

Title	Ubiquitous Nuisance
Subtitle	A study on the effectiveness of soundwalk as a research tool to discover sources of urban noise in Singapore public parks.
	Dissertation by
Name in full	Koh Qing Wen, Ariel
Student ID	22302
Class	BADC6E
	Supervisor: Andreas Schlegel
	Presented to the Faculty of Design, School of Design Communication
	LASALLE COLLEGE OF THE ARTS
	in partial fulfilment of the requirement for the Bachelor of Arts with Honours in Design Communication.
	Singapore
	21 February 2023
	6279 words

Dedication

I dedicate this dissertation to my family, friends and lecturers, who've always supported and been there for me.

Acknowledgements

I am eternally grateful for the help and support of all the individuals who have shown a surprising and undeserving amount of enthusiasm and provided guidance throughout this dissertation project.

Abstract

In a world of constant distractions today, people tend to pay little attention to the soundscape of their environment. With the rapidly accelerating rate of societal growth, there is an increasing amount of man-made noises in the local soundscape. The effects of such urban noise harm the well-being of humans and animals living in the same environment. Urban sound pollution has become such a commonplace occurrence that humans have become desensitised to it. To increase public awareness of urban sound pollution and evoke a change in routine behaviours, this dissertation study reviewed ways in which the practice of soundwalks could be used to understand the effects of urban noises on the environment. Using the practice of soundwalk as the primary research method, field recordings from public parks in Singapore were collected and analysed in order to study the levels of urban noise pollution in local parks. The collected field recordings were used in the final prototype creations to achieve the intended outcome of raising awareness regarding the effect of human actions on the soundscapes of the local environment.

Table of Contents

Dedication	2
Acknowledgements	3
Abstract	4
Table of Contents	5
1.0 Introduction	6
Background	6
Research Objective	7
Literature Review	8
2.0 Approaches / Methods	12
Critical Journal Approach	12
Soundwalk	12
Prototyping	13
3.0 Discussion	15
Mixed Soundscapes Soundwalk	15
Public Parks Soundwalk	17
Experiments	18
Ideation	24
Prototypes	26
4.0 Notes for Further Research	31
5.0 Conclusion	32
6.0 References	33
Appendix A	36
Reading resources	36
Mind Maps	36
Field Recording Device	36
Appendix B	37
Mixed Soundscapes Soundwalk	37
Public Parks Soundwalk	38
Appendix C	40
Sound and Shape Experiment	40
Electric Paint Sensor Experiment	42
Conductive Sensor Experiment	42
P5.js Sound Generative Graphics Experiment	42
TouchDesigner Sound Generative Graphics Experiment	43
Appendix D	45
Play Kit Set Prototype	45
Textile Noise Maker	45
Moss Carpet Prototype	45

1.0 Introduction

Background

Amidst the relentless onward rush of modern society, urban noises have become increasingly erratic. People hear less of natural soundscapes due to the increase in artificial noises caused by an overly heavy reliance on machines (Franinović and Serafin 7). This trend has resulted in a soundscape with overcrowded signals, making it difficult for people to focus and relax because of noise pollution (Franinović and Serafin 8). Noise pollution, also known as environmental noise or sound pollution, harms both animals and humans who share the same environment. Today, urban noises have overwhelmed the natural soundscape in Singapore. Instead of natural animal sounds like birdsong and insect chirps, urban noises populate the natural soundscape of Singapore's local parks. This situation runs counter to the original intent of having these places for families and people to relax and take a break from Singapore's busy lifestyle, as the parks get polluted by noise caused by various modes of transportation and construction sites in the area.

A study conducted by Saurabh Garg, Kian Meng Lim, and Heow Pueh Lee from the Department of Mechanical Engineering, National University of Singapore in 2018¹ studied the effectiveness of smartphones as a platform for recording environmental noises. The authors built a mobile application 'NoiseExplorer' that measured the sound level of a location. Two case studies were conducted to evaluate the success of the application. The first study compared noise levels in five polytechnic institutes, while the second study compared noise levels in five residential neighbourhoods in Singapore. Based on the first study, the major source of noise in all five polytechnics were canteens and other areas where many students tended to gather. In particular, polytechnics near prominent areas of traffic, such as Singapore Polytechnic and Ngee Ann Polytechnic, reflected the highest levels of environmental noise. For all five neighbourhoods, the major source of noise pollution was identified to be from traffic flow. High traffic flow and a major trunk road resulted in the Jurong West neighbourhood being the noisiest, while the Chai Chee neighbourhood was quietest because of its distance from the main roads. Extrapolating from these research efforts, it would be valuable to explore the effective utility of soundwalks as a means of collecting firsthand information about urban noises found in

¹ A case study of a smartphone based platform for mapping and analyzing environmental noise in Singapore (Garg et al.)

Singapore's parks.² As one moves throughout space, they will understand, remember, and relearn the sounds they might have missed about the environment (Schine). Since everyday activities and lifestyle decisions heavily influence the amount of urban noise generated, this study has identified soundwalk to be a potential tool to support change, through enabling, motivating or discouraging certain practices that affect the soundscape in Singapore. To disrupt deep-rooted unmindful consumption tendencies about the effect of sound pollution, this study posits approaches in which public awareness of urban noise can be increased.

Research Objective

Given humans' continuous engagement with their environmental soundscape, each and every interaction which generates sounds would exacerbate noise pollution and emphasise the impact of such sounds. In light of the inescapable presence of sound in day-to-day living, this paper explores the explicit use of soundwalk as a strategy to promote behavioural changes in the way we treat and care for the sonic quality of our environment. The soundwalk practice is used as an important tool to understand the condition of the soundscape and as a way to assess if the quality of the soundscape is good enough for people and animal species living in the same space.

While the concept of noise pollution might be familiar to most, efforts to reduce the effects of noise pollution in Singapore remain lacking. While soundwalk is a familiar and more commonly used practice overseas, it is still considered as a foreign and underutilised tool in Singapore. Soundwalks provide essential opportunities to increase one's engagement with the soundscape of local spaces. When purposefully used and designed, soundwalks can meaningfully challenge current patterns of thinking and encourage self-discovery of unnoticed background sounds, which is especially pertinent for residents in Singapore who tend to be oblivious to hearing the natural soundscape due to the hustle and bustle of their busy city lives. In this context, this dissertation examined how the practice of soundwalk could be strategically employed to stimulate attitudinal and behavioural changes, so practitioners could be more mindful of their actions, given the hypothesis that the soundwalk practice could highlight the issue of urban noise pollution through personal, experiential engagement.

² Soundwalk is an autobiographical tool for exploring the environment with the intention of active listening (Schine).

Acoustic ecology and soundwalk studies were used to understand the social aspects and impact of urban noise. The primary goal was to help people understand the negative effects of noise pollution and motivate them to take steps to address this issue. To that end, soundwalks in Singapore's public parks were conducted to learn more about the urban noises found within these soundscapes; these included parks near residential areas as well as parks that were more secluded to understand and compare location-based differences. The information gathered through the research process helped inform subsequent choices in creating the final design artefact. This artefact comprised various collected soundscape recordings that were intended to increase awareness of urban noise pollution and to inspire people to imagine what the future might sound like if urban noise issues were given the attention they deserved. This process was guided by the following research questions:

- 1) Is the increased use of portable acoustic devices such as smartphones and media players an attempt to create our own personal soundscape because we have no control over outside urban noises?
- 2) What are the conditions under which urban noise is more than just a nuisance, but a clue to understanding our environment?

Literature Review

Existing literature on sound studies have studied pervasive emphasis on the effects of noise pollution. Following those findings, this paper summarises the key issues and challenges of soundscape management in cities and how noise pollution can affect the mental health of people and the well-being of animal species. With new insights from previous comprehensive reviews of soundscape design, along with several key themes and concepts from seminal readings, particularly relevant topics such as multimodal listening, the concept of soundscape design, the action of soundwalk, and the impact of urban noises on our environment were surfaced for this research project. In light of these focus areas, this research project explored different perspectives on the definition of urban noises, as well as the utility of the soundwalk as a tool to understand soundscapes. For the final design artefact, it was important to have considered multimodal listening theories and how they could create an informative and engaging listening experience, along with different writers' use of new concepts to improve our environment, particularly the different views on the definition of soundscape and soundwalk studies.

What is multimodal listening

With regard to the concept of multimodal listening, the author of 'Playing with Sound: A Theory of Interacting with Sound and Music in Video Games', Karen Collins, postulated three basic listening modes for listening.

