of sound onto a rotating cylinder covered with a soot-coated surface. The resulting visual representation of sound could be analyzed and studied, but the phonautograph did not have the capability for sound playback. Although it took two more decades to solve the problem of reproducing these representations of sound, Thomas Edison's phonograph, patented in 1877, solved this issue, and gained the title of "the first device capable of recording and reproducing sound" (Figure 2.7).

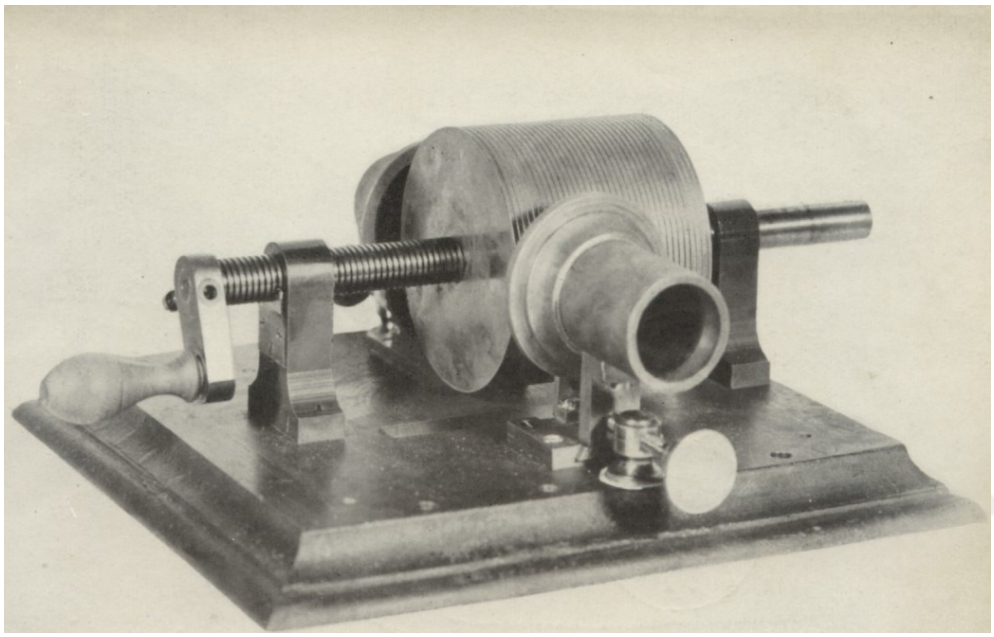

Figure 2.7 : Edison's original tin-foil phonograph (CHARM, KCL, 2009).

Edison's phonograph used a rotating cylinder covered with a sheet of tinfoil or wax. It employed a diaphragm and stylus to capture the vibrations of sound, which were then engraved onto the cylinder. To play back the recorded sound, the stylus would trace the grooves on the cylinder, vibrating the diaphragm. A mechanical process resulting in the production of sound waves (Beardsley and Leech-Wilkinson, 2009). While the phonautograph and the phonograph both involved the use of a diaphragm and stylus to capture sound, their key distinction lies in the recording medium and the ability to play back recorded sound. The phonautograph recorded sound visually, without the means for sound reproduction, while the phonograph recorded sound onto a medium that allowed for subsequent playback. Edison's invention revolutionized the way sound could be captured, stored, and played back, leading to the development of modern audio recording and playback devices.

With these, it was evident that tinfoil was not a practical medium for the long-term preservation of recordings and mass adaptation of this newly acquired recording technology. It was prone to damage, and the recordings had limited durability. In the late 19th century, inventors and engineers experimented with different materials for sound recording. In 1887, Emile Berliner introduced the gramophone which used a flat disc made of vulcanized rubber coated with a layer of hard wax. The use of a flat disc marked a departure from the cylinder format, and the vinyl records were about to appear. The reasoning was clear, it was easier to make multiple copies, less need for space, and durability. However, although vinyl records also had superior sound quality and distinct features that made them suitable for mass adaptation, it was not until the 1940s that vinyl records gained widespread popularity. But, once it gained attention, these advances made vinyl records the dominant medium for music distribution and audio playback for the next several decades (Beardsley, and Leech-Wilkinson, 2009).

The accelerating advancements in sound recordings experienced another revolution back in the early 1920s: Engineer Fritz Pfleumer developed the magnetic tape (Figure 2.8). Magnetic tape consisted of a thin strip of plastic coated with a magnetizable substance, typically iron oxide. Magnetic tape offered several advantages over previous formats. It allowed for higher fidelity audio recordings, with the ability to capture a wider frequency range and wider dynamic range.[21] It offered the convenience of editing and splicing recordings, making it a favored choice for professional audio production and broadcasting. Its erasable and reusable nature further added to its flexibility, allowing for easy re-recordings. By the 1940s and 1950s, magnetic tape recording systems became more easy to use and accessible.

The late 19th, and 20th century century witnessed a surge of discoveries and inventions. Scientists and inventors sought to unlock the mysteries of the natural world. The process of storing sound information has evolved significantly throughout history, transitioning from mechanical to electromagnetic means. Each stage of this evolution has been marked by innovations that have expanded capabilities for capturing and reproducing sound, shaping the landscape of sonic arts in the process. Initially, these innovations were met with skepticism and often perceived as a threat to the 'purity' of live music. Many thought that recorded music could not capture the spontaneity and nuances of a live performance. Despite this, these technological advancements started a brand-new era of music and sound appreciation.

[21] Dynamic range in sound technologies is the range between the softest and loudest sounds that can be accurately reproduced without distortion, enhancing realism and fidelity in audio experiences.

Figure 2.8 : Fritz Pfleumer, with his tape recording machine,
(Museum for Communication Frankfurt, 1931).

Prior to evolving towards another influential status, the practices of this re-defined listening continued to unfold up until World War 2. Capitalism, rationalism, scientific advancements, colonialism, and a multitude of other elements, all contributed to the tumultuous 'maelstrom' of modernity as Berman (1992) puts it, and had significant impacts on the development of concepts related to sound, the ability to hear, and the act of listening. To refer to one of his statements once again, Sterne articulates this metamorphosis with the following words:

> In the modern age, sound and hearing were reconceptualized, objectified, imitated, transformed, reproduced, commodified, mass-produced, and industrialized. To be sure, the transformation of sound and hearing took well over a century. … Changes in sound, listening, and hearing happened bit by bit, place by place, practice by practice, over a long period of time (Sterne, 2003).

During this era, sound transitioned from being perceived through idealized instances such as voice or music, to becoming an entity and a sphere of thought and practice in its own right. Upon acknowledging hearing as a physiological phenomenon subject to documentation, a renewed perception emerged, viewing it as a capacity rooted in the tenets of physics, biology, and mechanics. Along-side this paradigm shift in perception, numerous luminaries from the arts scene including Arnold Schönberg, Igor Stravinsky (e.g. Le Sacre du Printemps, 1913), Eric Satie (e.g. Parade, 1917), Luigi Russolo (e.g. The Art of Noise, 1913), George Antheil (e.g. Ballet Mechanique, 1926), John Cage, Edgard Varese, and many others, contributed “the great opening up of music to all sounds” (Chadabe, 1997).

This signifies that, during this period, the artistic utilization of sound transcended the confines of traditional musical instrument sounds. This was pivotal because, without the emergence of this acceptance, sound art would remain behind the rest of the art world. While the questionings about reality, perspective, and intellect were way beyond the conservative nature of art music back in the time, the understanding of music was strictly limited to ‘musical’ sounds that are produced by musical instruments. Without overcoming these cognitive barriers, perhaps it wouldn’t be possible to discuss the concept named “sound installation” today.

Throughout this chapter, the artifacts stemming from sound research have been thoroughly explored, with due attention to the surrounding context. Although some have been eclipsed by newer discoveries, assertions that esteemed writers and scholars of bygone eras remain integral to the discussion. Their foresighted observations remarkably accurate, ensuring that their contributions remain relevant in ongoing scholarly discourse. For instance, some scholars have described this "maelstrom" as the "material foundation" of the modern sense of space and time. This emergence was part of a “perceptual revolution” that took place in the early 20th century (Kern, 1983; McLuhan, 1964). They suggested that sound technologies have significantly expanded the perception of sound itself and our ability to hear, stretching these elements across time and space. Referencing these statements indirectly supports the assertion that this transformation indeed marked a revolutionary period, the effects of which continue to be evident in contemporary times.

In conclusion, with the development of newly acquired sound technologies, qualities related to sound and art once considered imaginary began to be explored in the Industrial Era. The advent of sound recording enabled sound to be treated as it a tangible, static entity. The emergence of magnetic tape technology in the 1930s expanded the lexicon of sound perception, incorporating previously uncharted noises, sweeps, and electronic nuances. The fresh horizons that these advancements bring were about the be the backing track of the 20th century. All these gave artists a new level of control over their craft, enabling them to design sound and its placement in the sound field in a precise manner. The tape also facilitated the emergence of *musique concrète*, a genre of music that utilized recorded sounds as raw material. And the rest is history.

2.4. Modernity

So far, the discussion has delved into the intricacies of evolution resulting in cognitive and practical ways now defined as *modern*. While the term “modernity” often defines an amorph conceptual frame extending beyond merely “recent times”, in this chapter, a discernible yet arguable historical demarcation will be drawn at the Second World War. This is largely due to the post-war era witnessed a transition where technologies originally designed for warfare found their way into the broader societal realm.

This significant post-war period in history marked not only enormous geopolitical, societal, and cultural changes but also catalyzed a leap in the realm of widespread accessibility of novel technologies. Historical accounts suggests that before the overwhelming effects of WW2, signals that led to sound art were apparent but seemingly there was a semantic void. Over time, these signals ventured beyond the familiar territories of traditional music, embracing instead a newfound language. Prior to WW2, many of the emerging technologies were largely inaccessible to the general public. The advent of war, however, caused an acceleration in technological adoption and innovation among people. Amidst this turmoil, society started to get familiar with the idea of technology being integral to everyday life, with radio and electricity being prime examples. In the aftermath of the war, a newfound intimacy developed between the public and technology, leading to the absorption of wartime innovations into civilian life. This process of technological repurposing found fertile ground in the domain of sound art. The technology that once served mostly in military ends, such as tape recording, gradually became available for people who had long desired to work with it, becoming a medium for creation and expression.[22] The period witnessed the establishment of numerous sound research studios across Europe, most of which were associated with national radio institutions.[23]

A watershed moment during this period was the emergence of *musique concrete*, an avant-garde genre that departed from traditional forms of music to embrace everyday sounds as musical elements. Contrary to conventional music-making methods which are typically grounded in notation and instruments, *musique concrète* utilized the materiality of raw sound, or the “sonorous object", to engage with compositional practice in a novel way. The experimental appeal of this concept marked an important step in the evolutionary pathway that would eventually lead to sound installations.

[22] It is known that composers like Edgar Varese and John Cage were interested in them for a long time but the related technology was not available to the general public back in the time.
[23] Back then, owning such a studio was a symbol of prestige, promoting the widespread even further.

As an event organized to celebrate postwar technological progress and peace, the World's Fair of 1958 represents a key milestone in this journey. In particular, the futuristic exhibition building (Figure 2.9), the Philips Pavilion, commissioned by the architecture firm Le Corbusier and designed by Iannis Xenakis, was sensational. Composer Edgard Varese's piece *Poème électronique* was presented to a massive audience here. Although the term 'sound installation' was yet to gain common usage at the time, this exhibition is often considered one of the earliest examples of the art form retrospectively.

Figure 2.9 : Philips Pavilion, 1958 World's Fair, Brussels (Wikimedia Commons, 2008).

Poème électronique is an electroacoustic work that has a lasting reputation. It was a five-channel tape-piece with a duration of eight minutes. It is known that more than 400 loudspeakers in 12 different trajectories were used to represent the work at the event (Britannica, 2022). Because it was hard to keep it running, engineers from the electrical products company Philips worked around the clock to maintain it (Wilson, 2021). This work combined elements of architecture, visual art, and sound to transform the audience's experience of the space. It served as an ad hoc, bespoke example of tape music and installations on a massive scale. As idiosyncratic one-offs such works are often challenging to reproduce, and thus can be considered ambitious in nature. But their effect definitely not only marked the history of spatial sound but aroused colossal discussions about what an artwork is and how to represent it.

This kind of work, blurring the boundaries between composition, architecture, and sound installation, resonates with a critical tenet in sound studies: The understanding of sound as a medium of expression. Within this paradigm, sound is a malleable fabric, capable of both influencing and being influenced. Projects akin to Poème électronique extend beyond mere sound production and manipulation of sound but also show concerns about its relative position with space, a notion integral to the essence of sound installations. All these discussions were about to be explored further and developed in the following decades in the works of influential artists like Max Neuhaus, David Tudor, Bill Fontana, Alvin Lucier, Janet Cardiff, and so on. Another worth noting example, is Max Neuhaus's "Times Square" (1977), one of the most well-known works of him. It is situated on a sidewalk on Broadway, specifically, between 45th and 46th Streets in New York (*Figure 2.10*).

Figure 2.10 : Times Square by Max Neuhaus, New York, 1977 (Dia Art Foundation, n.d.).

The piece is an installation artwork that introduces an unanticipated auditory layer to the city's sonic environment and consolidates the relationship between sound, space, and audience in an immersive urban soundscape (Collins et al., 2013). The installation is a resonant sound work, emanating from grates in the sidewalk. The sound, described as a rich harmonic drone, seems to originate from the underground infrastructure of the city itself, blurring the boundaries between the installation and the pre-existing urban soundscape. Here, Neuhaus transforms the aural experience of passersby, and manipulates the public sonic environment, making the sound installation an integral part of the landscape.

His approach to *Times Square* emphasizes sound's ability to sculpt a space and influence the perception of it. Conceptually this has overlapping interests with R. Murray Schafer's idea of "soundscape design" or "acoustic ecology," which advocates for a thoughtful and deliberate approach to the sonic environment instead of polluting it (Wrightson, 2000). Neuhaus's work Times Square was temporarily removed in the 1990s due to maintenance and environmental challenges. However, it was re-installed in 2002 as shown in *Figure 2.11.*

Figure 2.11 : Times Square by Max Neuhaus, New York (Untapped Cities, n.d.).

Another significant example of a large-scale sound installation is "The Morning Line," which was displayed in Istanbul in 2010 as part of the European Capital of Culture celebration (*Figure 2.12*). Imagined by Matthew Ritchie, Benjamin Aranda, and Chris Lasch, this monumental movable outdoor installation is composed of a modular aluminum structure incorporating a multi-channel sound system. The structure enabled the projection of various compositions from sound artists including Bruce Gilbert, Cevdet Erek, Erdem Helvacıoğlu, and Lee Ranaldo, among others. *The Morning Line* integrated advanced sound technology, with loudspeakers positioned throughout the installation to emit a carefully designed sonic composition. The sound composition featured a combination of original musical compositions, ambient sounds, and spoken-word recordings, resulting in an immersive audio experience that interacted with the architectural structure (Ritchie et al., 2010). Its size and multi-channel nature made for an immersive sonic environment that could be experienced differently depending on the viewer's position in and around the structure.

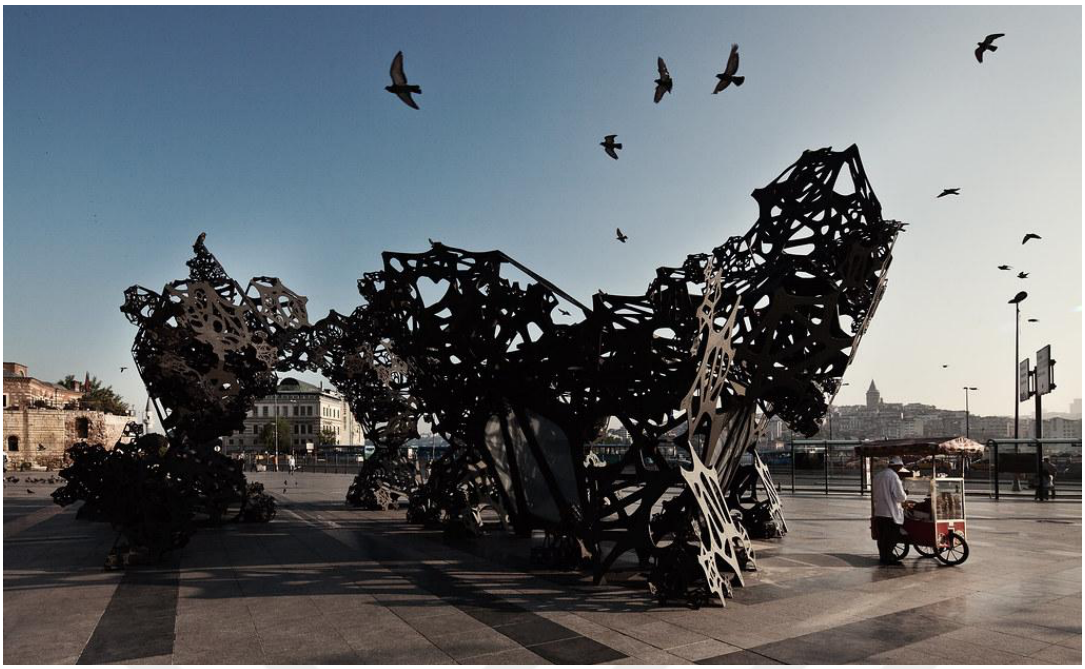

Figure 2.12 : The Morning Line, Eminönü, Istanbul (Ritchie et al., 2010).

This novel way of representing sound considering its context and surroundings roughly started in the mid-20th century in contemporary sense and has continued to evolve to the present day. These seminal sound installations not only exemplify the technologically-mediated expansion of aural perception but also reflect a sociocultural shift in understanding the acoustic environment. Therefore, the modern era represents a significant new chapter in the way sound is considered in relation to its surroundings. As such, the remarkable artifacts of it still contribute to the evolution of contemporary auditory culture and the academic discourse around sound studies. As these explorations continue to grow, attracting the attention of institutions, individuals, composers, and corporations alike, the question of distributing sound within a space has become a focal point of research in this field. The treatment of space as a pivotal compositional component paralleled the increasing importance of presenting sound artworks in specific spaces. Yet, this heightened focus on spatialization sparked debates among composers, which will be discussed in the following chapter.

It is also crucial to acknowledge the advent of computer processing. The invention of digital audio technology started becoming influential, especially in the latter part of the 20th century. The sound wave could now be measured at discrete intervals (typically at rates dividing each second from 44 to 192 thousand) and converted into binary computer code through a process known as "sampling”. This technological advancement altered the processing of sound significantly.

The movement of digitalization signified an acceleration in the ability to capture and preserve sound information, manipulate sound in ways that were not possible earlier, and reproduce/represent it in completely new ways. It paved the way for new frontiers in spatial sound. The newly acquired and spreading of formats like stereophony,[24] quadraphony, octophony, surround sound, and sound-field synthesis, began to offer listeners immersive audio experiences. These developments broadened the audience for spatial sound studies, propelling the field into the public domain. Furthermore, this era has left its mark on the architectural design of concert halls. Modern orchestras perform works from across the musical canon, necessitating that concert halls cater to the acoustical requirements of compositions spanning from the centuries earlier periods to the 21st century's immersive works. Therefore architects and designers have incorporated features ranging from retractable absorption systems to adjustable ceiling and wall planes into concert hall designs. Two of the most striking examples of this architectural adaptability are the Institute for Research and Coordination in Acoustics/Music's (IRCAM) concert hall *Espace de Projection* in Paris and Birmingham Electroacoustic Sound Theatre (BEAST)[25].

2.5. Post Scriptum

During this millennia-long transformative process, as life evolved in tandem with sound and space, nature shaped the culture. Human culture created methods to cope with the current conditions each and every time, and these creations led to newer versions of perceiving the world. Versions, arguably, that are increasingly more dependent on the tools that it creates. A hazardous dance through evolution, where societies create new dependencies for themselves. Marshall McLuhan's contemporary[26] John M. Culkin expresses this dance simply as "We shape our tools and thereafter our tools shape us" (Culkin, 1967). However, to avoid an overly deterministic view in this highly interdisciplinary research area of spatiality with a focus on sonic arts, claiming that new breakthroughs always come with new technological achievements will be avoided. Certainly, advancements in sound technologies influenced the characteristics of sound and the act of hearing dramatically. However, it is crucial to acknowledge that they were not the creators of the social and cultural currents in which they emerged.

[24] In today's world stereo may sound not interesting but it was a big challenge in sound technology research back in time. Adoptation from the skeptical public was another issue and stereo sound only became commercially available in the mid-1950s.
[25] BEAST is a portable system and its current home is at Elgar Concert Hall at the Bramall Music Building.
[26] This quotation is often referred to as McLuhan's, hence his name is explicitly present here.

As it is introduced in this chapter dedicated to Evolution, the discourse of arts, sound, and spatiality offers a wide array of discussions binding conjunctures among changes in society including economic, environmental, practical, and material changes. Thus, studying technologies related to this discipline (as is the case with any other discipline) requires attention to a variety of fields including natural, cultural, social, and political activities, from which these technologies emerge.

> Technologies sometimes enjoy a certain level of deification in social theory and cultural history, where they come to be cast as divine actors. In 'impact' narratives, technologies are mysterious beings with obscure origins that come down from the sky to 'impact' human relations. Such narratives cast technologies themselves as primary against historical change: technological deification is the religion behind the claims like 'the telephone changed the way we do business', and 'the phonograph changed the way we listen to music' (Sterne, 2006).

The prevailing beliefs people held about sound-related technologies, such as the arguments that they could "detach sound from its origin" or "enable the hearing of the dead", were not objective observations but rather their desires that were projected. These desires then became the primary impetus behind the advancements and use of technological research.[27] In fact, numerous inventors and early adopters embodied the potential of science, rationality, and industry as symbols of modernity and humankind's power to surpass the domains of life once considered magical. This certainly is not the stance here in this study. The stance of this text on this duty is the following: It seeks to balance acknowledging the role of technology in shaping societies with a critical awareness of its non-autonomous nature, recognizing that complex socio-economic factors are the primary drivers behind technological advancements and their adoption.

In conclusion, examining the historical and sociological evolution of spatial sound perception contributes significantly to a deeper comprehension of sound art's emergence and helps to develop predictions about its future trajectories. Throughout the latter part of the 20th century and into the 21st, this field has consistently advanced, broadening its scope in tandem with technological and conceptual progress, and continuing the enriching lineage of utilizing sound to engage with spaces and societies.

[27] Contemporary reflections of this phenomenon can be seen in titles like American Prometheus (Bird and Sherwin, 2006), where physicist Oppenheimer's association with the mythic Prometheus isn't just a nod to history but a testament to ongoing societal yearnings.

3. DISCUSSION

From the prehistoric ways of interacting with sound to the architectural marvels and the technological advancements that caused massive societal changes... So far, a lineage of the symbiosis of spatiality and sonic arts across time has been traced and how ever-evolving concepts and practices gained their contemporary meaning and importance has been discussed. It has shown how questions in this research field have been uniquely intertwined in the canvas of human culture. In this chapter, the focus shifts from the underpinnings of the subject to the aesthetic and practical considerations of creating sonic art in today's milieu. The aim is not to give a complete documentation about the methodological landscape, but rather to enrich the dialogue that has been developed so far before investigating the exemplary work that is linked to this research in the next chapter. In sum, this chapter serves as a bridge between the previously discussed sociocultural framework and contemporary practices, leading to an analysis of the exemplary installation work.

3.1. Depicting Sound

A myriad of material has been written regarding the ontology and perceptual effects of technologies used to capture, store, process, and represent sound. From the arts and psychology to engineering, renowned experts globally have made significant and in some cases ever-lasting observations. One of the challenges in discussing sonic characteristics has remained the same: the vocabulary. For instance, as discussed above, being able to represent sound through reinforcement technologies was allegedly referred to as "the power to split sources and copies". In the preceding chapters, this transformative "power" that technology has introduced to the sonic arts was explored to some degree. An instance of this is the advent of tape recordings inspired the genesis of *musique concrète* as a novel form of expression. This subchapter aims to explore this shift's influence on depicting sound, and the significance of this to be able to freely assess the qualities of sound installations in the following parts of the text. To do so, a transformative term in the sonic arts lexicon that is referred to frequently, "acousmatic", will be centered.

The term acousmatic refers back to the ancient Greek philosopher Pythagoras, who conducted his lectures behind a veil, to ensure his students concentrated solely on his words, apart from “visual distractions”. Translating this concept to sonic arts, "acousmatic" signifies experiencing sound without visual or contextual cues, as if a metaphoric veil separates the listener from the sound source. Jérôme Peignot, a French writer and poet, was one of the pioneers to define reproduced sounds as “acousmatic” (Peignot, 1960). Consequently, a great deal of composers started to argue whether this was the way to understand these technologies or not, including widely-known names like Pierre Schaeffer, Francis Dhomont, Denis Smalley… leading to the spread of the concept. Yet, as Sterne (2006) points out, another similar definition came from Barry Truax and R. Murray Schafer. They developed the term “schizophonia” to define the same phenomenon, “*split between an original sound and its electro-acoustic reproduction*”. John Corbett expanded this idea by using a psychoanalytic framework and said “*It is the lack of the visual, endemic to recorded sound, that initiates desire in relation to the popular music object*” (Corbett, 1994). According to Corbett, the inability to see the source was leading the listener to attend.

While these propositions have been heavily debated over recent decades, they remain compelling to many within the arts and sciences community. However, prevalence does not mean accuracy. The terms *acousmatic* and *schizophonic* bear embedded assumptions that warrant scrutiny. These terms posit that physical presence and face-to-face communication are the normative standards, thereby casting sound reproduction as a negative modification of an undisturbed interpersonal co-presence. As Jonathan Sterne argues (Sterne, 2006);

> They assume that face-to-face communication and bodily presence are the yardsticks by which to measure all communicative activity. They define sound reproduction negatively, as negating or modifying an undamaged interpersonal or face-to-face copresence. … Because they assume the primacy of face-to-face interaction, these authors assume that sound-reproduction technologies will have a disorienting effect on the senses that are otherwise oriented or grounded in coherent bodily experience. The assumption of prior sensory coherence requires a notion of a human body that exists outside history.

This is a treatment of these technologies as if they are just apparats disconnected from the sound they produce. It accentuates the original versus copy dichotomy and overlooks the process of reproduction. This is prone to misrepresentation of the creative process. These assertions are loaded with a multitude of assumptions like seeing sound reinforcement technologies as mere tools with no connection to the sound they produce.

This view parallels the earlier discussion on Jonathan Dunsby's claim that "*any electronic reproduction of a sound recording is not an actual reproduction but a mere simulacrum, that doesn't quite capture the 'realness' of live music"* (Dunsby, 2001). To remind briefly, in contrast to this stance, previously, attention was drawn to another ontological approach from Jean Baudrillard. According to his view of the simulacrum, a simulated version of something isn't necessarily inferior or less real due to the blurred separation of today's world between what is "real" and simulated. The simulacrum does not have to be a poor imitation and it can be considered as a valid musical experience in itself. Therefore defining an electrified recreation of a sound as acousmatic, claiming that there is a separation between its source and itself is a questionable suggestion. Furthermore, remember how it is discussed before the deification of novel technologies and the change they bring to societies as if they are apart from the society and dynamics within. Neither such technological deification and determinism nor to conclusion on specifications that separate real music from the simulacrum can advance the understanding of sound's essentials.

Nevertheless, a remarkable critique of acousmatic and schizophonic assumptions would be that these concepts provide a discussion point that leads to a deeper understanding of sound, its reproduction, and its diffusion. As we move through the theory of sound, it is essential to acknowledge that the task is not necessarily seeking definitive answers to these suggestions but rather, questioning encounters and preconceptions to explore new horizons. This inquisitive stance deepens the understanding of sound and related technologies, causing the growth of knowledge in this research field. Therefore, while accepting these criticisms that the acousmatic definition gets, its utility as a conceptual tool will not be underestimated.

Depictions based on the "acousmatic image" from authors like Denis Smalley help to evaluate sound art by emphasizing the role of spatiality, form, and perception. This perspective opens up new avenues of thought, especially when considering the physical diffusion of sound in space. Although the problematic facet of employing these terms is introduced at first, they allow researchers to question and challenge preconceptions, thereby driving the expansion of the field of sonic arts. Lastly, before continuing, it is necessary to state that to define sounds that are emanating from loudspeakers, the term electroacoustic will be preferred as terminological a stance. As composer Scott Wilson states, this term simply indicates a sound coming out of loudspeakers regardless of the sound's source, a simple but more holistic definition (Wilson, 2021).

The debates surrounding terms like “acousmatic” and “schizophonia” highlight a fundamental challenge in the sonic arts: how do we communicate, interpret, and represent sound experiences, especially when stripped of their original context? This challenge isn't limited to terminologies. As demonstrated, even if depictions don't originate concepts, they shape our perceptual world. While communicating the intangible characteristics of sound often requires nuanced linguistic tools, taking the form of potent analogies, analogies function as linguistic bridges, connecting the ephemeral sonic experiences with more relatable sensory domains. Consider expressions like "sculpting" or "blurring" sound. While they seem rooted in visual or tactile contexts, they can vividly capture the manipulations and transformations of sound. They mirror the artist's process, similar to a sculptor's shaping forms out of amorphous materials or a painter's blurring lines in a painting to merge distinct elements. These analogies align closely with the conceptual framework proposed by composer Denis Smalley in his paper “*Space-form and the acousmatic image*” where Smalley is picturing a precise terminological toolkit to describe three-dimensional sonic experiences (Smalley, 2007). He elucidates concepts like "zone's identity," highlighting the unique character of a space; "proximate space," detailing the perceptual intimacy to a sound source; and "nested space," exploring the layers and complexities within a sonic environment, among other conceptualizations. The application of such a vocabulary enables the communication of intricate sonic information, anchoring abstract experiences in defined linguistic parameters and therefore allowing the transmission of an experience. This is substantial because it is often nearly impossible to depict the experience of a sound installation and explain it fully to a person who couldn’t find a chance to be in it physically.

Lastly, another set of definitions used for describing the spatial experience comes from Scott Wilson. As a researcher who studies sound diffusion in *massively* multi-channel systems, he propels researchers to consider dichotomies like localized versus diffused, spectrally diffuse versus fused, texturally diffuse versus fused, and more (Wilson, 2021). These categories draw attention to the interactivity of sound artwork with its environment, a symbiosis that generates rich aural cues about both entities. Being able to express the influences that are born out of this interaction in a way like “source size”, “spaciousness”, or “envelopment” of a sound, adds a dimensional depth to the communication of a sonic experience. If enriching the audience's interaction with an artwork is a concern, going beyond the mere design of the sonic landscape and contemplating the facets of conveying meaning is essential.

3.2. Sound Installations

According to Alvin Lucier, Max Neuhaus was the first composer who made sound installations, or at least he coined the term (Lucier, n.d.). This concept represents a convergence that often includes architecture, plastic arts, and sound to transform the audience's spatial experience. It encompasses artworks primarily established by sound as the expressive medium, involving varying intersecting elements such as interactivity, and multisensory experiences. It differs from a music presentation due to its specific focus on exploiting the properties of sound in a given space and its interaction design. It transcends the preconceptions found in traditional sound art related to spaces like concert halls, opera houses, and theaters and provides a broadened expressive palette to the artist and the audience. To deepen this general definition, it can be composed specifically for a site, can be adapted into other spaces for exhibition, or can be integrated into urban settings. As explored in this text in chapter 1.4, sound installations fall under the category of sound art and fully experiencing it requires time investment from the audience, ranging from a few seconds to several hours or even much longer. While the time aspect prominently differentiates sound installations from other types of installation art there are a multitude of parameters to distinguish sound installations from one another. These defining characteristics will be the focus of this subchapter.