The first mode is listening casually, which is the act of focusing on the sound. The second mode is semantic listening, which is the ability to listen and interpret the meanings of sounds (Collins 4). This mode of listening finds the characteristics of the sound and what makes it unique. Collins views the act of listening as not just hearing, but also as a way in which we consciously respond and attend to sound (Collins 4). Jean-François Augoyard and Henri Torgue, who wrote the book 'Sonic Experience: A Guide to Everyday Sounds', also mentioned a similar process to everyday sound interaction within the context of physiological processes. The sound of marking inhabited or frequented space, sound encoding of interpersonal relations, symbolic meaning and value is said to be linked to everyday sound perceptions and interaction between heard sound and produced sounds (Augoyard et al. 8). These processes provide a space for human communication and the management of the environment and soundscape. These spaces can then help to create a sense of connectedness and solidarity, and help to improve the quality of lives (Augoyard and Torgue 8). Steph Ceraso, the author of 'Sounding Composition: Multimodal Pedagogies for Embodied Listening', viewed multimodal listening as a different process from the normal approach of listening, where the focus is to hear and interpret sound. To Ceraso, multimodal listening is focused on multiple senses, which means that the listener can hear, see, and feel the audio or video content. With this understanding of multimodal listening as a practice of taking in and seeking sensory, contextual, and material aspects of sound, one could gain a better understanding of the world around them (Ceraso 6), and allowing for different types of listening would give them a more complete understanding of sound. Put differently, multimodal listening enables listeners to understand how their bodily experiences in specific contexts are shaped by sound. Multimodal listening echoes the way we process information in digital environments. It is a practice that is aligned with the ways we have been developing through interacting with computers and mobile devices (Ceraso 6). The objective of this multimodal listening practice relies heavily on the conscious, heightened awareness of the body, to help people learn to focus on how various senses interact and use their multisensory senses to help create unique personal embodied experiences with the environment (Ceraso 7).

Soundscape studies

R. Murray Schafer, author of the book 'The Soundscape: Our Sonic Environment and the Tuning of the World', popularised the term 'soundscape'. Initially coined by Schafer in the 1960s for his World Soundscape Project, this word was used to describe the relationship between humans and the sonic environment (Ceraso 21). The intent of the original project is aligned to that of this research study, which was to raise awareness of the issue of noise pollution and its effect on the environment. Schafer was unhappy with how the Vancouver soundscape was developing rapidly because of the advancement of society and the increasing reliance on

technology and machinery ("The World Soundscape Project"). With the support from a group of young composers and students studying music education and The Donner Canadian Foundation, Schafer managed to establish the World Soundscape Project, which allowed people to understand the overall tone and feel of a scene or environment ("The World Soundscape Project"). The benefit of soundscape studies is also supported by Kay S. Voigt and Alex U. Case, authors of the book 'Exploring Our Sonic Environment Through Soundscape Research & Theory'. Voigt and Case argued that understanding the sounds of the urban environment would help us better understand how the impact of sound on people and animals living in the same space, and through this process, people could create connections and find meaning in the sounds found in the environment (Brooks et al. 30). By using soundscape studies, urban noises can be evaluated to make sure that every living species sharing and living in the same environment is treated fairly (Brooks et al. 30), and the results of the studies could contribute to better inform further decisions in tackling the issue of noise pollution.

The action of soundwalk

Marcia Jenneth Epstein and Arline Bronzaft, authors of the book 'Sound and Noise: A Listener's Guide to Everyday Life', claimed that sound research has moved beyond the acoustic realm, and now includes systems from acoustic ecology. Soundwalks are a commonly used method to bring attention and awareness to the well-being of our environment (Epstein 43). Schafer recommended "soundwalk" as a method to help identify and describe a specific soundscape of a location (Franinović and Serafin 128). Multiple researchers have highlighted soundwalks as a tool to better understand how sound affects people and the world around them. In the article 'Soundwalking as a methodology for understanding soundscapes' written for the Institute of Acoustics by Mags Adams, Neil Bruce, William J Davies, Rebecca Cain, and Paul Jennings, the writers raised different interpretations of the methodology of soundwalks. Nevertheless, the act of conducting soundwalks was able to help researchers immerse themselves into the soundscape of an environment and presented a way for people to listen to unnoticed sounds (Adams et al.). This dissertation research study took reference from the approach suggested by Jennifer Schine, the author of the paper 'Movement, Memory & The Senses In Soundscape Studies', in which soundwalk is taken to be an activity where one explores the sounds of the environment. The soundwalk practice would be one that makes the participant walk through the environment with the active intention of finding and hearing sounds they would typically miss because of being distracted by the overcrowded mixed signals from noise pollution (Schine).

The impact of urban noises on our environment

In general, people prefer smaller, quieter, and less noisy soundscapes when trying to relax. Unfortunately, there are instances where places of relaxation are filled with urban noises which tend to be disturbing and distracting. For example, many public parks in Singapore are affected by noise pollution because they are located near busy roads. Todd Anderson-Kunert and Alison Baker, the authors of the journal 'Journeys in and Through Sound', claimed that the act of listening could help us create a personal auditory space where one can feel more in control (Baker and Kunert 14). The authors of the book 'Ecoacoustics: The Ecological Role of Sounds', Almo Farina and Stuart H. Gage, also mentioned that it was very important that we maintained the well-being of societies and the environment. To do so, the effects of human-generated noise pollution because of the advances of technology in our society have to be mitigated such that the chance of hearing natural ambient sounds that are not artificial could be increased again (Gage and Farina 24). Saurabh Garg, Kian Meng Lim and Heow Pueh Lee, the authors of the journal article 'A case study of smartphone-based platform for mapping and analysing environmental noise in Singapore', conducted a study on the use of smartphone devices for mapping and analysing urban noises in Singapore. The authors described how noise maps could be a useful tool to analyse and compare the sonic quality between different places (Gage and Farina 1). They created an Android application known as 'NoiseExplorer' to measure the sound levels in various locations, and the audio data collected from the application was used to generate noise maps for their research paper (Gage and Farina 1).

2.0 Approaches / Methods

Research was conducted using two methods: Critical Journal as the main framework, together with the practice of soundwalk as a primary research method to collect field recordings to support the research process. In order to achieve the design outcomes for the artefacts, prototyping and user testing were included in the process.

Critical Journal Approach

The main framework for this research study was the Critical Journal approach.³ Having conducted a series of experiments and prototypes before creating the design outcomes, the critical journal approach was a suitable framework to keep documentation of the different stages of the project's progress, including studio work and soundwalk studies.

Soundwalk

The practice of soundwalks was used as the primary research method to collect information to support this project's investigation of urban noise found in public parks located in Singapore. Soundwalking is a practice in which users listen and discover clues about the quality of the soundscape in their local environments. The environment sounds or noises collected during the soundwalk help the researcher make critical judgments about the sounds heard, for example, to identify if these sounds were useful or harmful to the sonic quality of the environment (Soundwalk). The soundwalk practice facilitated an empirical way of studying the soundscape of Singapore's public parks, which was helpful when reflecting on the collected soundwalk field recordings to analyse the amount of urban noise pollution.

³ Critical journaling is a way of making the connection between a design activity or project with research. This framework of the journaling approach emphasises the importance of the chronological recording of the research journey, self and peer critique such as reflection and user testing for experiments and prototypes for the final design outcome (Conference and Sadokierski 4). The critical journal approach provides a structure for documentation towards a final design outcome (Conference and Sadokierski 4).

Prototyping

The objective of building a prototype is to test ideas and concepts before the creation of digital or physical artefacts. Prototyping is a process which helps designers brainstorm and experiment with their ideas so that they can bring design concepts to life. This method involves making a low-fidelity sample of a designed artefact to help the designer visualise or interact with it before developing a final version (20 et al.).

The diagram shows the timeframe to create, test and iterate on prototypes in the Human-Centered Design (HCD) process (see Fig. 1).