Since they all necessitate a conscious consideration of the sonic environment the philosophy underlying sound installations reminds R. Murray Schafer's concepts of "soundscape design" or "acoustic ecology" (Schafer, 1994). Schafer emphasized the impact of soundscapes on human perception and overall quality of life, challenging the notion that ideal sound experiences are confined to acoustically engineered environments. Similarly, sound installations look for alternative ways to approach a soundscape and space. One of the major debates concerning sound installations is about spatiality and it seeks answers in two primal directions. Either, pursuing perfection and trying to minimize the influence of a given site or recognizing its nature by embracing its unique spatial parameters. This raises a seminal question: Should one strive for an idealized sonic field, or embrace the influence of the space on the sonic outcome? The answer, as often the case, differs based on the particular artistic and philosophical orientation. In the practical facet of this thesis, the second approach is embraced, acknowledging space as a vital participant rather than an obstacle to sonic perfection. In some cases, this approach sacrifices adaptability, but it also transforms the distinctive characteristics of each space into defining features.

3.2.1. Attributes

Although sound installations can be evaluated by taking advantage of notably different attributes, it is important to acknowledge that there isn't a universally agreed-upon classification system. This subchapter aims to navigate through this by exploring a series of pivotal attributes including spatial interaction, temporal structure, immersiveness, multimedia usage, interactivity, and technical execution. While distinct and useful to come up with comparative analysis, they often overlap and/or intertwine, reflecting the fluid and experimental nature of this niche within the sonic arts. Additionally, the attribute of adaptability[28] will be discussed more extensively in a subsequent chapter. This exploration seeks to deepen our understanding of the multifaceted and evolving nature of sound installations.

The first attribute of that will be explored here is the *spatial interaction*. This feature encapsulates the relationship and interplay between a sound installation and its environment. It focuses on how the work interacts with, responds to, and is influenced by the characteristics of a space. Within this framework, *site-specificity* emerges as one of the key and most publicly recognized attributes. It prompts the inquiry of whether a sound installation, such as Max Neuhaus's iconic Times Square, is meticulously crafted for a specific site. Intentionally positioned in one of New York City's busiest intersections, exemplifying how such installations can be inextricably tied to their locations, offering singular experiences that are near-impossible to replicate elsewhere without compromising their intended effects. In contrast, some installations are more versatile, designed with the ability to adapt other spaces.

It is instructive to consider how these re-imagined environments differ from traditional venues dedicated to sound-related arts. As discussed in Evolution, unlike the latter, which typically offer preconfigured settings with minimal chance to repurpose its settings, sound installations foster a heightened sense of intimacy with the space. As stated in the introduction of this text, at this intersection, there are two arterial paths to follow. The first involves leveraging the unique characteristics of a space, allowing it to influence and resonate with the work, thereby transforming the site into an active participant in the artistic outcome. This approach embraces the site as a vital material. Alternatively, some artists might seek ways to minimize the influence of a space to achieve precision in spatial cues or even replicate the characteristics of another room in the residing space of an artwork, underscoring the diversity in strategies.

[28] Sound installations' potential to be reinterpreted in different contexts. The concept will be explored in the following paged in detail.

The former approach, treating space as a material integral to the artwork, is demonstrated in "Cyclope" by Carlos Casas. Commissioned for the Istanbul Biennial 2022, this work was located in the Yaklasim Tunnel beneath Taksim Gezi Park (Figure 3.1). Upon entry into a dimly lit tunnel, participants were greeted with sounds from subtle ambient details to loud, explosive ones. Due to the specific acoustics of a tunnel, even minute changes in sound were creating a long-lasting, reverberating effect. Participants were required to navigate through the tunnel's uneven terrain in low light conditions, their senses heightened by the enveloping darkness and the escalating intensity of the soundscape. This sensory engagement was further amplified by abstract paintings that appeared on the walls towards the tunnel's end. By exploiting the specifics of the site, the work created a disorienting experience initiating a dialogue on memory and war as the artist intended (IFCA, 2022).

Figure 3.1 : Carlos Casas, *Cyclope*, (IFCA, 2022).

Building on the concept of site-specificity, this example is also appropriate to demonstrate another critical attribute regarding sound installations, *temporal structure.* This is a variable that was briefly explored previously in 1.4. Sound Art, thus it is known by now that sound artworks, including installations, occupy varying durations. Whether acoustical, utilizing a repeating tape loop, or a generative algorithm stimulating sound sources, temporality is inherently tied to the method employed in sound creation. Therefore, the timeframe of a sound installation can range from a fraction of a second to extended periods spanning months or even years. In interactive cases this metric can be bound to audience interaction, or, in works exploring indeterminacy and/or generative systems, it might operate within a minimum/maximum value range. In the case of Casas's "Cyclope," the soundscape spans nine hours, a considerable length knowing that a wind tunnel of Italian military was used in the composition process to be able to mimic the actual exhibition site (Bouscaren, 2022).

Next up, *immersiveness:* In the context of sound art and sound installations, it refers to the quality of an artwork that engages the audience's senses, emotions, and intellect in such a way that they feel fully enveloped by the experience. It is about creating a comprehensive experience that often transcends the traditional, more passive forms of art engagement. It often relates to how the sound component of a work envelops the audience, manipulating auditory perception to create a sense of three-dimensionality and presence. While immersiveness is not quantifiable, it is influenced by factors such as the spatialization method of sound, scale, intensity, interactivity, and multisensory engagement. Spatialization, indicating the arrangement and movement of sound sources in space, plays a critical role in immersiveness, with considerations stemming largely from psychoacoustics. Some interpretations regard spatialization as a primary determinant of immersivenes, however, the scale, loudness, or intensity of the sound also significantly contribute to the immersive qualities, ranging from a subtle ambient sound to a powerful, overwhelming noise.

Another attribute that helps differentiate installations and enhance their immersiveness, is multisensory engagement. Like immersiveness, it integrates a multitude of aspects with the aim of integrating varied sensory stimuli. It might incorporate visuals, tactile elements, and even olfactory and gustatory cues to craft a holistic experience that resonates with multiple senses simultaneously. The inclusion of these elements amplifies the perception of immersion, leading to render increased memorabilia. Placing of the elements or techniques such as projection mapping, lighting, tactile interactions, scents, and even taste can be intricately synchronized with sound to provoke emotions, bring immediacy to the experience, and transcend the audience to altered states of consciousness.

Expanding on this concept, multimedia usage in art serves as a pivotal tool in blurring the boundaries between disparate art forms, and fostering a synergistic interplay between architecture, plastic arts, video, audio, digital technologies, and interactive elements. This amalgamation not only facilitates active audience participation but also enriches the narrative, adds depth to the meaning, and intensifies the emotional resonance of the sound installation. By combining multimedia elements, artists are empowered to fabricate immersive sound installations that reverberate with audiences on a myriad of levels. This results in a comprehensive sensory experience that is not merely audible but also visible, and tangible. A striking example of an installation that reflects these versatile qualities is Bill Fontana's "Resounding Io," which was displayed at the Arter Museum in Istanbul in 2022.

“Resounding Io” was based on Fontana's surveys in Istanbul, in which he collected sound and video recordings at various locations along the Bosphorus. The collected sound data was then played in the Basilica Cistern at night via loudspeakers when there were no visitors, creating a resonant response from the structure's vast vaults. Fontana then recorded these sounds back with updated qualities. This method of "re/sounding" turned the unique acoustics of a massive structure into a defining feature of his work. It is important to emphasize that while the Basilica Cistern played a crucial role in the creation of "Resounding Io", the finished work was not exhibited within the Cistern itself. Instead, these sounds and visuals were installed in Arter’s cubical performance space, Karbon, where the artist utilized the room's advanced technical features to deliver an immersive audio-visual experience (Figure 3.2).

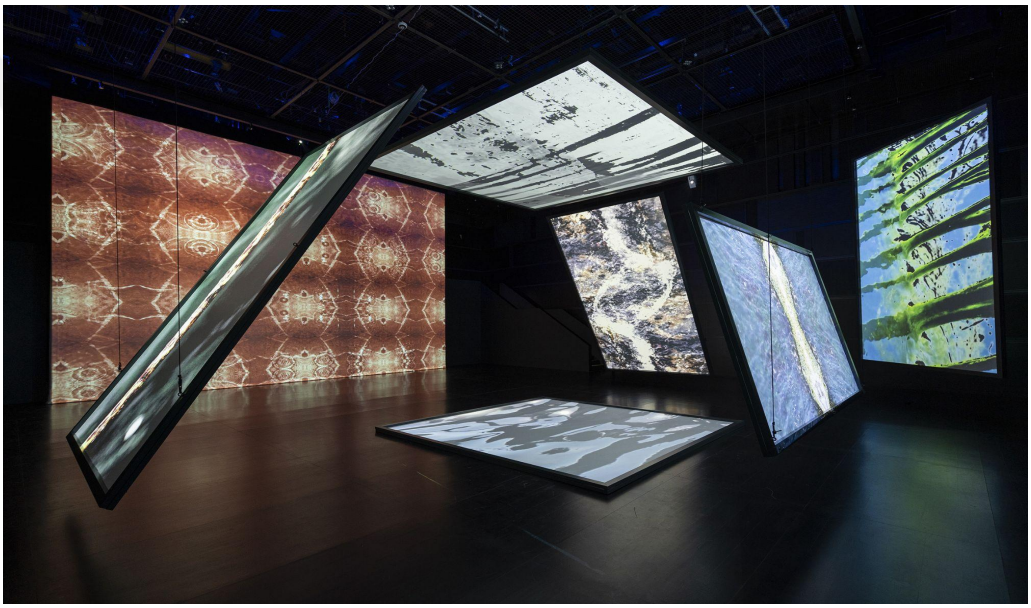

Figure 3.2 : Resounding Io by Bill Fontana (Arter, 2022).

Upon entering Karbon, a large wall screen welcoming the audience, aligned with ambisonic recordings from the Basilica Cistern was played back through a matrix of eight loudspeakers situated near the walls of the room.[29] The exploded cube arrangement, further enhanced by additional screens positioned at different angles[30], was connecting visitors to the locations of the original recordings through both sound and image. By adopting the art form with a multi-disciplined approach, Fontana was rethinking the definitions often made to installations with "Resounding Io". The recontextualization of the ingredients here evidences how rapidly definitions can change and/or overlap in multiple ways in installations.

[29] Demonstrating a unique methodology of representing sound that was discussed earlier above; *ambisonics*.
[30] As if there is a reference to a tesseract, a four-dimensional cube.

Moving towards another attribute: Interactivity. This concept, denotes the reciprocal relationship between the audience and the artwork, evolving the role of the audience from passive receivers to active participants in influencing or altering the experience. Drawing parallels with the previously discussed attributes, interactivity, while it can be referred as a “standalone” feature here, it encompasses a range of variables, and allows a wide spectrum of audience influence on the sound and integrated mediums within the installation. The influence of interactivity lies in its ability to foster personalized, engaging, and immersive experiences, where participants shape and are shaped by their sonic environment. In sound installations, the variables of interactivity depend on the methods employed to gather audience input. From attaching its moving values to parameters of sound like amplitude or frequency, this input can be used in limitless ways. Although it is not the only way, in general terms, to collect input, sensors are employed. While some of these sensors are capable of monitoring the audience’s movements and proximity, some others are sensitive to heat, light, voice, and/or sound changes in the installation site. Once these changes have been collected, they can be used to modify the soundscape, change the duration, trigger variations in sound events, and practically any other potential changes in attributes that an artist can imagine. This diversity potential emphasizes in which ways visitors can influence not only sound but also other integrated mediums, a synergy earlier observed in the discussions on multisensory engagement and multimedia experiences. Last but not least, since the interactivity necessitates active participation of the audience, installations that encourage their visitors to move around itself to offer a complete experience can be considered as interactive too.

As it has been explored so far in this chapter, all attributes have their internal dynamics, and setting a stance regarding at each variable enriches the expressive qualities of a vision. In the realization of all attributes counted above and beyond, it is essential to grasp the significance of execution. Therefore, the creator’s technical prowess in realizing a conceptual vision influences all attributes from temporal structure to interactivity and immersiveness. It is where the decision-making process crafts a diverse landscape, fostering a spectrum of subjective experiences to explore the emotional and intellectual resonance of these attributes over installations. Every interaction, every concealed hum or overt vibration, contributes to a collective yet uniquely individualized experience, underscoring the significance of execution in shaping the sonic mosaic and its myriad receptions.

3.2.2. Diffusion Strategy

In the context of sonic arts, diffusion refers to the spatial distribution of sound events as deliberately determined by the artist. Composer Denis Smalley elucidates this concept, stating it is the "*projection and the spreading of sound in an acoustic space for a group of listeners, as opposed to listening in a personal space [living room, office or studio]*" (Austin and Smalley, 2000) a definition which underscores the distinction between collective auditory experiences and intimate, individualized listening environments. The strategy associated with diffusion pertains to the systematic approach employed to distribute, project, or disseminate sound content within a specified site. Beyond its specific relevance to the research presented in this thesis, diffusion remains a pivotal component in most sound practices concerning spatiality. It embodies a set of decisions governing the movement and interaction of sound within a space, thereby influencing the audience's perception of sonic qualities. Its scope covers acoustic and psychoacoustic assessments, loudspeaker configurations, and audio formats. It also includes discussions on spatialization techniques, decisions about sonic materials, their perceptual correlates, and interactivity.

A diffusion strategy serves as a blueprint that navigates an artist amidst a multitude of variables that a given context holds. In the realm of sound installations, making use of it is nigh a requirement to facilitate a balance of aesthetic considerations and technical boundaries. Beyond merely a series of choices, it sculpts the manner in which sounds inhabit and engage with space. Thus, diffusion serves as the medium in which a sonic *reality* is fashioned. It becomes the framework that informs decisions, from the placement of sound sources to the nuanced modulation of their outputs. Bridging aesthetics and technology, it highlights the artist's intentions, not just in terms of spatial distribution but also in constructing an emotive or intellectual response. For instance, one method of sound diffusion is stereo, which employs a two-channel system typically utilizing two loudspeakers. It has an optimal listening position, an equidistant point between the two loudspeakers, forming an equilateral triangle, also known as the *sweet spot*. It allows for a dynamic interplay, creating an immersive sense of space that reaches beyond simple left-right directionality, creating an illusion of three-dimensionality. Ensuring the loudspeakers are calibrated is essential for conveying the sound as the creator intended. Yet, artists may bypass rigorous calibration, choosing instead to leverage the influence of room acoustics and the specific character of a loudspeaker to alter the sound projection. Such decisions illustrate the strategic depth in sound diffusion, each choice carries its trade-offs.

Perhaps the most widely known example of bypassing the calibration of loudspeakers and treating them as if they are instruments is the concept of acousmonium (Wilson, 2021). This term refers to a specialized sound diffusion system used primarily for the performance and/or representation of acousmatic music. It was introduced in the 1970s by the Groupe de Recherches Musicales (GRM) in France. The Acousmonium is essentially a large orchestra of loudspeakers. Each loudspeaker has its unique timbral quality and spatial placement, enabling the diffusion of music in a way that can be extremely detailed and spatially rich. The loudspeakers are of various sizes and types, and they are positioned at different heights and angles in a concert hall. This type of music stems from the previously discussed idea of *acousmatic sound*, where one hears without seeing their originating cause. During a performance, a *diffusion artist* actively manipulates the distribution of sound among the loudspeakers in real-time, based on the acousmatic composition being played. This means that the spatial and dynamic characteristics of the music can change from one performance to another, much like how a conductor might interpret a symphonic work differently across concerts. This approach to the representation of electroacoustic music has made it possible for audiences to experience artworks that often lack performative qualities due to their fixed media nature in a concert setting with an enhanced sense of spatial depth and movement. Therefore paves the way for future applications in sound art that approach diffusion as an integral part of the creative process. Though the original Acousmonium is most closely associated with the GRM and its performances in Paris, the idea has inspired similar loudspeaker orchestras and sound diffusion practices worldwide. (See *Figure 3.3*)

Figure 3.3: The Vienna Acousmonium.[31]

[31] Photo by Markus Gradwohl (Gorbach, n.d.)

This ideer of of questioning the diffusion of sound events in deliberately designed “loudspeaker orchestras” continued its widespread adoption later in the 20th century. Following the invention and popularization of the Acousmonium, other institutions, and composers began exploring more extensive and often modular multi-channel sound systems for the diffusion of electroacoustic music. These systems allowed for even more detailed spatialization and movement of sound within a concert space. As mentioned in the modernity chapter as modern concert halls too, two examples of these systems come into prominence: BEAST (Birmingham ElectroAcoustic Sound Theatre) and IRCAM's *Espace de projection*. BEAST is associated with the University of Birmingham in the UK. It was developed during the 1980s by Jonty Harrison and has since been central to the diffusion and performance of electroacoustic music in the UK and abroad (BEAST, 2020). Like the Acousmonium, BEAST is a multi-channel sound diffusion system comprising a wide variety of loudspeakers. These can be arranged in various configurations depending on the requirements of the specific composition and the characteristics of the venue. A diffusion artist, during a BEAST performance, manipulates the distribution of sound in real-time, exploring the spatial dimensions of the concert space and the design of the compositions being played. Due to the portable design of the system, it has been used on occasions abroad too, and thus has inspired composers to create works designed for its capabilities.

On the other hand, the *Espace de projection* is one of IRCAM’s dedicated concert spaces for electronic and electroacoustic music mostly used for the exploration and development of contemporary music and technology (IRCAM, 2023). The room itself is tailored for the advanced diffusion of sound with capabilities for a vast array of loudspeaker placements and configurations, allowing for sophisticated multi-channel spatialization setups. Known for its cutting-edge research in music and acoustics, IRCAM has developed several software tools and technologies like SPAT that allow composers and sound engineers to spatialize sound in innovative ways, which can be showcased in *Espace de projection* (IRCAM, n.d.). Given IRCAM's global reputation, this space has been a crucial venue for the presentation and exploration of new ideas in sound diffusion, multi-channel composition, and electronic music performance. Examples like BEAST and *Espace de projection* represent the evolution of sound diffusion from the earlier days of the Acousmonium era to the modern days, demonstrating how technological advancements and the artistic drive to explore new sonic territories can lead to innovative approaches to music presentation and spatialization.

Surely, a diffusion strategy is not strictly bound by the arrangement of loudspeakers. Zimoun[32] offers an inventive interpretation that pushes the boundaries of traditional loudspeaker-oriented approaches that have been discussed so far. Instead of dispersing sounds through loudspeakers, his installations generate sounds through the mechanical movement of industrial objects like DC motors, plastic bags, and cardboard boxes (*Figure 3.4*). These sound-producing components transform their surrounding space into an immersive auditory canvas, exemplifying an "organic" form of diffusion strategy is possible (Collins et al., 2013). The minimal, yet remarkably dynamic soundscape of a Zimoun installation arises from the interplay of repetitively moving components and the natural resonance of the space itself.

Figure 3.4 : 198 prepared dc-motors, Centre d'art Neuchâtel, Switzerland, (Zimoun, 2012).

This results in an evolving sonic experience, ever-changing with the listener's position and movement within the installation site. As listeners navigate, they encounter an orchestra of simple industrial materials, each contributing to a complex, rhythmic symphony of sound and silence. Zimoun's work, defined by its blend of artistry, acoustic science, and innovative use of accustomed technologies, embodies a holistic and pioneering approach to the sonic experience. His choice of employing everyday industrial materials isn’t purely an aesthetic one. It is a strategic decision, intended to transform ordinary objects into auditory agents, illustrating how even aesthetic preferences can be rooted in well-considered strategies to shape the experience.

[32] A Swiss artist known for his generally site-specific sound installations and immersive works.

In the context of sound installations or any form of art, the strategy does not imply merely a calculated, utilitarian approach. Instead, it fosters making choices, whether they be based on aesthetics or other factors, aimed at achieving a specific experiential outcome. Even the decision to introduce randomness can be a strategic decision intended to craft a particular result. This interpretation of diffusion strategy illuminates the intricate dance of sound, space, and audience interaction. Be it loudspeakers in traditional setups or unique sources as seen in Zimoun's work, factors like the number, type, and orientation of sound sources profoundly influence the sound's diffusion. Although this demands a comprehensive evaluation of numerous aspects, modern technology affords sophisticated control and the limit is theoretically endless which can be liberating and blinding at the same time. Strategy comes into prominence in this state by guarding the creator from drifting away from the essence. It allows the creator to transcend sound diffusion and its presumed capabilities.

3.2.3. Focus

Up until now, the issue of focus was kept untouched in previous chapters in favor of setting the context through examples at first. With all the steps taken, the way is now paved for this aspect of perception. Before delving deeper, reminding the ontological question addressed in the introduction is important: "*When evaluating auditory input, attention can be directed to capture focal details or used to grasp layers globally. Can these polarities co-exist harmoniously and how to address this dichotomy within an installation artwork?*" To delve into this question, let's first define the notion of "focus".

In general terms, it refers to the center of an activity and/or the state or quality of having or producing a clear sensory definition. In psychology, focus refers to the cognitive process of selectively concentrating on one aspect of the environment while ignoring other things. In auditory perception, focus or auditory attention refers to the ability to concentrate on a particular sound source in the environment while disregarding or filtering out other sounds. This is commonly exemplified by the "cocktail party effect," where a person is able to focus on a single conversation in a noisy room. Similarly, sound installations often broadcast layers of sounds, "orchestrated" through loudspeakers or like Zimoun's case with hundreds of DC motors within the site. The concept of focus in this context can be multi-faceted. The artist might focus on creating specific auditory instances or on how the listener's attention will be guided through the sonic landscape. However, due to the audience side of the experience, albeit this attention can be guided, it can't be dictated.

The attention of the audience is selective in itself and determines which sounds they pay attention to and/or how they interpret the relationships between the sounds. The artist might use certain strategies to direct the listener's focus, but ultimately, each listener's personal engagement, interpretation, and experience will be inevitably unique, mostly due to the factors discussed in *1.3. Psychoacoustics*. This intrinsic quality leads the artist to a departure point in deciding two key issues, firstly, the difference between *focused versus holistic* sound experience. As the author Sethares points out, people have a tendency to listen holistically, therefore rather than focusing on individual sounds, embracing the entirety of a soundscape comes first (Sethares, 2010). On this end, without any pre-designed intervention, the audience's role is critical. However, since counting on this active role requires audience participation, depending on it might be a decision that causes ambiguity and uncertainty in an artwork. Surely, this can be an artistic direction. Yet another path might be adding and/or subtracting elements from the artwork to stimulate the parameters that the audience is using while trying to make sense of their surroundings.

The second case about the "focus" subject is regarding sound projection, and it is about designing *focal point(s)* within an installation space. As it is discussed in diffusion strategy, rather than psychoacoustic factors, this time a range of considerations on spatiality is the issue. Thus, parameters like the listener's potential position relative to the sound source(s) come into prominence. In fixed-media artworks like cinema there are similar concerns too. Their idea is to include as many viewers within the focal point (or "sweet spot") as possible. However, in the context of installations, particularly those placed in large or open environments, even there is an open invitation, imagining the audience ever will be in that spot is unrealistic. While global focus encourages listeners to conceive space as a holistic entity, fostering a broad and inclusive auditory experience, focal attention reminds that even within this entity, there are unique and significant points of interest that should not be overlooked. In either direction, the chosen strategy will shape the experience and interaction within the installation site greatly. It provides artists opportunities to maneuver the listener's auditory engagement by molding their experience within the sound environment. Rather than being seen as conflicting, this dichotomy can be understood as two different layers of engagement that can be thoughtfully interwoven, creating a richer, immersive auditory experience. As shown with examples so far, the nature of sound installations necessitates continuous dialectic evaluation on often seemingly apart directions and dichotomies of focus are no exception.

By assessing the merits and limitations of each approach, deciding the most effective means to realize their expressive intentions is the duty of the artist. However, the process concerning this doesn't have to be a fixed configuration either. Another nuance that leads to different possibilities regarding focus comes with the interactivity parameter, again. This attribute presents a unique tool-set that concerns both of these definitions made above. As is explored, "interactivity" employs elements like sensors or motion detection algorithms to shape sonic landscapes in real-time in response to audience interaction. This dynamic approach offers a more holistic perspective on sound design, viewing the entire space as a canvas for expression, and not binding the focus strategy to static decisions. Although harmonizing these perspectives requires a careful contemplation of the installation's nature and the message it aims to convey, the potential to simultaneously integrate these dichotomies further enhances the richness of the spatial sound experience. With the help of layers like interactivity, the dichotomy between focal and global focus seems to dissolve.[33]

It appears that the unification of these elements isn't contradictory. Rather, they can coexist harmoniously, each representing different levels of engagement and enriching the spatial experience in their own unique way. Focus acts as an integral compass, and through employing attributes like interactivity, it guides artists in their navigation of spatial sound design, allowing for a larger exploration of the sound-space continuum.

All in all, a sound installation is an art form that draws heavily on the strategies used to rethink a space. Whether it is the placement of sound sources, the preferred sound fabric, the use of focal zones, fostering a local/holistic listening approach, or including interactive components, each strategy has its merits. Each direction offers unique benefits and potential limitations. By exploring the various outcomes, artists can craft installations that engage audiences in meaningful ways. As demonstrated through this chapter, the installation art that centers sound is multifaceted and each facet has its own unique variables to consider. The decision-making process necessitates an aesthetic stance, technical know-how, and a deep understanding of how sound behaves and is perceived in space. In composing spatiality through this medium, paying attention to the contiguity of an auditory image to pursue a continuous space, conjuncts all of them up.

[33] For further discussion on audience engagement: Ascott, R (1968). *The Cybernetic Stance: My Process and Purpose*. Leonardo, 1(2), 105–112. https://doi.org/10.2307/1571947

3.3. Adaptability

In sonic arts, adaptability refers to the capacity of an artwork to be distributed or transmitted across platforms, mediums, or audiences. In the context of sound installations, it refers to the ability to repurpose and/or optimize an installation for different spaces. Adaptability has its own variables as well, mostly influenced by the artist's intentions and technical boundaries that a particular project possess. When evaluating the adaptability potential of an installation artwork, portability and replicability are the primary variables to look for. The former, as the name suggests, evaluates the portable qualities of a work and encompass qualities around repurposing and optimization. If the work is not site-specific or does not demonstrate site-bounded attributes like aiming to interact with a specific aspect of a space, it can be considered as portable. Replicability, on the other hand, refers to how well the concept and design of a sound installation can be reproduced or adapted to different instances while preserving its defining qualities. Typically, installations with repeatable layouts[34] or formats[35] tend to exhibit more adaptabliliy than those tied to a site.

Every intellectual work has unique features and goals. The combined influence of these two variables causes the adaptability level of a sound installation to fluctuate. Site-specific works for instance, as discussed, are designed to engage with a particular space, thus their details are shaped around their residing space. Although such design may seem to intrinsically inhibit adapting it in different scenarios, artists may reconfigure and adapt their installations to different contexts. While this may seem like an alteration on the originality, this suggests that site-specific works can be adaptable too, sometimes with minor adjustments, and sometimes as they are. Only issue with the definition ‘as they are’ is the change of the context that surrounds the artwork. As long as the necessities are facilitated, an artwork can be reincarnated and experienced in various locations and different cultural contexts. This ensures the artwork's continuity and mobility, enabling it to be experienced in varying locations worldwide. Their striving for uniformity and scalability provides a controlled, repeatable experience and demonstrate a higher level of adaptability. They can be installed in another museum or public space, perhaps even simultaneously in multiple locations, if there is no element in the installation that strictly can’t be replicable.

[34] Whether it is making use of an acoustical source or a loudspeaker arrangement, a layout in this context is a pre-figured combination of sound sources and elements to absorb and diffuse sound.
[35] Such as installations that make use of ambisonic formats (or in that regard formats like quadraphonic, Dolby Atmos, et cetera) as Bill Fontana’s “Resounding Io” does.

An noteworthy example of adaptability is the work Silent Echoes: Notre-Dame by Bill Bill Fontana. It is an installation artwork that was commissioned by IRCAM-Centre Pompidou where it was premiered in June, 2022 (Centre Pompidou, 2022) at the culture centre's south terrace (See *Figure 3.5*). The work used seismic accelerometers[36] to capture the vibrations of the ten bells of Paris's Notre Dame Cathedral, which were silenced after the 2019 fire that devastated the iconic structure. Fontana sonified the hidden acoustic environment resonating from inaudible ambient sounds. Then, he composed and projected this onto the installation's thirty loudspeakers at the Centre Pompidou's south terrace, almost directly facing the cathedral (Despretz, 2023).

Figure 3.5 : Silent Echoes' installation site, Paris. (Centre Pompidou, 2022).

The installation was subsequently reincarnated at Arter, Istanbul in September 2022. In this reincarnation at Arter, the original thirty-loudspeaker setup from Centre Pompidou was adapted to ten loudspeakers, matching the work's original channel count (Arter, 2022). Another alteration in its Istanbul exhibition was the addition of experimental video, hinting that the original work evolved and expanded in this new iteration. While not explicitly stated in introductory texts or the analyses made by magazines regarding the work, the video addition appears to compensate for the visual absence of the Notre-Dame Cathedral, which was present at the installation's original site. Thereby, *Silent Echoes: Notre-Dame* demonstrates how an installation artwork can come to life in different locations and gives hints on which kinds of modifications are made.

[36] A seismological tool to measure the speed of mechanical vibration in any material, exceeding the human auditory systems range and allowing the "hear" the inaudible.

Another instance that fits the discussion's purposes is Cevdet Erek's Bergama Stereo (*Figure 3.6*). It was designed to be a sonic and architectural reflection of the Great Altar of Pergamon[37], which was excavated and brought to Berlin partially in 1871 to reconstruct it apart from its actual context. The original altar is adorned with friezes depicting the battle between the underground giants and the celestial Olympian gods, considered one of the greatest works of Hellenistic art (Aldoğan, 2020). Instead of replicating it visually, Erek chose to represent it audibly through loudspeakers. Thus the facets of the installation is *decorated* with sound compositions ranging from war songs to short, repetitive beats, reminiscent of contemporary sounds to reflect different scenes from the original altar. After its premiere at in Bochum back in 2019, it then exhibited at Hamburger Bahnhof in Berlin. The first transition of the installation was from Bochum to Berlin, and in terms of elements it remained *as it is*. (Erek, 2019)

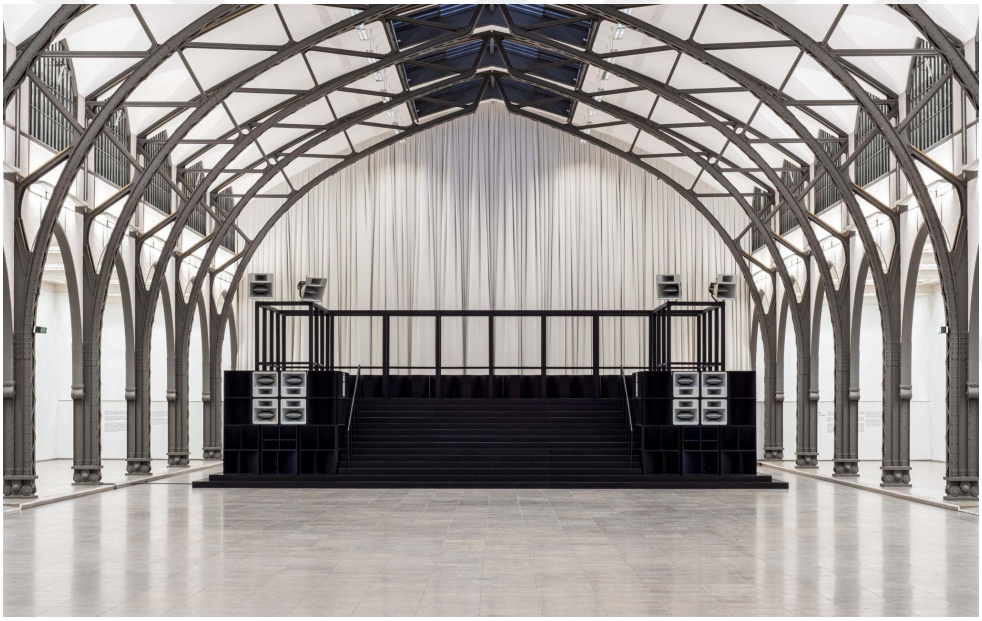

Figure 3.6 : Bergama Stereo by Cevdet Erek. Hamburger Bahnhof, Berlin 2019.[38]

A year later, the installation was reincarnated at Istanbul's Arter Museum with a new appearance; *Bergama Stereotip*. In this relocation, the installation was not merely replicated, but also adapted and transformed to suit the new space, name and context. The architectural construction of multilayered blocks filled up Arter's gallery space, both with its large-scale dimensions and with its use of a 13-channel sound system, which sends vibrations through the room and trembles the approaching audience. The color scheme also changed, and *Bergama Stereotip* developed a red appearance at Arter. (See: *Figure 3.7*)

[37] A historical artifact originally from Pergamon, present-day Bergama in the province of Izmir, Turkey.
[38] Photo by Mathias Völzke (Erek, 2019)

It is In this reincarnation too, in each face of the installation sound changes, fostering the audience to navigate within the room. To experience the installation fully, a visitor should walk around it and also spend some time with each side to receive the meaning that the work conveys. Thus, again, the interactivity between the audience and the installation was a key aspect here. Aligned with its defining attributes, *Bergama Stereo* encapsulates the features essential for adaptability as well and facilitates an example to explain it. Erek's work demonstrates how an installation can be adapted and recontextualized for different spaces and audiences while still maintaining the core of a concept or idea.