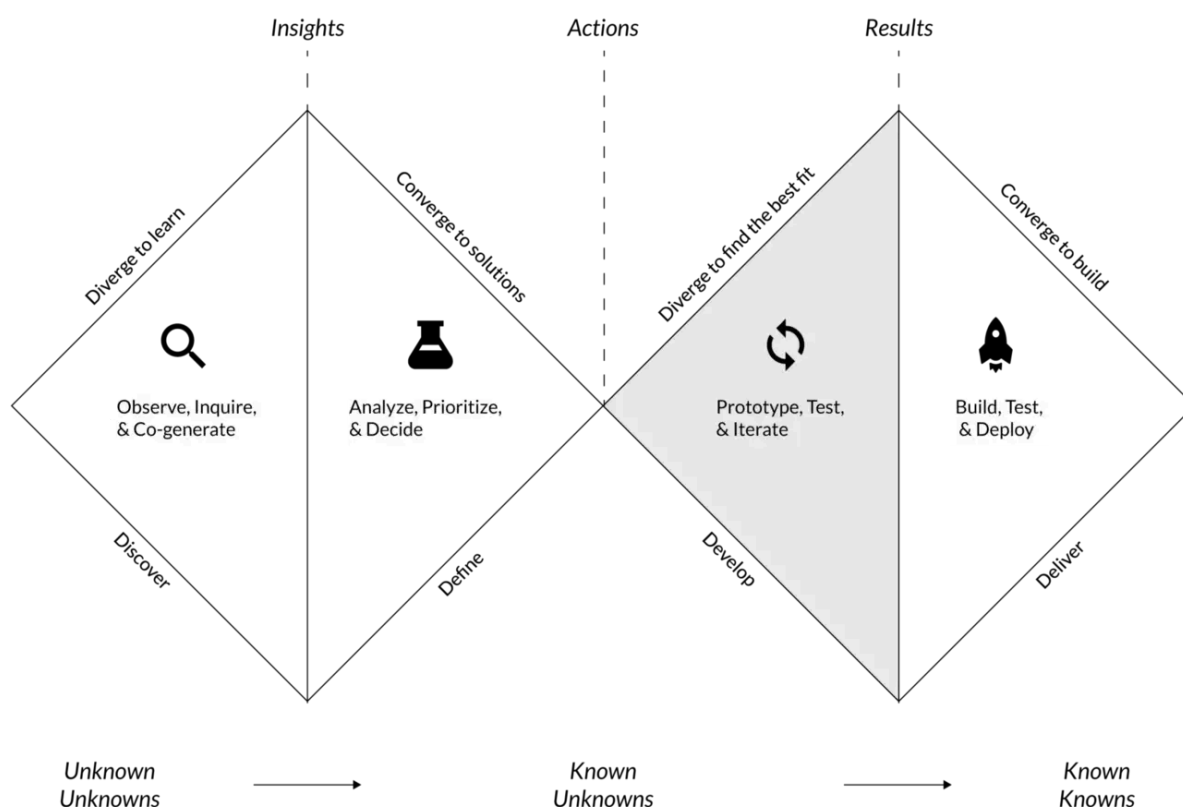


Fig.1. HCD double diamond process.

Low-Fidelity Prototyping

A combination of mind mapping, sketching and paper prototypes was used for this process. The low-fidelity prototyping approach was useful to break the prototyping process into smaller steps so that the testing of ideas would not become overwhelming because low-fidelity prototypes are used to test board concepts instead of the fine details (Dam and Siang). Using the methods of mapping and sketching in conjunction with paper prototyping, this project achieved a well-rounded exploration of the visual artefacts derived from research.

High-Fidelity Prototyping

Following low-fidelity prototypes, high-fidelity prototypes are prototypes made to be as similar as possible to the actual artefact. With a clear, solid understanding of the purpose of the artefact, the high-fidelity prototype creation process commenced. Then these high-fidelity prototypes underwent several rounds of user testing in a process of refinement to produce the final design artefact. Early prototypes were refined to produce high-fidelity prototypes by utilising Arduino and Bare Conductive to create touch sensors that were central to the final experience of the artefact. TouchDesigner was used to create interactivity for the audience, and the punch needle technique for fabric sensors and the hiding of electric components.

3.0 Discussion

Mixed Soundscapes Soundwalk

In this primary phase of the design thinking process, the practice of soundwalk was used to guide ideation. In utilising soundwalks, this research queries how they can serve as an important tool to increase people's awareness of the soundscape of their local environment. Soundwalks were conducted at different locations in Singapore and required field recordings were collected accordingly. The analysis of the field recordings revealed that the initial recording originated from too many different soundscapes to provide a clear analysis of the recordings, which also could not be circumvented by organising the locations by human traffic flow. A completely fair comparison could not be achieved given the multiple differing variables at each location. To listen to all the soundwalk recordings, refer to appendix B. A description of each location's soundwalk has been detailed below, in chronological order.

Pasir Ris Coastal Park 01

The recording quality at Pasir Ris Coastal Park was not good because it was very windy and also a first attempt at conducting soundwalks. Places such as the mangrove and the playground at the park were included in this soundwalk. The recording of children playing at the playground surfaced the familiar sounds of children's laughter, which felt comforting after the disquieting nature of empty playgrounds during the previous period of pandemic restrictions. This revealed that playgrounds would not exist purposefully without children engaging in activities there, because the location would have lost its original design purpose.

Pasir Ris Coastal Park 02

The second recording at Pasir Ris Coastal Park successfully yielded audio recordings of birds, bicycles, and people talking and walking and playing music. One of the recordings included sounds from vehicles as some parts of the park were located near a road. The second visit to the mangrove forest at Pasir Ris Coastal Park included a recording of people playing music at loud volumes with their speakers, which masked the natural sounds of birds. Public parks in Singapore should be treated as a place of relaxation but man-made noises generated from human actions and unavoidable construction noise masked the pleasing natural sounds. In addition, the park was very crowded on the weekend where the recording was made. There were many children playing at the playgrounds with their families. The increase in visitors affected the soundscape of the environment and were reflected in the field recordings. The recordings highlighted the impact of human actions, especially in the case of music being played aloud, and was a good reminder for the importance of

being considerate for others. Just being mindful about one's surroundings and playing music at a lower volume, or even using headphones or earphones would be one small step in improving the soundscape quality of our local space, to the benefit of others as well as the different animal species living in the same space.

Chinatown

The soundwalk was conducted at different parts of Chinatown, which included the street market, wet market, and a gathering place with tables and chairs designed for people to play traditional Chinese board games, for instance, 'Xiangqi' (Chinese chess). The recordings revealed an interesting overlap of voices and background noise stemming from people talking and selling their items. Upon removing the familiar background music, the place would no longer be easily identifiable as the Chinatown area. It was particularly intriguing that the players gathered around and seated at tables attempting to play the complex Chinese chess game could concentrate on making their strategic moves with so many spectators and a noisy soundscape near the market area.

Singapore Botanical Gardens

The recordings from the Singapore Botanical Gardens included sounds from people doing their activities and the chirping of birds within the same space. Besides the naturally-generated sounds, there was also audio of a moving vehicle in the background, which impacted the tranquillity of the entire soundscape. The sound of the vehicle arose from the staff's use of a buggy or tram-like vehicle to traverse the large park landscape quickly, but with the unintended consequence of creating urban noise. This example reflects the pervasiveness of urban noises: even in spaces where people are supposed to be free and able to relax, urban noises remain unavoidable because we are so heavily reliant on machinery. The soundscape of this location sounded pleasant in the secluded areas, but that differed for areas near the main road, because of the presence of loud vehicles moving and machine noises. Notable example locations include the staff-only workshop space hidden away from the visitors, and the loud music playing at the nearby cafe.

It was challenging to analyse the collected field recordings in a comparable manner given the insufficient parameters set in the soundwalk methodology, and the difficulty in ensuring consistent numbers of visitors across locations

Public Parks Soundwalk

With different variables at play, it was complicated to analyse the recordings. As such, the project continued with a focus specifically on parks that are near residential areas and parks that are more secluded. This approach arose from a comparison of the recordings collected from Pasir Ris Coastal Park and Singapore Botanical Gardens, where it was revealed that the soundscape at the Singapore Botanical Gardens was a lot quieter because there were no major residential areas located near it, in comparison to Pasir Ris Coastal Park which was surrounded by residential areas. To listen to all the soundwalk recordings, refer to appendix B.

Tampines Park

There were several collected recordings of Tampines Park at different timings, including the afternoon and evening hours on the weekend. As the park is located right in the middle of several residential blocks and a carpark and road surrounds the entire park, urban noises would come from all possible directions. The recordings included noises coming from the unseen grass-cutting machine from far away and heavy vehicle sounds masking the birds' sounds in the background. While the afternoon session had few visitors because it was the lunch period, the evening timing had a lot more visitors as many families brought their children and dogs to the park to hang out and play at the playground. It was harder to hear the natural soundscape because of the increase in human traffic flow.

Pasir Ris Coastal Park

Similar soundwalk investigations were performed at Pasir Ris Coastal Park on the weekdays during the morning and evening. There were few people compared to the previous soundwalk conducted on a weekend at the same location. During the morning timing, a few adults were doing their workouts and a couple of preschool children were playing at the nearby playground. The areas of the park near the residential areas and main road had more urban noise compared to areas such as the mangrove forest, which is located further from the residential area and road traffic. The evening timing had more children playing at the playground and more signs of urban noise coming from the construction sites and vehicles because it was the peak hour when everyone was returning home from work.