Figure 3.7 : Bergama Stereotip by Cevdet Erek, Arter Museum (Arter, 2020).

As highlighted in this chapter dedicated to discussing sound installation's dynamics, regardless of which attributes an installation incorporates, the responsibility of designing the work’s relation with the audience and space properly is a noteworthy matter for the artist to think of. How the artist designs the work's relationship with its context, whether there is a focal zone or multiple zones for sonic intensities, or if the space is utilized more holistically, how to design the diffusion of a work… All in all, the questions on/off this axis shape the final output of an installation artwork and alter the experience it represents.

3.4. Conclusions

The interplay of sound and space in the context of sound installations highlights the transformative qualities of art. In essence, it is about the unity of spatiality and human perception, by filling the cracks between art and form with the guidance of the artist. The approach brings forth a sense of authenticity to sonic experiences either by embracing the site's defining features and incorporating them into the work or reforming itself to fit the unique characteristics of a site. Alternatively, it has the ability to create instances that can manifest independent of the environment by applying methodologies that neutralize the effect of a space or by defining the work as being abstracted from its surroundings. Both approaches facilitate direct engagement with the audience's senses and expand the scope for expression.

Each issue examined in this section of the research provides an analytical lens through which we can appreciate the multi-faceted nature of spatiality in sound installations. At the heart of this exploration lies the attributes that shape the sonic experiences' perceptive qualities. Central to this inquiry are the elements that define the perceptual quality of sonic experiences. These range from diffusion techniques, which influence how sound is disseminated within a given space, to the design of interactive experiences that guide or guided by audience engagement. While helpful to assess sound installations and differentiate one from the other, these attributes all have their parameters offering individual insights, and often intersect and interact in ways that transcend their individual identities.

For instance, a well-crafted diffusion strategy integrated with a particular set of elements, can cultivate a spectrum of auditory experiences. One configuration might present an experience where interactivity and immersiveness are in the foreground, another combination might foster a realistic auditory experience by prioritizing spatial clarity, allowing for distinct sonic elements to be discerned in a collage of sound events within the installation. The selection of these elements and their ongoing refinement shape the narrative trajectory of the artwork, revealing its subtleties and affirming the dynamic and exploratory essence of sound installations. Curating elements for a sound installation transcends mere composition by actively engaging with the space on multiple levels, transforming the environment and, in turn, reshaping itself, rendering an entity far beyond a static arrangement waiting for an audience. Instead, they actively redefine the intrinsic qualities of their environments, influencing the audience's role and experience in a continuous process.

In conventional settings like concert halls, where sonic experiences tend to follow pre-established patterns, the spatial arrangement of performers and audience shapes specific expectations.[39] However, sound installations present a striking contrast, offering a diverse array of interactive experiences through configurations that vary significantly from such setups. They foster a dynamic interplay with their environment, where the emphasis shifts from predetermined acoustics to a fluid engagement with spatiality, characterized by acute responsiveness to the nuances of space. In this dialogue, installations are not just reactive but proactive, continuously adapting and shaping the auditory experience based on spatial intricacies. Whether through the adaptation of sound to the architectural nuances of the site or the reinterpretation of the site's contextual significance, installations challenge and redefine spatiality.

In instances like "Silent Echoes: Notre-Dame" and "Bergama Stereo" this means harnessing the historical or cultural significance of a site, and imagining what is unheard and unexplored by transforming their essence, inviting the audience into a redefined experience in the sonic realm. When juxtaposing the structures of the former experience type with this dynamics, the contrast is revelatory. The former's soundscape is often preset, and predictable while a sound installation, with its attributes and malleability, becomes a living entity, continually evolving in dialogue with its space and its audience. This is not to undermine the former, but to highlight that sound installations occupy a unique intersection. Predictability is useful in its terms and allows qualities like distribution and repetition which have immense importance in art forms like cinema, opera, and fixed-media sound works.

As we transition into an exploration of an exemplary work in the forthcoming chapter, it is imperative to recognize the overarching theme of this discourse; the harmonious confluence of sound, space, and perception in installations. Harping on it matters: Their capability to intertwine sound, space, and human perception fosters an art form that posesses holistic qualities. Installations aren't merely about art occupying a space; it is about art transforming a space, challenging perceptions, and elevating experiences. Sound installations, in their essence, defy static definitions. They are fluid, dynamic, and continually evolving, a testament to the boundless creativity and innovation in this captivating domain of the sonic arts.

[39] Including creating spatial cue templates as discussed in 1.3 Psychoacoustics, and even behavioral expressions like preferring a certain style of clothing. This might be risky in terms of creating patterns that might difficult to be question in the long run and cause stagnation in creativity. For more on this topic and cognitive biases, Safsatalar Ansiklopedisi is a detailed source in Turkish. (Tolstoyevski, 2021)

4. WORK

After setting the theoretical backdrop in the preceding pages, with this final chapter, the practical methods chosen for the exemplary work will be explained including how the context setting strategy constituted at large. The aim is to initiate a dialogue by bridging varying perspectives on the issues discussed until now. The dichotomy that was introduced at the very beginning of this text would be appropriate to begin this part: Trying to minimize the influence of a given space to pursue perfection or recognizing its “imperfect” qualities and embracing it. As explained with various examples and from the perspectives of different schools of thought, each direction has its own advantages and one is not superior to the other. It is a matter of choice, answers vary over questions ranging from psychoacoustic reasons to philosophical approaches. Within this exemplary work, spatiality is acknowledged as a vital and defining participant. The intention with CLSR is to shed light on the interplay between sound, the space's response, and how this creates a different picture than the sum of the parts.

As a psychological theorem that emphasizes the holistic tendencies of perception and experience, Gestalt principles are perhaps the most appropriate theoretical framework to evaluate here to explain what it means ‘to be different than the sum of the elements of an equation’. Emerged in the early 20th century as a reaction to the reductionist approach of structuralism, it attempted to understand psychological phenomena by breaking them down into smaller components. The theory posits that individuals perceive objects and experiences as whole entities rather than a collection of separate parts. Gestalt psychologists identified several principles that explain how we perceive and organize information about our environment. These principles include *similarity* (items that are similar tend to be grouped together), proximity (objects that are close to one another are perceived as a group), *closure* (we often perceive objects as being whole even when they are incomplete), *continuity* (lines and patterns are seen as following the smoothest path), *figure-ground* (we tend to separate objects from their background, focusing on the figure and perceiving the ground as a separate entity).

The last principle is represented by one of the most widely reproduced images, a diagram of two facing profiles, in the space between which, one can see the silhouette of a chalice.[40] (*Figure 4.1*) The diagram of facing profiles elucidates an optical illusion where two distinct images, contained within the same spatial framework, difficult to be observed simultaneously. Even though these images are contained in the same space on a single sheet of paper, two very distinct images can interchangeably appear. This illustration underscores the concept that perception is an act of attending, where one aspect is highlighted and the other relegated to the background. Perceptions are not isolated but instead occur within a contextual interplay with one another. This idea extends beyond visual perception to encompass sensory experiences and arguably cognitive processes. Gestalt principles provide a framework for understanding perception and interaction with the environment and have been influential not only in psychology but also in fields like design, education, and human-computer interaction.

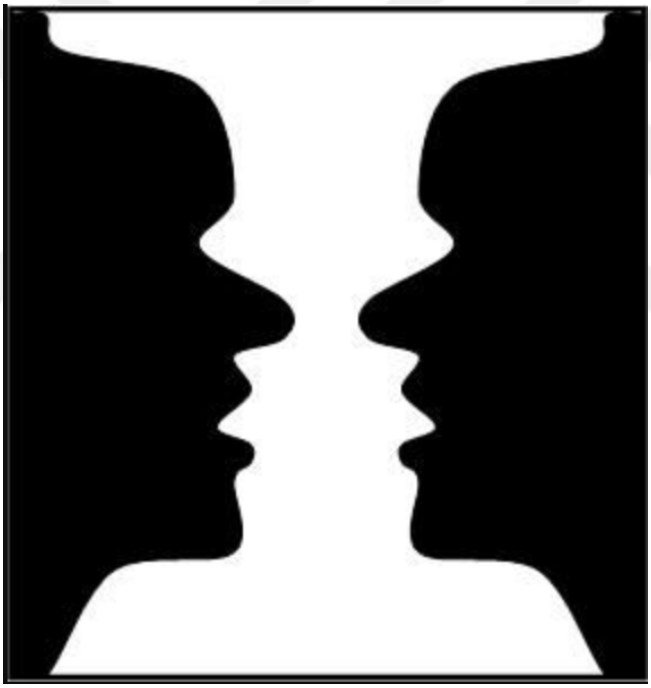

Figure 4.1 : Rubin Vase (Edgar Rubin, 1915)

The lineage of Gestalt Theory can be traced back to Max Wertheimer, a Czech-born psychologist significantly influenced by Christian von Ehrenfels. In 1890, Ehrenfels introduced the notion of *Gestalt qualities* through a musical analogy, arguing that a melody's identity resides not in its individual notes but in their arrangement (Ehrenfels, and Barry, 1988), reminding Claude Debussy's assertion on the same quality "music is the space between the notes". (Koomey, 2017)

[40] It is often mentioned as a discovery of the Gestalt theorem, in particular by Danish psychologist Edgar Rubin, however, this is a known optical illusion for centuries before him and applied especially in arts.

Later on, Wertheimer's encounter with a zoetrope[41] led him to gain insights into the mechanics of perceived movement. Alongside colleagues Kurt Koffka and Wolfgang Kohler, Wertheimer employed instruments to make tests and their endeavor revealed that the illusion of motion is predicated not on individual images, but on their sequential arrangement and temporal spacing This finding laid the foundation for Gestalt psychology, a movement that further proliferated through the contributions of Wertheimer, Koffka, Kohler, and their protégés. Without delving deeply into the historical milestones of the theorem, let's come back to the principles counted above and focus on one of them particularly where the exemplary work's inspiration comes from: The closure principle. The figure-ground principle is a valuable starting point for elucidating the contrasting tension between space and sound, to express how their interplay amalgamate to construct a larger, unified mult-faceted perceptual experience. The principle of closure points out that we often perceive objects as being whole even when they are incomplete and detached (See *Figure 4.2* for examples). It posits that individuals tend to perceive incomplete shapes, patterns, or sounds as complete by filling in the missing information.

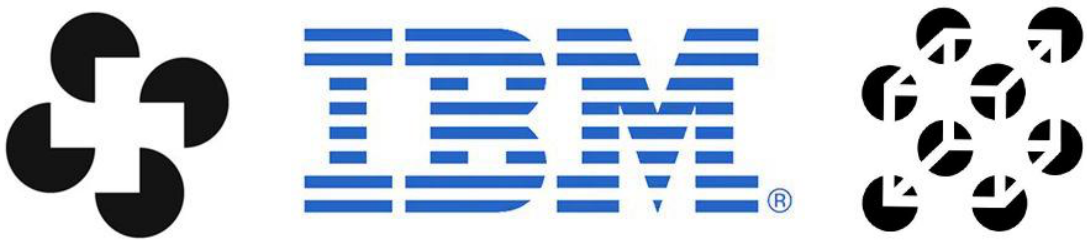

Figure 4.2. : Visual examples of closure principle.

While this observation primarily suggests that it is a tendency towards visual stimuli, as it is explained and referred to from different sources within this text, hearing has a similar holistic tendency as well. (Sethares, 2010) It is because human perceptive abilities have "factory defaults" that indicate certain minimum and maximum values for processing sensory stimuli. For instance, accepting more than 12 frames of a visual input within a second is considered as "apparent movement" as Gestalt psychology researchers call it. This is similar to sound as well, although we could feel it as a tactile stimulus, we are not able to hear below 20 Hertz, in other words, waves that have less than 20 oscillations in a second.

[41] A zoetrope is an early animation device that creates the illusion of motion. It consists of a spinning cylindrical drum with images on the inside. When viewed through slits while spinning, the rapid succession of images tricks the brain into perceiving motion. It predates cinema and was popular in the 19th century.

Besides these limits, as discussed in the Psychoacoustics chapter, being able to process sound information has the ability to pick specific sounds in a sound panorama however being able to decode all input at once is not possible. Therefore even though there is only a single sound source, in spaces where excessive echo and reverberation are apparent, it is harder to make sense of what is heard. This is mostly due to the spectral dispersion effect. When the sound waves interact with surfaces or objects, they get dispersed unevenly and travel at varying speeds, causing different frequency components to be heard at varying times in differing qualities from the original source, significantly influencing the perception of music and speech. In such environment, the brain gives up trying to make sense of what is specifics and instead handle details globally by seeking matching qualities like patterns and spatial templates.

These phenomena are in close proximity to Gestalt's theorem's principle of closure which also focuses on to human tendency to seek a unified, coherent experience. As it will be discussed in the following pages, in the context of *CLSR*[42], the reverberations, echoes, and reflections aren't just incidental; they are considered to complete the auditory experience. When a sound emanates within a space, it interacts with the environment, and features that make speech unrecognizable, igniting an interaction that fills the 'gaps' between the sound source(s) and space, creating a fuller, enriched auditory experience. By embracing the influence of the space like natural acoustic properties, the audience is invited to an integrated experience. Utilizing the principle of closure, *CLSR* is aiming to provide a compelling lens through which to explore and articulate this symbiotic relationship, and how together they contribute to a more interactive and holistic auditory and spatial experience.

Given this context, *CLSR* echoes the sentiments of artist Roy Ascott, underscoring the importance of process, system, and the interplay of ordered and random elements within modern art (Ascott, 1968). This work aims to develop a system that serves as an invitation to experience, question, and engage with the lively nature of space through sound. Thus, instead of imposing a conclusive, definitive composition with a strict beginning and end, aim is to initiate dialogue, a conversation between the audience, and the space that the artwork is within. It is an invitation to delve deeper into the acoustic ecology and to recognize that the environment is not a passive receiver, but an active participant.

[42] The code name for this exemplary work. Please visit page 2 for further information about the concept.

4.1. Method

To explain it simply and very broadly in a single sentence, *CLSR* is a stochastic quadraphonic real-time reference tone-generating sound installation with an indefinite duration. Reference tones are best known for their utility in sound reinforcement systems. They are being used to make calculations to detect *deviations* and minimize the influence of space *if necessary*, acting as a reference point. While this is immensely important in experiences incorporate sound like cinema to be able to hear sounds as they were intended, they also contribute to a process of disconnection from the space inhabiting the sound experience. Therefore *CLSR* is deliberately employing them in a loudspeaker system that normally *has to be* calibrated and keeps the system untouched to allow the space to influence the sound and express itself.

In this part of the text, incorporated concepts and what they mean in the context of *CLSR,* what are the key attributes of the artwork, how the diffusion strategy compiled and the installation's stance regarding the focus will be explored. To be able to come up with a final version that is being prepared for the defense day for this thesis research[43], prior studio experiments and two on-site experiments were realized (The first on-site installation can be seen in *Figure 4.3*). A combination of empirical data gained from the experiments, and inputs from the thesis advisors shaped the the process in each step. This chapter of the text is dedicated to the reflect the sum of all.

Figure 4.3 : *CLSR*'s first appearance at the installation site, June 2023.

[43] Therefore the documents and the final form of the CLSR's algorithm will be added as an appendix.

During the emergence of the work, one of the most influential encounters was the installation space itself. The site is a mezzanine-like structure with eight columns in two rows and there are two stairs on each side of the platform at the Istanbul Technical University's Macka Campus in the School of Foreign Languages building in between the two rectangular major blocks (See the plan of the floor in *Figure 4.4*). Due to its binding role in the architecture, it has access to four corridors on its floor and four more on the floor beneath it. To put it poetically, the site has a magnetic effect that pulls everyone from all directions. It can be seen in Figure 4.3 that the site only has reflective surfaces like stone walls and windows. There is nothing in particular to absorb sound, therefore it has an excessive reverberation and is prone to hear echoes. The spectral splitting effect is also present and if the source is far enough, it becomes harder to understand voice and recognize sounds.

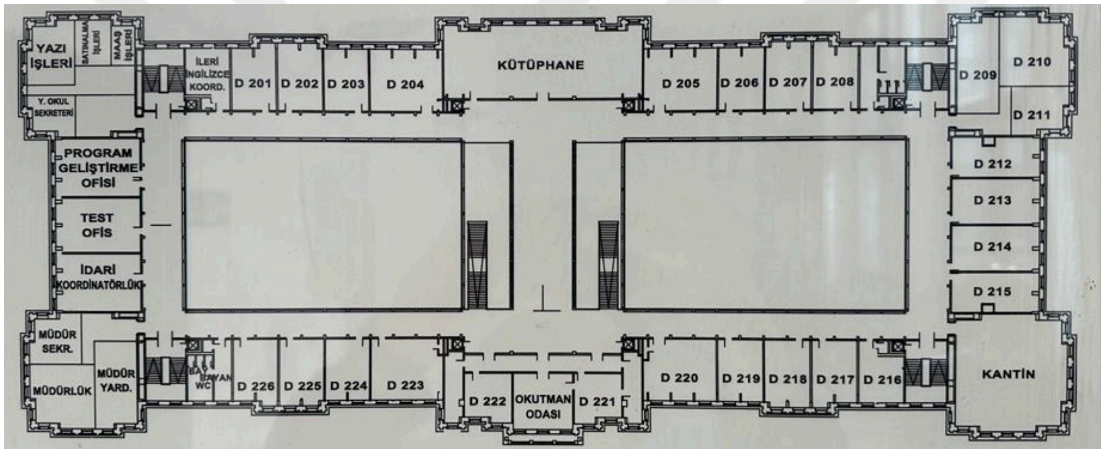

Figure 4.4 : Plan of ITU's Maçka building, 2023. (Photo: Cevdet Erek)

Decisions regarding the installation's temporal and perceptual qualities were made based on the aforementioned studio and on-site experiments. The key idea that was centered during the decision-making processes was to make use of as much empirical data as possible to be able to strike a balance between perceptual and conceptual realms regarding the understanding of this medium. The first on-site installation took place back in May 2023. Since the acoustic qualities of the planned installation site were apparent and known as reflective, the algorithm tested in studio settings and durational decisions, and the contrast between sounds and silences was designed accordingly prior to the first test installation. Although attempts were made to adapt beforehand, the site responded to the generated sounds by *CLSR*'s system much more profoundly than imagined. This situation caused immediate fine-tuning on attributes like durations, spectral qualities, and the way that synthesis operations activated and deactivated.

After the initial experience took place, to be able to focus on the key issues that the artwork is planned to reflect more, it seemed reasonable to translate the sound system and its algorithmic counterparts into stereophonic rather than quadraphonic (*Figure 4.5*). In the presence of a 4-loudspeaker, making this presumption was somewhat easy. However, following the second on-site test in stereophonic orientation, certain problematic details emerged quickly, first and foremost was loudness. Due to the sound pressure level that needed to be able to highlight the definitive qualities of the space, loudspeakers needed to work in high amplitude. This created a “blind spot” in between loudspeakers where it was quite hard to understand the generated sounds’ interaction with the site, which is one of the core aims of the artwork.

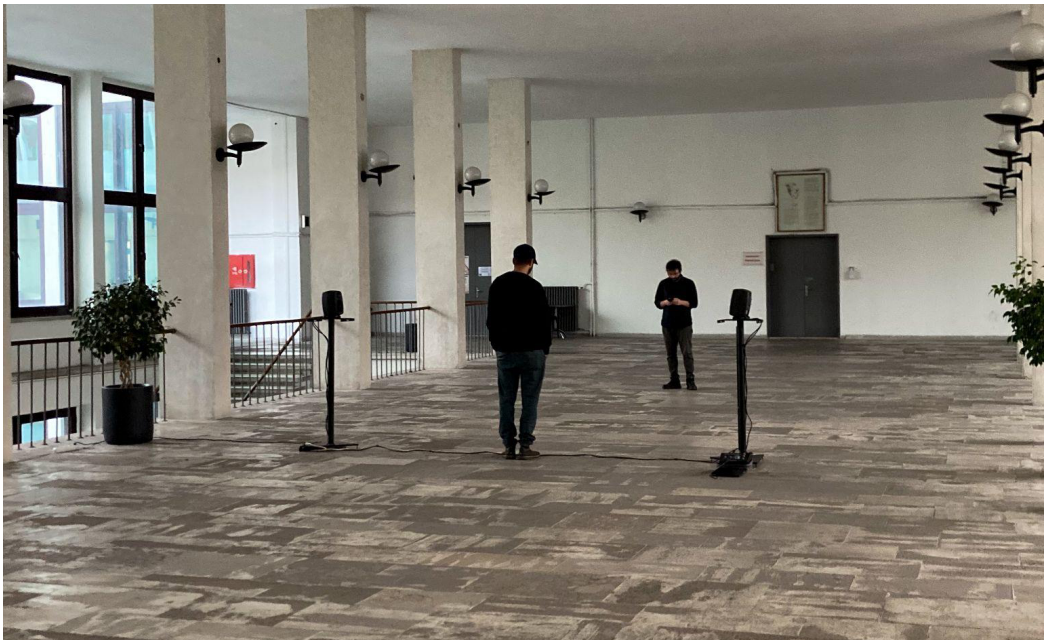

Figure 4.5 : Test installation 2, in stereo, on site.

Due to the nature of sonic materials that have been employed, it is not considered problematic to have different loudspeakers from one installation to the other in *CLSR*. However, the loudspeakers of the second test were unable to generate sounds below 70 Hz and the absence of low frequencies caused more auditory bias in the center of the installation. Moreover, the loudspeaker orientation and angles were questionable. In the initial version, the aim was to replicate the quadraphonic loudspeaker setting, having a system that has been iterated for decades. Therefore there was an *ideal* setup already, and it was in sync with the idea that *CLSR* was trying to reflect. The shift from quadraphony to 2-loudspeaker necessitated a front-bias, which was another major issue while the work was trying to have no front bias.[44]

[44] "Front bias" emphasizes sound coming from the front, necessitating listeners to face the system.

To preserve this intention loudspeakers were placed directly towards each other but this created other conceptual issues due to the processing of this perceptual input indicating a presentation of a direct sound. But since there is no listening position to be “idealized” this positioning and angles ended up being off from the conceptual ground of the artwork. The sum of these effects caused a group of decisions, the primary one being to go back to the initial settings of quadraphony but enhance it based on the observations made. Details of this transformation will be discussed in the following pages.

Although the site’s acoustic qualities were at the center and the systemic decisions were made accordingly, due to necessities like waiting for people to leave the building before making sounds was creating the false impression of a silent space. Thus, another major issue being the first two on-site experiments indicated was that the soundscape of the installation had been neglected. However, after the installation hype was over and there was no sound generated in real-time, it became apparent that there were sounds that had to be included as participants of the artwork because, in essence, this was not an acoustically organized *sterile* place.[45] Refrigerators on the floor beneath the installation site, air conditioning system, sound of traffic, people moving around the building in the distance… all amalgamated into the excessive reverberation of the site, and creating a subsidiary noise.

4.1.1. The Blend

In this third reincarnation of the sound installation on site, once again a carefully considered combination of factors will take place, this time with the support of empirical data gained from the previous tests. As stated in the 3.2.2 Diffusion Strategy, the blend of incorporated attributes and the strategical decisions made on diffusion is the medium in which a sonic reality is fashioned in the realm of sound installations. This is what serves as a fingerprint for the artwork and the artist. As media theorist Marshall McLuhan conveys the importance, “the medium is the message” (McLuhan, 1964). Therefore, the conceptual stance of the artwork will continue to be elaborated in this part of the text hand in hand with the technical aspects of the work while discussing their perceptual counterparts. Due to its central position in this work, it has been stated several times so far that in the dichotomy of accepting the space and its influence on sound events as a symbiotic participant and minimizing its influence, the former is accepted as a defining quality.

[45] This was indeed one of the appealing features of the site at first but it appears that human cognitive capabilities are also limited to focusing on multiple details at once. Therefore it had to be *remembered*.

With that said, this doesn't mean this installation artwork is planning to be a strictly site-specific example. As it is discussed in 4.1.3 Adaptability, installations with repeatable layouts exhibit replicable qualities than those tied to a site. *CLSR*'s intention is to highlight the relationship between space and its inhabitants and how these parts create a different picture than their sum. It has no binding to a particular site or a specific type of loudspeaker, thus the offerings of the system can be replicable even in contexts never imagined suitable for such representation. This stance demonstrates a high level of adaptability and does not get negatively influenced by the change of context.

In the "simple and very broad" definition of *CLSR* above, the duration of the work is expressed as "indefinite". This statement goes beyond indicating a lack of consideration for the temporal qualities of the work. Once the sound generation operation starts, the algorithm is programmed to generate sounds continuously until an interruption. This way it can continue its operations at the installation site as long as necessary, depending on the length of the exhibition. In the aspect of individual sounds that the system is generating, there are different and more sophisticated considerations and their dynamics will be explored in 4.1.3 Software. Also, it can be argued that *CLSR* is an interactive sound installation. This is not because there is an incorporation of a technique to harvest audience input and convert it into an activity in the installation. It is because the visitor should participate actively and navigate within the installation site to understand fully what the artwork is trying to convey. Without trying to make sense of the sounds, their interpretation by the space, and the space's defining qualities by moving around in the site, the experience would be incomplete.

The expectation of involvement from the audience might lead to ambiguity. But as it is stated, in 3.2.3 Focus, it is possible to make an intervention and lead the audience's interaction with the space with varying stimuli. This is one of the reasons that the sound sources of the *CLSR* are deliberately visible, and in a quadraphonic setting. Because there is a visible focal point in the site that is designed with no front bias on purpose, this makes it easier to fully comprehend the work just by walking through it. The "magnetic" effect of this orientation seemingly proved to be working in prior tests on site. Considering the principles that Gestalt theorem introduced on natural tendencies, it is not a surprising result, and thus implemented in the final version as well.

4.1.2. Hardware

The hardware system of *CLSR* is not complex. However, in a simple system that expresses something fundamental and yet sophisticated, each element, each angle, and each word that is used to constitute and define it profoundly matters. Therefore, to prevent confusion, the hardware and software facets of the sound installation work will be separately explained. To come up with the *CLSR*'s current system, the following ingredients are needed; four reference monitors[46] as sound sources, a sound interface that has four discrete outputs to translate digital signals to the analog realm and feed the monitors, and a computer that can run the audio programming language SuperCollider that will operate the algorithm (*Figure 4.6*).

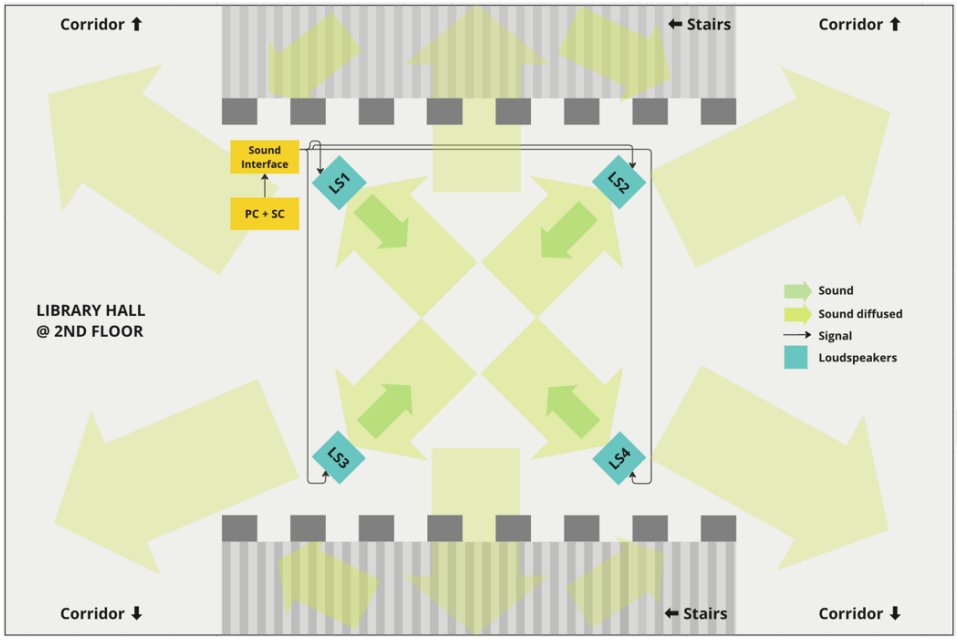

Figure 4.6 : Plan sketch of the installation and the site.

In the context of audio, a reference monitor refers to a type of loudspeaker used in audio production environments to provide an accurate, flat representation of sound. This allows audio engineers, producers, and musicians to hear a recording as it truly is, without any enhancements or alterations. *CLSR* employs precise reference tones that are conventionally used to calibrate audio equipment, in particular reference monitors. In the realization of the project, the very subject of the process is incorporated as the sound source. As long as a loudspeaker is classified as a reference monitor, it can be employed in the context of *CLSR*. The only concern is their ability to produce the high-frequency range that the work necessitates.

[46] This aspect of the work was mentioned as simply "loudspeaker" until now. This was due to prevent any confusion before setting the necessary context.

The first on-site experiment of *CLSR* employed four *Yamaha* HS8 Active Studio Monitors. These studio monitors have a frequency range of 38Hz - 30kHz, featuring an 8” cone for the low end and a 1” dome for the high end.[47] It was successfully able to reflect what the system is generating. Having four of them was useful to distribute sound in healthy amplitude each of them without leaning on a single loudspeaker or a pair too much. In the second experiment, *Genelec* 8020A Active Studio Monitors were employed, which has a free field frequency response of 66 Hz - 20 kHz (‡ 2.5 dB). With this said 8020A’s performance is quite limited below 80 Hz due to its 4” cone for the low end.[48] In theory, a 70 Hz sound wave has a full wavelength of approximately 5 meters. Because of this fact, before to the on-site experiment due to its dimensions, this usage seemed logical to employ this near-field reference monitor for the installation. However, as explained in previous pages, their usage caused certain problems, therefore for this specific site, they will not be included in the final on-site installation of the work.