The photos below show the waveform of two audio recordings. Based on the readings from Adobe Audition, the soundscape of Tampines Park is much noisier compared to Pasir Ris Coastal Park (see Fig. 2-3).

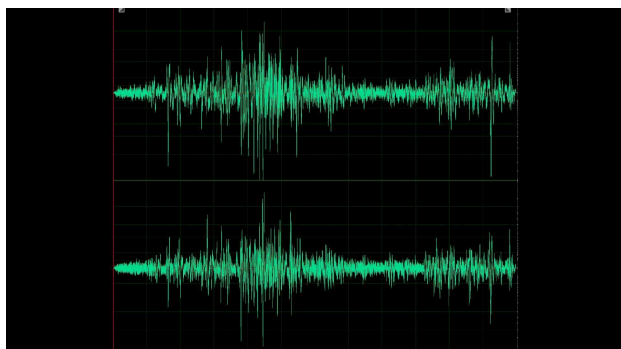


Fig. 2. Recording of grass-cutting from Tampines Park.

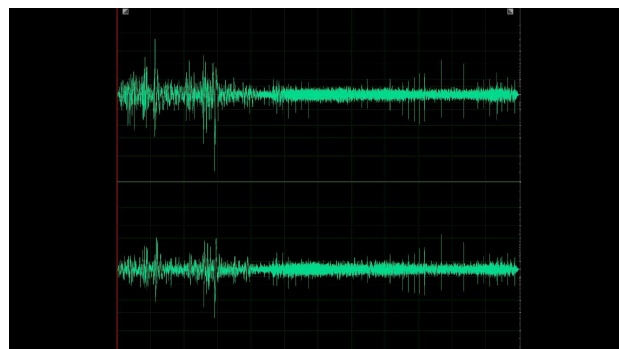


Fig. 3. Recording of construction and birds from Pasir Ris Coastal Park.

The soundwalk practice has been a useful tool to understand more about the local parks in Singapore. Researchers, such as Adams, Mags, et al., who authored the article ‘Soundwalking as a methodology for understanding soundscapes’, claim that the act of conducting soundwalks is useful because it helps the researcher to immerse themselves into the soundscape of an environment. The practitioners of the soundwalk methodology can also benefit from such a practice because they can engage and listen to unnoticed sounds that are often ignored or masked by sound pollution.

The various forms of urban noise pollution collected from the abovementioned soundwalks were then used to produce the design outcomes. Based on the recordings, the parks near residential areas reflected more sources of noise pollution. Essentially, places of relaxation, such as parks, had been supplanted by many sources of urban noise because of human activity and actions, and the consequences ended up going against the original design intentions for these parks. Using the field recordings collected, the design outcomes and prototype generated would hopefully bring more awareness to this problem.

Experiments

Sound and Shape Experiment

It was my curiosity that led me to investigate how different spaces would affect sound. This experiment determines if structures or building materials can mask urban noise. My experiment was not accurate because of the variety of materials I used to construct the structures. The triangles and cubes were constructed with foam, while the other shapes were constructed with cardboard. Since foam shapes are the

most consistent, they were used to reach my conclusion. According to Adobe Audition, the small triangle has the loudest volume, while the big triangle shape has the softest volume. As urban noise will have to travel a greater distance, it is likely that a more open space will mask it better. The recordings for this experiment can be listened to in Appendix C. Each shape is accompanied by an audio reading extracted from Adobe Audition.

Structures made from foam and cardboard for this experiment (see fig. 4).

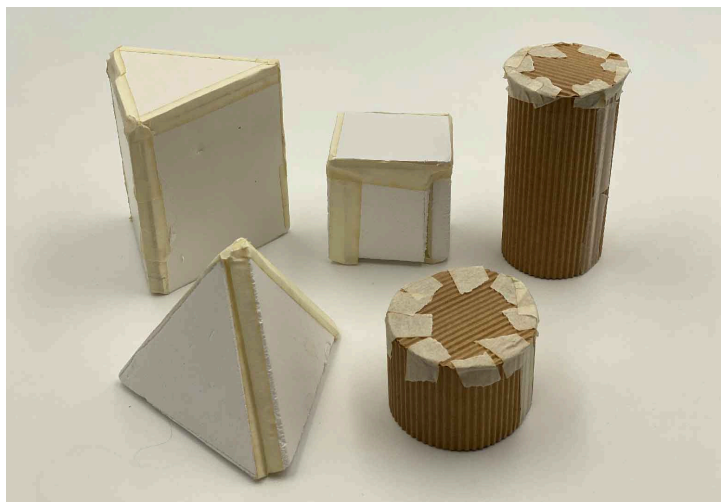


Fig. 4. Different shape structures.

The big triangle shape gives the lowest audio output based on the reading from Adobe Audition (see fig. 5-8).



Fig. 5. Big triangle shape.

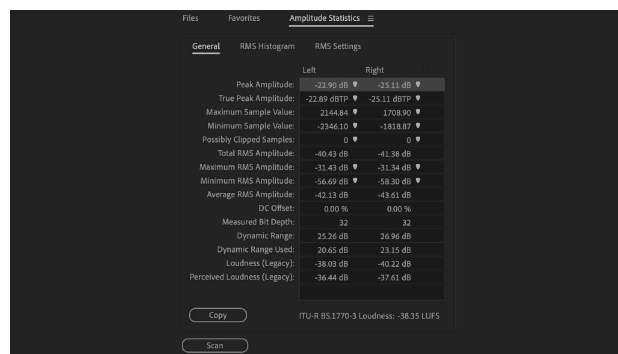


Fig. 6. Big triangle audio reading.



Fig. 7. Small triangle shape.

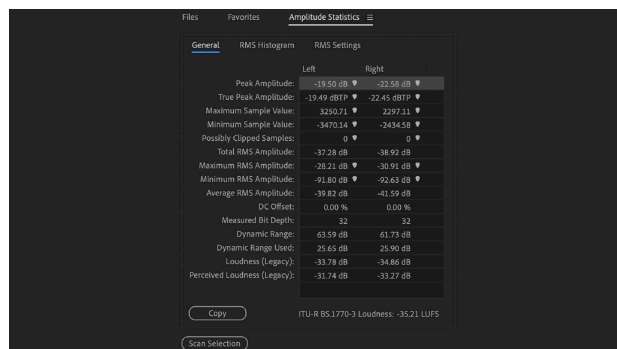


Fig. 8. Small triangle audio reading.

Electric Paint Sensor Experiment

By creating a physical artefact, I could visualise my design outcomes more clearly. Bare Conductive's user-friendliness piqued my interest in the platform. Through my research, I discovered a product called Touch Board made by Bare Conductive, which is an excellent complement to their electric paint. It is equipped with 12 capacitive touch electrodes that can transform different materials and surfaces into interactive sensors. As part of this experiment, I created sensors for playing my field recordings using electric paint. As soon as I tried this approach, I realised that the water-soluble nature of the electric paint made the sensors less durable since the paint would rub off when you pressed on them, resulting in short circuits. Refer to appendix C for a video that illustrates the results of this experiment.

Alligator cables connecting the painted sensors to the touch board (see fig. 9).

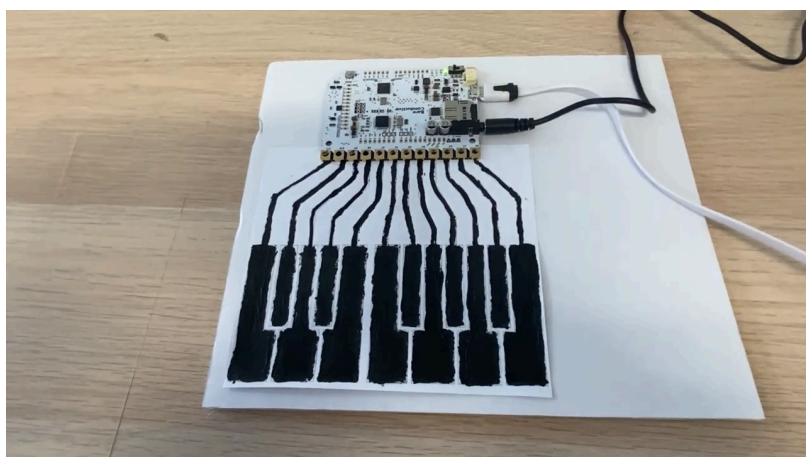


Fig.9. Electric paint sensor experiment.

Conductive Sensor Experiment

As a result of the failure of the previous experiment, I attempted a different method of creating sensors from aluminium foil tape. The Aluminium foil tape was cut into 12 rectangles to serve as sensors, and alligator cables were used to connect the sensors to the touch board. It was determined from the experiment that the conductive sensors worked better because they did not require me to paint the surface with electric paint evenly. Refer to appendix C for a video that illustrates the results of this experiment.