Another difference between the two on-site experiments was the height and angles of the sound sources. In the initial version, the reference monitors were elevated approximately 0.6 meters above the ground. Due to the work’s no-front bias approach to the quadraphony, the relative angles of them were 45 degrees towards the center of a square orientation. However, their height did not align with the goal of replicating the *ideal* listening position, which was intended to introduce a conceptual contrast to the artwork. Therefore in the second edition, the height was nearly duplicated to 1.1 meters. Another issue in the second version was the angles of the loudspeakers, which were directly pointing at each other, again not reflecting “the ideals”. (Figure 4.5) Therefore aim is to keep the renewed height in the final version but go back to the initial angles and the quadraphony.

In quadraphony, it is typical for the distance between loudspeakers to be equidistant, regardless of whether there is a front bias or not. The listener is presumed in a focal point in the center of this square. Although the implication of having only a single ideal listening position, which is something abstained within *CLSR*, the approach of locating four sound sources equally apart from each other is adopted. The intention of bringing a widely acknowledged methodology to the center is to create contrast in the artwork’s context.

[47] According the manifacturing firms’ websites, Yamaha and Genelec respectively.
[48] The diameter of a studio monitor's driver, measured in inches, directly influences its capacity to render lower frequencies due to the physical dynamics of air displacement.

A differentiating detail in the first public exhibition is the distance of sound sources from the nearest reflective surface, in this case, it is the concrete columns in the site. This is to minimize the physical realities of the sound wave generation process dependent on sound's speed on air and phase. The sound sources are planned to be 0.6 meters away from the columns in the site due to phase cancellation (*Figure 4.7*).

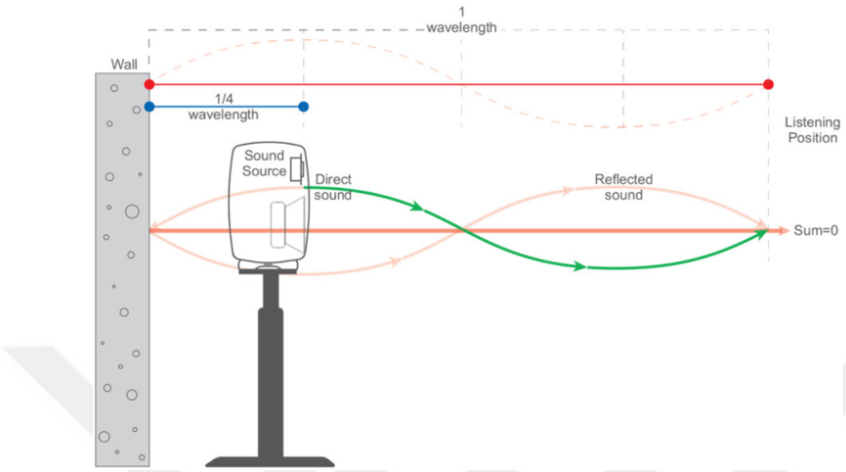

Figure 4.7 : Phase cancellation in loudspeaker-wall relation. (Genelec, 2023)

Another aspect is the direction of sound sources. In the second on-site experiment, one of the jury members of this thesis research Dr. Sair Sinan Kestelli asked what would be different if we located loudspeakers facing the exact opposite side. This highlighted reflected sound more and eliminated the direct sound from the center of the installation. However, in this formulation, there were two issues contradicting the intentions of *CLSR*. Firstly, while it holds functional significance, the conceptual orientation towards the outside of the installation center does not align with the representative stance that *CLSR* aims to convey. The typical usage of the reference monitors was to question them by bringing them into a different context.[49] Secondly, in this case, there was no *reference point*[50] in the sound installation. The intention of building such a zone in the installation was to open up space for listeners to compare varying qualities of direct sounds with the influence of space.

Before completing this subchapter dedicated to hardware, two more issues need to be elaborated more: The whats and whys of quadraphony, and the visibility of sound sources instead of making them less apparent on the installation site. Quadraphony or quadrophonic sound, to put it more directly, refers to sound reproduction that uses four discrete audio channels to provide a 360-degree surround sound experience, with sound sources being typically positioned in the corners of a room.

[49] This includes their height and angles, which emerged as vital qualities that needed to be designed.
[50] This means a region in the site that allow the audience to listen more directly, not a sweet spot.

It is an early form of surround sound system that predates the more commonly known multichannel sound systems of today. This configuration aims to create a more immersive and spatially accurate sound field for the listener. The placement of loudspeakers and the design of the audio mix are intended to provide depth and directionality on playback, beyond what is possible with a stereo setup.

This was the initial importance of its usage in *CLSR*. It seemed the illusion of depth that is possible to create in stereo with binaural rendering would be enough but on-site experiments exposed that the true effect of surround sound can be interpreted only to an extent with stereo. The depth that quadraphony provided was a defining feature and the absence of it affected the impact of the installation immensely. In essence, it is a four-channel audio system that allows sounds to be positioned in a listener's perceptual field with precision. To draw a comparison to the Cartesian coordinate system, stereo systems can only operate sound along the X-axis (left and right), while quadraphonic systems add the Y-axis (front and back). Therefore it introduces another plane to work with in sound design, composition, and spatiality.

As mentioned, the only drawback it necessitates being in the crux of the four loudspeakers to reflect these qualities properly. However, *CLSR* centers an imaginary cube object positioned in the sweet spot where the “optimal” auditory experience is possible. Therefore it does not have a front bias, so all four prime directions are the “right” direction to experience the work. Moreover, sounds that are passing behind the loudspeakers are also accounted for. The loudspeakers are directed towards the center, yet the room is intentionally larger than the central cubic structure. When sound is emitted, it not only travels beyond the loudspeaker facing it but also diffuses throughout the installation space, producing an omnidirectional ambiance. (See “Sound diffused” visualization in Figure 4.6)

Lastly, the visible presence of sound sources on the installation site is a deliberately designed strategy. As stated, the specific loudspeaker type preferred in *CLSR* is a reference monitor. A reinforcement system that has the claim of representing sounds “as they are”, aiming to minimize the effect of spatiality. Moreover, it has lots of connotations, because it is a widely known device from sound practices. Blended with the usage of reference tones a very precise sonic material that is typically used to calibrate them, this is a conceptual contrast that the installation aims to orchestrate. Bringing them into consideration in a completely different environment than they appear in general.

4.1.3. Software

Rather than adhering to a fixed media playback system, to bring to life its desired results, *CLSR* employs an algorithm programmed for the task in the audio programming language SuperCollider. This decision is to have the flexibility of fine-tuning when necessary and also as a reflection of the project's dedication to shed light on the constant dynamism inherent in space, concepts that pre-recorded sounds hardly can embody. The prime responsibility of *CLSR* 's algorithm is the generative audio creation process of the installation. In the sonic arts lexicon, generative refers to the creation of sound through rule-based systems or algorithms, allowing sound to be formed and evolved in real-time. This *responsibility* includes the creation of reference tones, which will be described below, and guiding their distribution within the quadraphonic sound system. At the moment before starting sound generation, these tones are programmed to be delivered through a separate audio channel from 1 to 4. This is to give equal space for each of the tones symbolically. Then the system launches a process of alternation between sound outputs based on stochastic principles, introducing another layer of deliberate unpredictability to the installation’s context and indeterminately continuing until an interruption.

Every experience is planned to be unique and unrepeatable, in *CLSR*, so its algorithm is designed based on a generative system, and the durational facet of the work is determined as indefinite. This is to invite the audience to discover the space sonically in ways not preconceived before. The project embraces probabilistic forces to provide a facility for a dialogue that emphasizes the symbiotic relationship between the spatiality and the sounds themselves. This methodology resonates with the following statements of Brian Eno; “All organic systems are probabilistic: they exhibit variety, and an organism's flexibility (its adaptability) is a function of the amount of variety that it can generate. Evolutionary adaptation is a result of the interaction of this probabilistic process with the demands of the environment. By producing a range of outputs evolution copes with a range of possible futures” (Eno, 2005).

Besides having this conceptual insight on how the system works for how long and what it stands for, it is also important what types of sounds it generates. The concept of reference tones lies at the heart of the work entitled *CLSR*, forming a critical layer of the methodological framework employed. As such, it is necessary to unpack the nature, types, and utility of these tones to understand their application within the work. Reference tones are specific sounds generated to calibrate, test, or compare audio equipment. They provide a consistent benchmark for audio professionals.

In spatial sound research, reference tones are one of the most important auditory markers, useful for both understanding the technological tools at hand and the gather information about a specific site. There are several types of reference tones, each with its unique sonic characteristics and applications. In *CLSR*, four distinct types of reference tones are employed; pink noise, white noise, sine wave sweep, and impulse signal. Pink noise is characterized by equal energy per octave, therefore it gets heard “darker” than white noise. Often used to assess frequency response, and identify potential anomalies in audio systems. White noise contains equal power within any frequency band, and it is also commonly used as a random signal in numerous applications, from spectral analysis to acoustic testing. The sine wave sweep moves through all frequencies within its range and is typically used for measuring system response in a particular site or testing audio equipment. Lastly, the impulse signal, essentially a short burst of sound, allows the analysis of reflections and reverberations.

As stated, reference tones are typically utilized to calibrate sound systems, neutralizing or minimizing the influence of space in a specific listening position or zone to ensure consistency of sound reproduction. Conversely, in *CLSR*, the intention is to allow the whole site to be perceived as unique and ideal as it is. Therefore although these tones are employed with a similar role in calibration, the aim here is not to make the space transparent but rather reveal the influence of it and its distinctive qualities. In other words, the work uses reference tones to emphasize and explore the influence of its residing space rather than to neutralize it. Aligned with the project's diffusion strategy which aims to strategically leverage the spatial characteristics of its given context, *CLSR* acknowledges that space is a living entity.

With these stated, three parameters especially concerning the software will be explored below briefly: Aside from the indeterminate duration of the work at large; the temporal qualities regarding individual sound events, the relationship of sound events with each other, and the influence of the soundscape that the particular space inhabits. Each has unique contributions to the multi-faceted process of recognizing what the installation is pointing out. The criteria that shaped them during the creation of the work are based on both theoretical and practical experience. Therefore is understood to a degree of building the work around them. Their fine-tuning is still an ongoing process as of October 2023 and will be fully completed with the final exhibition of the work on site. The outcome and the final version of the SuperCollider code is added to the thesis text as an appendix.

First of all, temporal qualities regarding individual sound events. The alterations of the employed sounds' temporal qualities at the individual level are the backbone of *CLSR*'s aesthetical touch on sound generation. There is no other similar interference with the purity of this deliberately selected sonic material like filters or effects. The algorithm of *CLSR* is responsible for the following procedure at an abstract level: Defining the sound sources (SynthDef recipes, short for synth definitions in SuperCollider) including their initial parameters with a group of variables assigned to each one of them. Then "call" these defined sources to generate sounds indeterminately in order, "infinitely". While doing so assign indeterminate values to their variables such as frequency and amplitude, and diffuse them either by making use of pairs of loudspeakers or using a single channel only. (See: *Figure 4.8*)

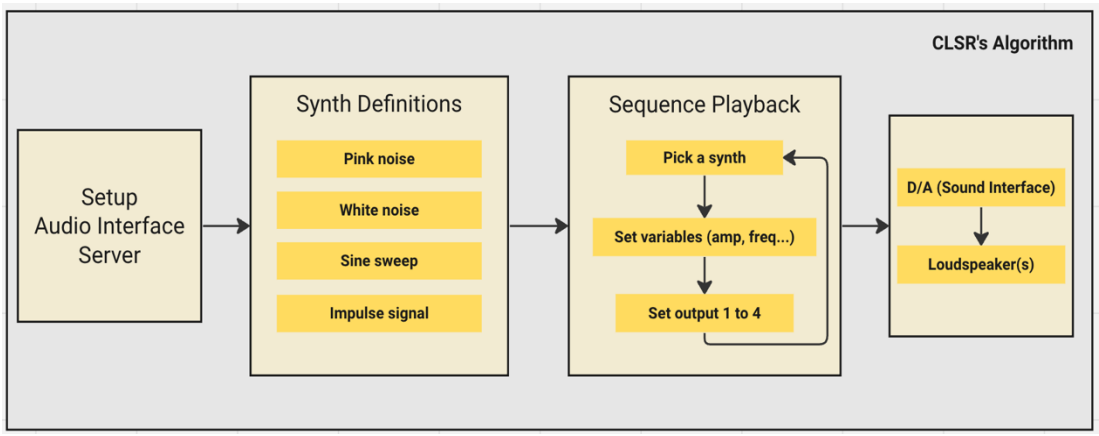

Figure 4.8 : The diagram of the algorithm.

There is no specific metronome or anything, in particular, to define a temporal rhythm conventionally. As stated, there are variables assigned to each SynthDef, and the system makes use of them to conclude the duration of each sound generated. Fundamentally this is an envelope operation.[51] Sounds almost start immediately as reference tones are used typically in engineering-alike processes. Therefore there is a very short attack in *CLSR* too with no decay[52], a fixed ratio sustain[53], and an indeterminate amount of release time in seconds generated specifically for each iteration. The only influence on the temporal qualities of the work besides this deliberately designed "randomness" can come from the necessities of computational processes like buffer size, sampling rate, and digital-to-analog conversion.

[51] In sound synthesis, an "envelope" defines how a sound evolves over time in terms of amplitude. Although there are other combinations, this evolvement typically characterized by four stages also known as ADSR: Attack, Decay, Sustain, and Release.
[52] This makes the employed envelope type ASR, Attack, Sustain, and Release.
[53] Because the amplitude variations are controlled directly by a variable within the oscillator.

The referred indeterminacy of release duration happens in the range between a minimum and maximum value. The algorithm picks an indeterminate decimal and sets the sound generation process's release time in seconds accordingly. This range changed several times during the creation of *CLSR*. At first, the aim was to constitute the exact usage of the engineering process. In studio experiments, this emerged into making their dullness less apparent by applying an envelope, while staying to the functionality they hold. At last, during the on-site experiments, the defined range for each sound type was affected greatly due to the unprecedented influence of space, the central issue being the excessive reverberation. Eventually a range of 50 milliseconds to 2 seconds appeared for each sound's creation.

However, as the jury members of this thesis research pointed out as well, it became apparent in the second on-field experiment that the designated temporal range might be insufficient to grasp intended details, especially for inexperienced ears. As opposed to continuously feeding the installation with direct sound and therefore causing an intensely layered reverberation, the design of the range from 50 milliseconds to 2 seconds was about highlighting the influence of space on sounds to be more apparent. Introducing bursts or sound events up to 2 seconds, then allowing space to reflect with its unique character. Two issues prevented the succession of this intention. Firstly, although it is abstained from, due to the proximity of sound events, this feature appeared anyway. Secondly, although it was apparent based on the studio experiments that the result of such an application causes acoustic shadowing between generated sounds, both on-site experiments demonstrated that the upper limit of temporal range can go slightly higher. Because there is more to explore in the direct sounds themselves and the nearly instantaneous response they get back from the site. A significant instance of the need for prolonging was the sine sweep because being able to process the information about the space it was aimed to emphasize was quite challenging. Thus, there the final version of the algorithm has considerations to prevent such problems that might caused by this updated design.

As well as their distance from each other, the issue of the temporal proximity of sound events encompasses their distance from silences. In other words, the negative space.[54] Regarding their aggregation, the system has the total freedom of generating all possible combinations of four reference tones without being bound to anything else besides the computation that causes only a minute effect. Meaning at any given moment it is possible to expect four or none sounds from *CLSR*.

[54] One of the best ways to explain the concept of negative space is Gestalt's figure-ground principle.