Alligator cables connecting the painted sensors to the touch board (see fig. 10).

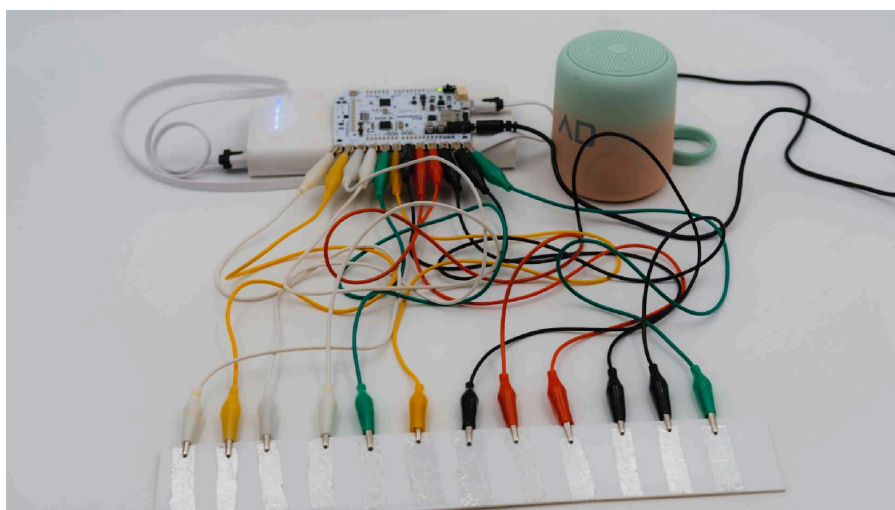


Fig.10. Conductive sensor experiment.

P5.js Sound Generative Graphics Experiment

Using the p5.js platform, I made three experiments using different techniques to generate sound-generative visuals. The concept behind this experiment was that the more urban noises that were found, the more distorted the visuals would be. In the first experiment, oscillators were used in the code to generate a tone. By mixing in my audio file, I attempted to edit the code to modify the audio file by changing the number of oscillators through the 'mousePressed' action. As part of the second experiment, I attempted to produce pixel image distortion for my park photo, but I was unable to do so audio-reactively. The last experiment involved creating an audio-reactive circular pattern with angular lines that produced spider web-like visuals. Refer to appendix C for the experiment results. A link is provided for each p5.js sketch.

Sound reactive graphics produced in p5.js (see fig. 11-12).

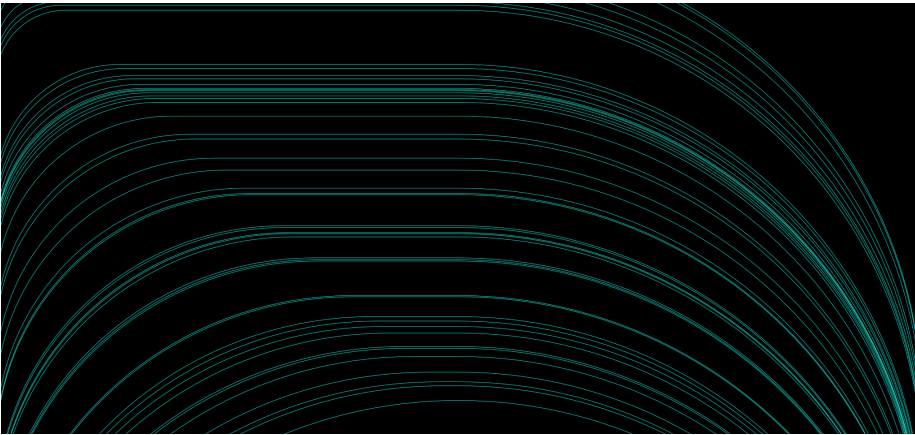


Fig.11. Experiment 01.



Fig.12. Experiment 02.

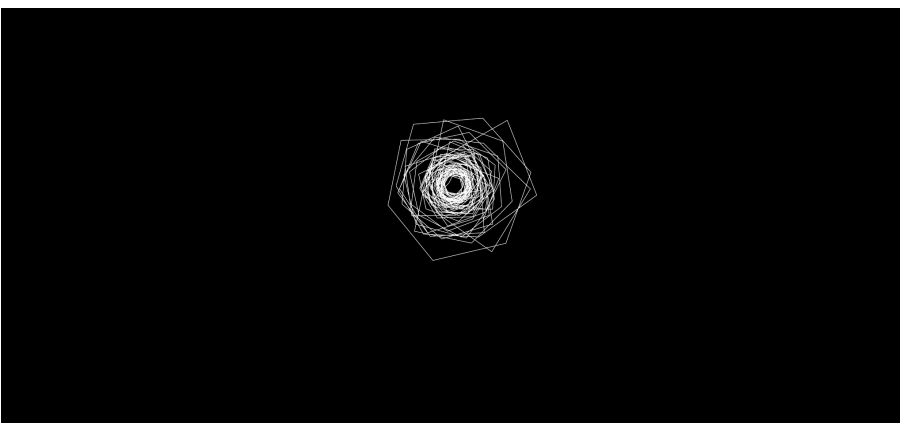


Fig.13. Experiment 03.

TouchDesigner Sound Generative Graphics Experiment

This experiment aimed at distorting park images according to the amount of noise pollution generated by my field recordings. Initially, I tried p5.js, but I did not get the results I wanted. I then tried TouchDesigner, a node-based visual programming language for interactive multimedia content. I used an audio recording of grass-cutting and a park photo taken during my visit to Tampines Park for the experiment. Despite the graphics reacting to the audio file, the result is not visually appealing. While I liked the audio generative effects, when paired with a photo, they don't look obvious enough. I will need to explore and experiment more. For more information on the results of the experiment, refer to appendix C.

I produced two variations of the experiment in TouchDesigner (see fig. 14-17).

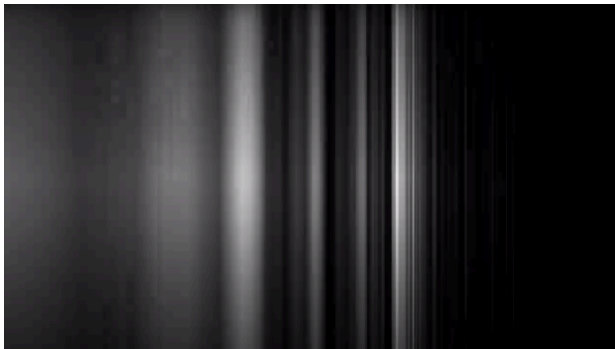


Fig.14. Generative graphics version 01.



Fig.15. Final composition version 01.

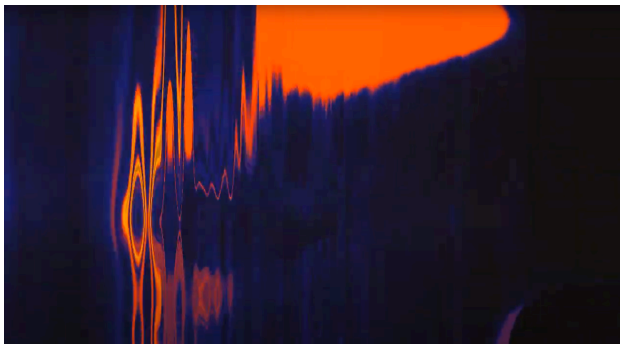


Fig.16. Audio generative graphics version 02.

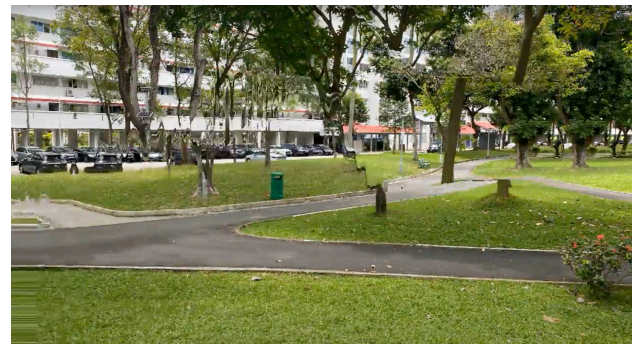


Fig.17. Final composition version 02.

Ideation

Cymatics Ideation

Cymatics is the study of visible sound and vibration, which is a subset of modal phenomena (“What is Cymatics? Science of Visible Sound Explained”). It was my intention to use a mini-projector that will be placed below a tray of water and my speakers will be located in between. Akira Okamoto's project inspired me to use this method. In his project, Okamoto visualised sound by shining a bright light through water in order to display patterns created by the vibrations caused by the speakers. Similar to my previous experiments, I thought this might be an effective means of representing noise pollution. The projected image should be distorted in accordance with how much urban noise my field recordings have. Based on the feedback received, this approach is too costly and has a greater chance of failure, so I should utilise code rather than this approach, as I will have greater control over the image distortion process.

Visualise Sound is the inspiration for the Cymatics concept (see fig. 18-19).



Fig.18. Visualise Sound by Akira Okamoto.

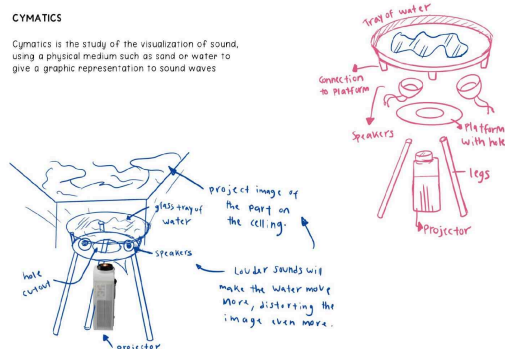


Fig.19. Cymatics artefact sketch.

Newton's Cradle Ideation

Newton's Cradle illustrates the conservation of momentum and energy when swinging spheres are lifted and released (Schulz). The 'Gift of the Gab: Interactive Sculpture' created by Xavier Sole Mora inspired this idea. The artist uses parrot candy head dispensers to create an artefact that has the parrot heads moving up and down while you listen to bird sounds. Instead of bird sounds, I thought it would be interesting to listen to man-made noises from a natural soundscape or animal. The metal spheres in my sketch were designed in a bird-like shape. As the balls swing, the sound that is playing will change as they contact each other. The feedback received indicated that this concept lacks interactivity because the audience will not be able to select which field recording will be played.

Visualise Sound is the inspiration for the Cymatics concept (see fig. 20-21).



Fig.20. Gift of the Gab: Interactive Sculpture by Xavier Sole Mora.

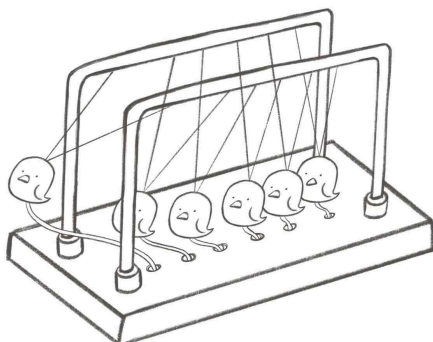


Fig.21. Newton's cradle birds artefact Sketch.

Prototypes

Play Kit Set Prototype

Initially, I envisioned a visual representation of Singapore's public park. In order to serve as sensors for the touch board, the birds and trees would be 3D printed with conductive material. The idea gradually evolved into a play kit set to help children become aware of the effects of noise pollution. It was the design intention to use the entire packaging to create a park background, and when a child touches any of the conductive models, urban noises will be played to illustrate how noise pollution affects a natural soundscape. Due to my lack of experience in 3D modelling, Blender's paper model export feature failed to work well for me. Therefore, I made a paper model of a tree and bird based on a template I found online. Conductive paint was applied to the models, and alligator cables were used to connect the models to the touch board. After completing the prototype, I was unsure whether children should still be my target audience, as I am not confident they will comprehend why the bird models are playing urban noises instead of the usual bird sounds. Additionally, I will have to consider how to conceal the cables and electronics. As a novice 3D printer user, it was difficult for me to understand how to produce the models in conductive materials since most 3D printers use ABS filament, which is not conductive. Refer to appendix D for a video that illustrates the results of this prototype.

Ideation sketches and prototype setup for the play kit set (see fig. 22-27).

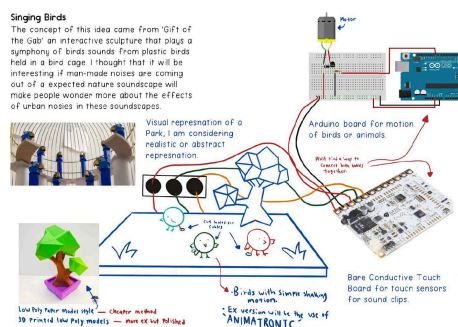


Fig.22. First idea for the prototype.

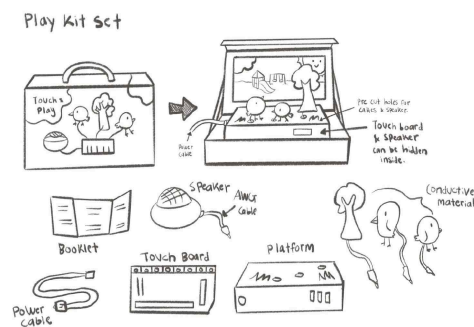


Fig.23. Play kit set artefact sketch.

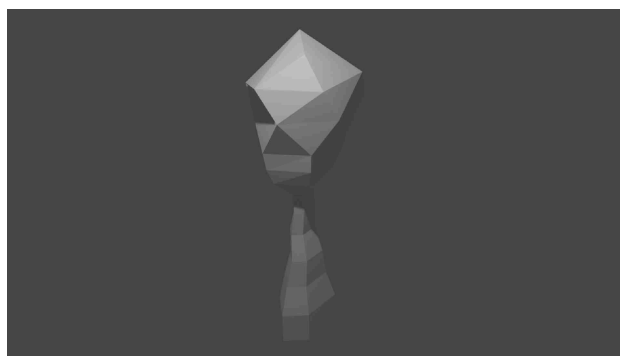


Fig.24. 3D tree model version 01.

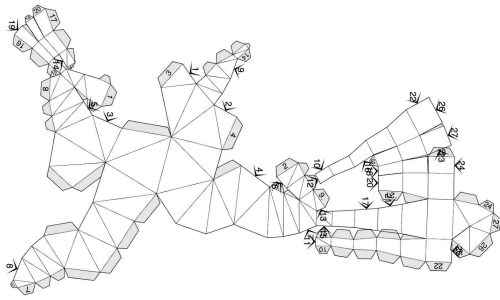


Fig.25. 3D tree model version 02.

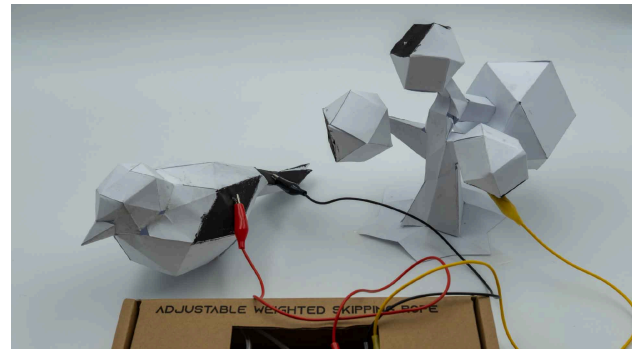


Fig.26. Exported paper template from Blender.

Fig.27. Play kit set prototype.

Textile Noise Maker Prototype

The original intention of this prototype was to create a noisy soundscape by mixing white and pink noises in an artefact. Combining white and pink noises was interesting to me since both noises are supposed to distract you from noise in the environment, but when combined will create unease since the frequencies of these noises are different. According to the feedback received, the artefact design was viewed as too common. Several amendments were made, and I presented a textile noise maker that produced noise by rubbing against the cube's various textures. At first, I was considering rigging a robotic arm to scratch the various surfaces, but I thought it would be too much and decided that a manual approach would be more effective. I had to experiment with several textures for this prototype. Sandpaper is my favourite texture, as it causes the most uneasy sensation when rubbing against it. As a result of the feedback I received, the prototype needed to be connected to the research topic because the noise maker did not adequately represent noise pollution, and I was advised to make use of the Arduino Piezo buzzer as a vibration sensor for the textile noise maker. A graph will be generated when Arduino is connected. I intend to use the graph's data to create data visualisations in TouchDesigner. To see the prototype outcomes, refer to appendix D.

Ideation sketches for textile noise maker (see fig. 28-33).

Noise Maker

Sound synthesizer that allows you to adjust the amount of white and pink noise, the concept is that white and pink noise do not match so the artefact uses the disconnection between the two noises to create a uncomfortable and noisy soundscape for the listeners.

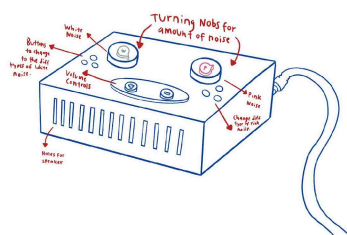


Fig.28. Noise maker artefact Sketch 01.