Regarding their segregation, again without a particular order, there are *plato zones* in-between sound events that sound(s) is still resonating in the space, but there is no new sound generated upon its presence. These states are advantageous for listening to how a sound or combinations of sounds experience its/their attenuation, reflecting the added qualities that the site introduced onto them. This is the particular state that the programming of the system is imagined to emphasize. As stated, after the last on-site experiment, it is planned to have longer intervals between sound events. Currently, there is approximately 10-15 seconds of silence every 5-10 minutes in the last version of *CLSR*'s algorithm. This resembles the *absolute* silence (which will be discussed in the following paragraph as to why it is not possible in this particular site) or the feeling of *approaching* to it. The aim is to have such auditory states slightly more frequently to allow the audience to experience both the aggregation and segregation of sound events more clearly. Also, this update is essential to allow sounds to reach out further since they cover a larger area than the immediate installation zone (Figure 4.4).

The examination of the sound events necessitates evaluating the soundscape already present in the installation site as well. As stated in the introduction of this text at large, and in between lines through the past pages, this thesis study had the intention of discussing spaces aside from "sterile" environments. This means the spaces that are not organized were the focus, instead of the non-space nature of conventional sound exhibition spaces including museums, concert halls, studios, and more. As stated, the first public appearance of *CLSR* will be in such space, and the planned site is a binding architectural unit inside ITU's Macka Campus in the School of Foreign Languages building. Therefore there are classrooms, a library, and corridors that bind different directorial units of the building and more.

Since the place is not crafted for an exhibition, there are sounds all around, creating a continuously unique experience and a lively amalgam of different details ranging from industrial hums and noises to distant traffic sounds and people walking around. This exemplary installation that aimed to complete this thesis research has no specific stance and tries to include them into the work. However, their presence is accepted and it is acknowledged that the space will never be silent or "sterile". The work focuses more on the acoustic qualities of the space in which it is quite impossible to think separately from its soundscape. Therefore, *CLSR* includes the soundscape but has no particular aim to create another layer of tension by creating a conceptual contrast.

4.2. Remarks

This research started with the following motto, “Composing sound in space is as important as composing them in time”. The intention was to highlight the significance of spatiality in the composition of sound art. After months of research around the subject focusing on facets ranging from psychology to sociology and physical properties of sound, this statement still seems valid. Although mastering the interplay between sound and spatiality remains a technically and ontologically detailed subject, pioneering works from various stakeholders, including individuals, universities, and corporations, the field has significantly expanded, and reaching out for information is becoming easier every day.

As experimentation flourishes, the audience's expectations have transformed with increased exposure to spatial sound in public spaces beyond conventional homes for sound-related arts like concerts, cinemas, and museums. With rapidly evolving technologies in modern times, spatiality in sound has taken on new dimensions, expanding the boundaries of sonic arts. Yet, as we become more adept in using these tools, the research field's complexity reminds us that mastering artistry is not a straightforward task, and new horizons continue to emerge. While we have come far in our appreciation and application of spatiality as a medium of human expression, the potential for further exploration and discovery remains vast, both from a theoretical and practical perspective. As technology continues to advance, so will our knowledge and capabilities, opening up new and exciting possibilities. Seemingly the limit is the humanly comprehension of sensory stimuli which we can exceed in multiple ways even with today’s *primitive*[55] technology.

[55] The word choice here might sound subjective but considering, advancements like electricity and the internet is like a glimpse when compared with the course of evolution and the period that it dispersed. According to anthropological evidence, homo sapiens are around 300,000 years old (Hublin et al, 2017), while the internet is roughly 50.

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APPENDICES

Appendix A – *CLSR*'s SuperCollider code.
Appendix B – *CLSR* caption text example.
Appendix C – Artist statement for *CLSR*.
Appendix D – As a digital addition to this thesis text, there is a CD that is attached to the back of the cover at the end as one last Appendix. It includes a PDF file of this thesis, real-time sound recordings from the final installation day that exemplifies how CLSR was sounding on site, and a sound recording of how the algorithm of CLSR sounds without the space's influence. Along with these, the SuperCollider code file, photo and video documentation of the work can be found.

Appendix A

```
1 ServerOptions.devices;
2 ( s.options.device = "SSL 2+";
3 s.options.numInputBusChannels = 0;
4 s.options.numOutputBusChannels = 4;)
5 s.reboot; s.meter; s.plotTree;
6
```

Figure A.1 : Initial settings for the system.

```
7  (SynthDef(\pinkNoise, {
8      arg outPN,
9          aPN, sPN, rPN, atPN, dtPN, stPN, rtPN, caPN, cdPN, crPN;
10     var source, env;
11     source = PinkNoise.ar(1);
12     env = EnvGen.kr(Env.new(
13         levels: [0, aPN,  sPN, rPN, 0], times: [atPN, dtPN, stPN, rtPN], curve: [caPN, cdPN, crPN]),
14         doneAction:2);
15     Out.ar(outPN, source * env);
16 }).add;
17 SynthDef(\whiteNoise, {
18     arg outWN,
19         aWN, sWN, rWN, atWN, dtWN, stWN, rtWN, caWN, cdWN, crWN;
20     var source, env;
21     source = WhiteNoise.ar(1);
22     env = EnvGen.kr(Env.new(
23         levels: [0, aWN, sWN, rWN, 0], times: [atWN, dtWN, stWN, rtWN], curve: [caWN, cdWN, crWN]),
24         doneAction:2);
25     Out.ar(outWN, source * env)
26 }).add;
27 SynthDef(\sineSweep, {
28     arg outSS, stFreq, endFreq,
29         aSS, sSS, rSS, atSS, dtSS, stSS, rtSS, caSS, cdSS, crSS,
30         panFreq, panPhase;
31     var source, env, freq, x, y;
32     freq = XLine.kr(stFreq, endFreq, atSS+dtSS+stSS+rtSS);
33     source = SinOsc.ar(freq);
34     env = EnvGen.kr(Env.new(
35         levels: [0, aSS, sSS, rSS, 0], times: [atSS, dtSS, stSS, rtSS], curve: [caSS, cdSS, crSS]),
36         doneAction:2);
37     x = SinOsc.kr(panFreq, panPhase);
38     y = SinOsc.kr(panFreq, panPhase + 0.5pi);
39     Out.ar(outSS, Pan4.ar(source * env, x, y));
40 }).add;
41 SynthDef(\sineSweep2, {
42     arg outSS2, stFreq2, endFreq2,
43         aSS2, sSS2, rSS2, atSS2, dtSS2, stSS2, rtSS2, caSS2, cdSS2, crSS2,
44         panFreq2, panPhase2;
45     var source, env, freq, x, y;
46     freq = XLine.kr(stFreq2, endFreq2, atSS2+dtSS2+stSS2+rtSS2);
47     source = SinOsc.ar(freq);
48     env = EnvGen.kr(Env.new(
49         levels: [0, aSS2, sSS2, rSS2, 0], times: [atSS2, dtSS2, stSS2, rtSS2], curve: [caSS2, cdSS2,
   crSS2]),
50         doneAction:2);
51     x = SinOsc.kr(panFreq2, panPhase2);
52     y = SinOsc.kr(panFreq2, panPhase2 + 0.5pi);
53     Out.ar(outSS2, Pan4.ar(source * env, x, y));
54 }).add;
```

Figure A.2 : Defining reference tone generator synthesis units, code lines 7-54.

```
55 SynthDef(\sinePulse, {
56     arg outSP, stFreqSP, endFreqSP,
57         aSP, sSP, rSP, atSP, dtSP, stSP, rtSP, caSP, cdSP, crSP,
58         panFreqSP, panPhaseSP;
59     var source, env, freq, x, y;
60     freq = XLine.kr(stFreqSP, endFreqSP, atSP+dtSP+stSP+rtSP);
61     source = SinOsc.ar(freq);
62     env = EnvGen.kr(Env.new(
63         levels: [0, aSP, sSP, rSP, 0], times: [atSP, dtSP, stSP, rtSP], curve: [caSP, cdSP, crSP]),
64         doneAction:2);
65     Out.ar(outSP, Pan4.ar(source * env));
66 }).add;
67 SynthDef(\impulse, {
68     arg outIM, freqIM,
69         aIM, sIM, rIM, atIM, dtIM, stIM, rtIM, caIM, cdIM, crIM,
70         panFreqIM, panPhaseIM;
71     var source, env, x, y;
72     source = Impulse.ar(freqIM);
73     env = EnvGen.kr(Env.new(
74         levels: [0.1, aIM, sIM, rIM, 0.1], times:[atIM, dtIM, stIM, rtIM], curve: 'exp'), // [caIM,
   cdIM, crIM]
75         doneAction:2);
76     x = SinOsc.kr(panFreqIM, panPhaseIM);
77     y = SinOsc.kr(panFreqIM, panPhaseIM + 0.5pi);
78     Out.ar(outIM, Pan4.ar(source * env, x, y));
79 }).add;)
80
```

Figure A.2 : Defining reference tone generator synthesis units, code lines 55-80.

```
81 (Pbind(
82     \instrument, Prand(
83         [   "pinkNoise",   \rest, "whiteNoise",  \rest,
84             "sineSweep",   \rest, "sineSweep2",  \rest,
85             "impulse", "sinePulse",
86         ], inf).trace,
87     \outPN, Prand([0,3], inf), \outWN, Prand([0,1], inf), \outSS, Prand([0,1], inf), \outSS2, Prand([0,1], inf), \outIM, Prand([0,1], inf),
88     \dur, Pwhite(1.1),
89
90     \aPN, Pwhite(0, 0.7), \sPN, Pwhite(0, 0.5), \rPN, Pwhite(0, 0.5),                    // ASR Levels - WHITE NOISE
91     \atPN, Pwhite(0, 1), \dtPN, Pwhite(0, 2), \stPN, Pwhite(0, 3), \rtPN, Pwhite(0, 1),  // ADSR Times - 7 secs max
92     \caPN, Pwhite(-10, 10), \cdPN, Pwhite(-5, 5), \crPN, Pwhite(-5, 5),                  // ADR Curves
93
94     \aWN, Pwhite(0, 0.8), \sWN, Pwhite(0, 0.7), \rWN, Pwhite(0, 0.5),                    // ASR Levels - PINK NOISE
95     \atWN, Pwhite(0, 3), \dtWN, Pwhite(0, 4), \stWN, Pwhite(0, 3), \rtWN, Pwhite(0, 1),  // ADSR Times - 11 secs max
96     \caWN, Pwhite(-5, 5), \cdWN, Pwhite(-5, 5), \crWN, Pwhite(-5, 5),                    // ADR Curves
97
98     \stFreq, Pwhite(20, 20000), \endFreq, Plprand(20, 20000),                            // Range - SWEEP 1 - higher pitches
99     \aSS, Pwhite(0, 1), \sSS, Pwhite(0, 0.8), \rSS, Pwhite(0, 0.7),                      // ASR Levels
100    \atSS, Pwhite(0, 1), \dtSS, Pwhite(0, 3), \stSS, Pwhite(0, 3), \rtSS, Plprand(0, 3), // ADSR Times - 7 secs max
101    \caSS, Pwhite(-2, 12), \cdSS, Pwhite(-4, 8), \crSS, Pwhite(-3, 3),                   // ADR Curves
102    \panPhase, Pwhite(0, 2*pi), \panFreq, Pwhite(0.1, 1),                                //
103
104    \stFreq2, Pwhite(20, 2200), \endFreq2, Plprand(20, 2200),                            // Range - SWEEP 2 - lower pitches
105    \aSS2, Pwhite(0, 1), \sSS2, Pwhite(0.5, 1), \rSS2, Pwhite(0, 0.9),                   // ASR Levels
106    \atSS2, Pwhite(0, 2), \dtSS2, Pwhite(0, 4), \stSS2, Plprand(0, 4), \rtSS2, Plprand(0, 2), // ADSR Times - 9 secs max
107    \caSS2, Pwhite(-4, 12), \cdSS2, Pwhite(-4, 8), \crSS2, Pwhite(-3, 3),                // ADR Curves
108    \panPhase2, Pwhite(0, 2*pi), \panFreq2, Pwhite(0.1, 1),
109
110    \stFreqSP, Pwhite(20, 600), \endFreqSP, Plprand(20, 600),                            // Range - SWEEP PULSE
111    \aSP, Pwhite(0, 1), \sSP, Pwhite(0.5, 1), \rSP, Pwhite(0, 1),                       // ASR Levels
112    \atSP, Pwhite(0, 0.2), \dtSP, Pwhite(0.2, 0.6), \stSP, Plprand(0.3, 1), \rtSP, Plprand(1, 2), // ADSR Times - 4 secs max
113    \caSP, Pwhite(-1, 1), \cdSP, Pwhite(-8, 2), \crSP, Pwhite(-1, 1),                    // ADR Curves
114
115    \freqIM, Pwhite([600,10000], [600, 5000]),                                           // Range - IMPULSE
116    \aIM, Pwhite(0.1, 1), \sIM, Pwhite(0.5, 1), \rIM, Pwhite(0.1, 1),                    // ASR Levels
117    \atIM, Pwhite(0.1, 0.3), \dtIM, Pwhite(0.1, 2), \stIM, Pwhite(0.1, 1.2), \rtIM, Pwhite(0.1, 2), // ADSR Times - 4.5 secs max
118    \panPhaseIM, Pwhite(0, 2*pi), \panFreqIM, Pwhite(0, 0),                              //
119 ).play;)
```

Figure A.4 : Sequence playback system and control section for variable specifics.

Appendix B

CLSR is an installation artwork that emerges as a culmination of months worth of research on the relationship between sound and spatiality and two prior on-site experiments by Abdulfettah Salih Gaferoglu. It made its first complete public appearance on 27.10.2023 at the Macka Campus of Istanbul Technical University, second floor of the Foreign Languages Building's library hall. The installation artwork employed four strategically positioned loudspeakers and an algorithm that is developed by the artist. Although there wasn't a front-bias regarding the listening position, the sound system was arranged in a square formation, and oriented towards the center, reminiscent of a quadraphonic system. The algorithm centers four discrete reference tones as sonic material with a generative approach; pink noise, white noise, sine sweep, and an impulse signal. The initial character of each tone is programmed to be close as to their pure and original character as possible, but the real-time nature of CLSR's sound generation process redefines them stochastically in each iteration. Although it wasn't a site-specific work, the installation site had influences on this iterative process. Influenced by the mezzanine-like architectural design of the site, two decisions have the most significant impact on the sonic outcome; the durations of each sound event and their amplitudes when enveloped.

Appendix C

Functioning as both an empirical facet and an integral component of a broader exploration into sound and space studies, CLSR is an integral element of the artist's graduate thesis titled "Sonic Symbiosis: The Interplay of Sound and Space in Installation Art." Within the fourth chapter of this text, aptly named "Work", the installation is extensively dissected, shedding light on its conceptual underpinnings and contextualizing its place within the realm of contemporary sound art. While this chapter is essential to understand its underlying mechanics and facets considered in CLSR more closely, this statement prepared to rafine and briefly summarize the ideas that are discussed more extensively in the text at large.

Instead of attempting to suppress the inherent characteristics of a space, as is customary in room acoustics applications, CLSR fosters reimagining the relationship between sound and space by utilizing reference tones. These tones are used to determine how a site responds to a sound system, and then according to measurements that are made with them, applications are made to silence the character of a room by calling them potential causes for "deviations". The direction of "fixing the room" has its advantages, however CLSR aims not to mute the space but rather to accentuate its distinctive features. Therefore, by bringing reference tones in an excessively reverberant space, it fosters ways of thinking like including the character of a room in an artwork.

The usage of four channels is not coincidental and constitutes another layer of sophistication to CLSR. All loudspeakers are deliberately pointing towards a center point in the installation even though the installation itself does not have a planned or programmed "sweet spot" for listening. This is to add another layer of contrast to the work, because otherwise, this speaker orientation has to be calibrated to get the intended effect psychoacoustically. This intentional departure from the norm and treating the space and the sound reinforcement system instrumentally is not only eschews the need for calibration but adds a nuanced contrast, inviting the audience to engage with the sonic landscape around them in unexpected ways.

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