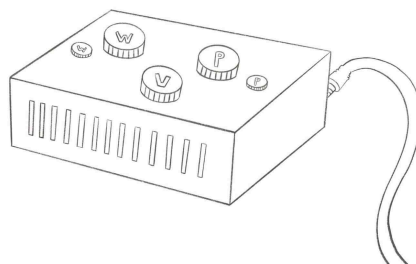


Fig.29. Noise maker artefact sketch 02.

Using textures to create textile noise

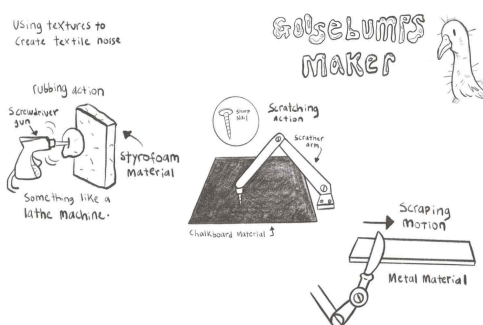


Fig.30. Robotic arm artefact sketch.

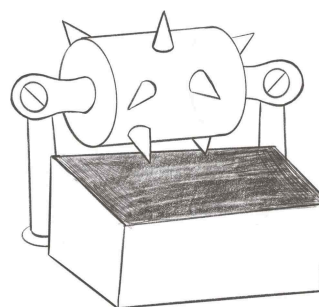


Fig.31. Textile noise maker artefact sketch 01.

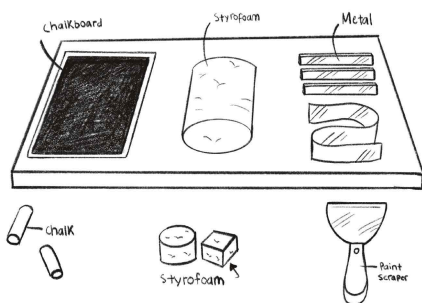


Fig.32. Textile noise maker artefact sketch 02.

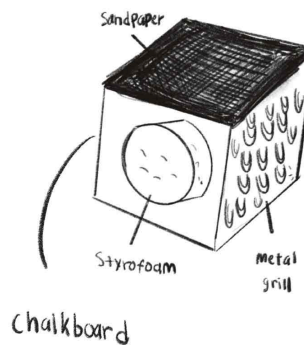


Fig.33. Textile noise maker artefact Sketch 03.

Textile noise maker prototype and Arduino Piezo setup (see fig. 34-39).

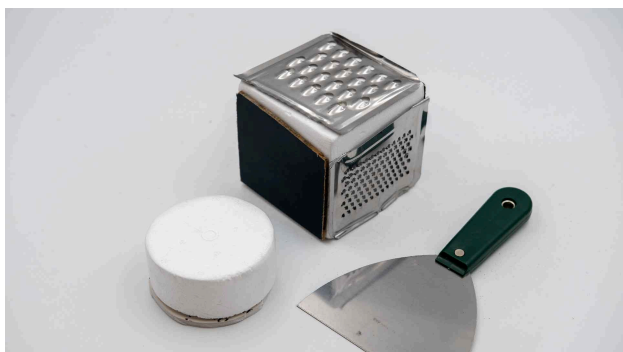


Fig.34. Textile noise maker prototype.

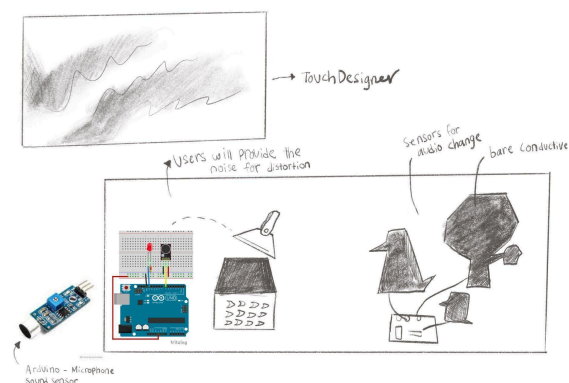


Fig.35. Textile noise maker Arduino Piezo artefact sketch.

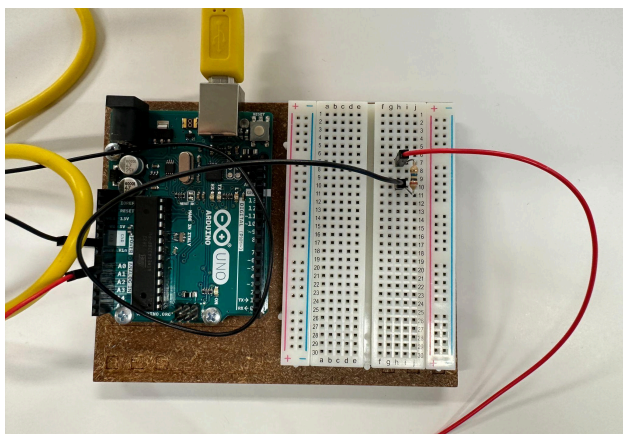


Fig.36. Arduino Piezo buzzer setup.

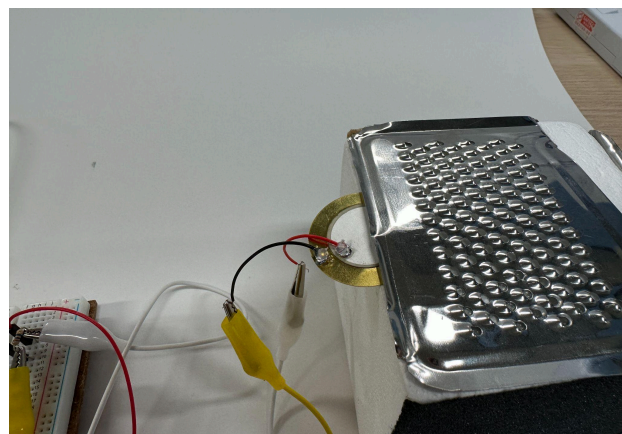


Fig.37. Arduino Piezo

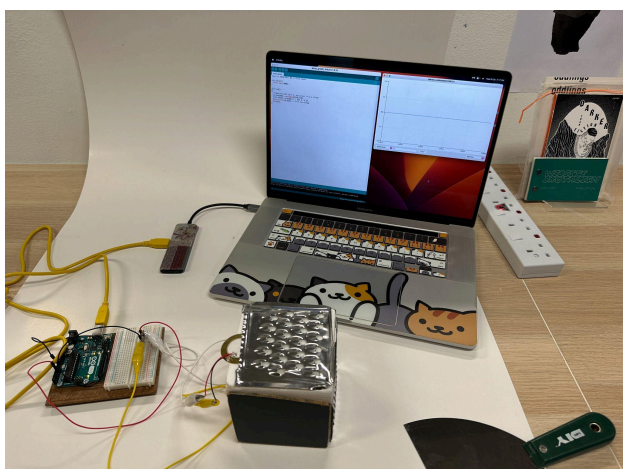


Fig.38. Arduino Piezo prototype.

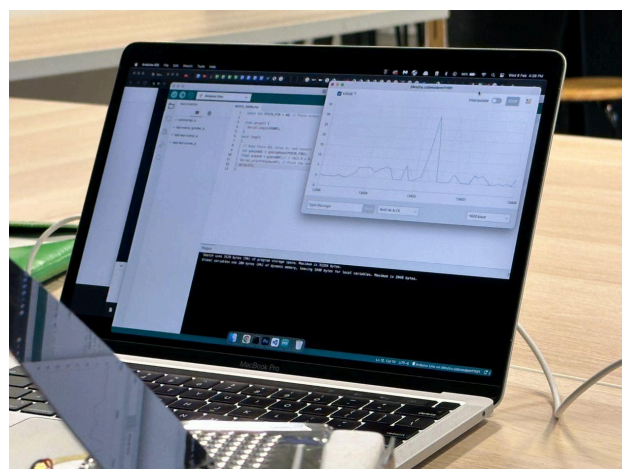


Fig.39. Arduino serial plotter graph.

Moss Carpet Prototype

As a result of using conductive copper wires and thread, I was able to create fabric sensors by combining them with my yarns, resulting in a moss carpet. Because the previous play kit set prototype had an issue of hiding the electronic components, I decided on this approach. With the moss carpet prototype, I was able to conceal electronic components and the touch board under the yarn and foundation fabric, which solved this issue easily. To produce the moss carpet, I used the punch needle technique, a method that I am familiar with because I have previously used it. The copper wires inside the alligator cable were exposed by cutting off one end of the cable for the connection. I then sewed the cables into the yarn to create sensors. The sensors were functional, however; I am confident that I can further enhance the sensitivity of the sensors in my next prototype. Refer to appendix D for a video that illustrates the results of this prototype.

Ideation sketch and moss carpet prototype (see fig. 40-43).

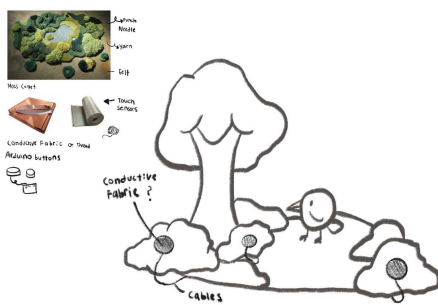


Fig.40. Moss carpet artefact sketch.



Fig.41. I sewed alligator cable connections in the foundation fabric.



Fig.42. Yarn moss patches made by the punch needle.

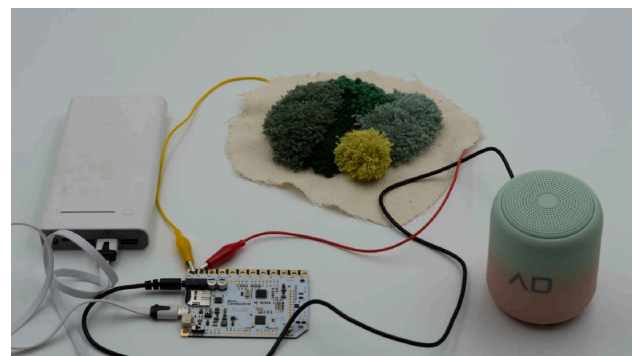


Fig.43. Moss carpet prototype.

4.0 Notes for Further Research

To further enhance the existing prototype, future user testing could be conducted for the design outcomes to assess effectiveness. The first focus area would be to evaluate the prototype's communication of the primary intention to the target audience – namely, to raise awareness of how human actions can affect environmental soundscapes – especially since some of the design outcomes are not a literal representation of urban noise pollution. Another focus area for the user testing would be to test the sensor's sensitivity as the sensors in the current design were not very responsive and only allowed the user to press a single sensor each time. The ideal situation would be for the user to activate multiple sensors simultaneously.

The discursive design approach was utilised in the process of producing the design outcomes so that the final artefacts could evoke emotions and communicate the message regarding the impact of human actions on the environmental soundscape. To allow the design outcomes to be thought-provoking for the intended audience, the artefact could be used in the context of an exhibition. The ideal exhibition design would encourage interactivity and discussion among my audience members, so they can ponder over the ways they could be mindful in their actions and take greater responsibility to protect the environment and reduce urban noise. For example, the textile noise maker could be in a larger size so that multiple people can use the noise maker at the same time. That way, the exhibition no longer remains solitary, but rather encourages interaction and discussion about the visuals that form reactions to the different textile noises.

5.0 Conclusion

This research sought to promote the effectiveness of the soundwalk approach for people in Singapore to develop a greater understanding of how their actions can affect the amount of urban noise and to notice ambient sounds that might have gone unnoticed in the past due to noise pollution, or the advancement of mobile devices as distractions from noticing the natural soundscape. The literature review expanded the understanding of multimodal listening and the practice of soundwalking as an active part of soundscapes. Although public parks are designed as places for relaxation, visits to these locations revealed that the natural soundscapes were unfortunately masked by other grating urban noises, and this issue was particularly prevalent for parks located near residential areas and higher traffic compared to those in secluded areas. Given the context of Singapore's limited land size and increased encroachment of residential areas into previously natural spaces, Singapore's public parks are getting an increased impact of noise pollution, and therefore there is a need to increase public awareness on this matter.

Through various rounds of ideation and prototype development, making use of urban noises found in the collected field recordings was found to be the most suitable method to raise awareness of the problem of noise pollution in Singapore. As such, the design outcomes were crafted in a way to leverage such noises to create unease, so that the intended target audience can understand the discomfort of noise pollution and in turn have more awareness of their noise-generating actions.

In conclusion, this research showed the potential for creatives to implement the soundwalk practice and subsequent field recordings in their workflow and for their creative pursuits despite the challenges and limitations faced while producing the design outcomes. There is still much to be explored through the intersectionality of soundwalk and design, especially where sound is a topic of interest. This paper serves as a starting point for further research into soundwalk studies.

6.0 References

- Adams, Mags, et al. "Soundwalking as a methodology for understanding soundscapes. Institute of Acoustics (IOA)." *ResearchGate*, April 2008,
https://www.researchgate.net/publication/286282168_Soundwalking_as_a_methodology_for_understanding_soundscapes_Institute_of_Acoustics_IOA. Accessed 9 October 2022.
- Augoyard, Jean François, and Henri Torgue. "Introduction." *Sonic Experience: A Guide to Everyday Sounds*, McGill-Queen's University Press, 2006, pp. 3-18.
- Baker, Alison, and Todd Anderson Kunert. "Listening as Practice: A Month in Ólafsfjörður." *Journeys in and through sound*, Emerald Publishing Limited, 2019, pp. 9-17.
- Brooks, Bennett, et al. "Exploring our sonic environment through Soundscape Research & Theory." *Acoustics Today*, vol. 10, no. 1, 2014, pp. 30-40.
https://www.researchgate.net/publication/272258435_Exploring_Our_Sonic_Environment_Through_Soundscape_Research_Theory. Accessed 22 01 2022.
- Ceraso, Steph. "Introduction: Toward Expansive Listening and Sonic Composing Practices." *Sounding Composition: Multimodal Pedagogies for Embodied Listening*, 1 ed., University of Pittsburgh Press, 2018, pp. 1-13.
- Ceraso, Steph. "Sounding Out Rhetoric and Composition and Sound Studies: Resonances, Perturbations, Provocations." *Sounding Composition: Multimodal Pedagogies for Embodied Listening*, 1 ed., University of Pittsburgh Press, 2018, pp. 14-27.
- Collins, Karen. "Introduction." *Playing with Sound: A Theory of Interacting with Sound and Music in Video Games*, Illustrated edition ed., MIT Press, 2013, pp. 1-18.
- Dam, Rikke Friis, and Teo Yu Siang. "5 Common Low-Fidelity Prototypes and Their Best Practices." *Interaction Design Foundation*, 2 May 2022,
<https://www.interaction-design.org/literature/article/prototyping-learn-eight-common-methods-and-best-practices>. Accessed 31 January 2023.
- Epstein, Marcia Jenneth. "Power and Danger." *Sound and Noise: A Listener's Guide to Everyday Life*, McGill-Queen's University Press, 2020, pp. 171-191.
- Epstein, Marcia Jenneth, editor. "Studying Sound." *Sound and Noise: A Listener's Guide to Everyday Life*, McGill-Queen's University Press, 2020, pp. 35-44.
- Franinović, Karmen, and Stefania Serafin. "Listening to the Sounding Objects of the Past: The Case of the \ Car." *Sonic Interaction Design*, MIT Press, 2013, pp. 3-38.

- Franinović, Karmen, and Stefania Serafin. "Pedagogical Approaches and Methods." *Sonic Interaction Design*, MIT Press, 2013, pp. 125-150.
- Gage, Stuart H., and Almo Farina. "The Duality of Sounds: Ambient and Communication." *Ecoacoustics: The Ecological Role of Sounds*, Wiley, 2017, pp. 22-24.
- Garg, Saurabh, et al. "A case study of smartphone based platform for mapping and analyzing environmental noise in Singapore." *Journal of Physics: Conference Series*, no. 1075, 2018, pp. 1-5, <https://iopscience.iop.org/article/10.1088/1742-6596/1075/1/012077>. Accessed 15 March 2022.
- Hurley, John. "Fig.1. HCD Double Diamond Process." *Medium*, 14 November 2020, https://medium.com/@johnhurley_des/high-fidelity-prototyping-28601b8e0659. Accessed 31 January 2023.
- Hurley, John. "Getting started with high-fidelity prototyping." *Medium*, 14 November 2020, https://medium.com/@johnhurley_des/high-fidelity-prototyping-28601b8e0659. Accessed 31 January 2023.
- Mora, Xavier Sole. "Fig.17. Gift of the Gab: Interactive Sculpture by Xavier Sole Mora." *Hackster.io*, Bare Conductive, 21 August 2018, <https://www.hackster.io/bareconductive/gift-of-the-gab-interactive-sculpture-by-xavier-sole-mora-5e8330>. Accessed 13 February 2023.
- Morales, Justin. "What Is Prototyping? | Adobe XD Ideas." *Adobe XD Learn & Support*, Adobe, 20 July 2021, <https://xd.adobe.com/ideas/process/ui-design/what-is-prototyping/>. Accessed 17 January 2023.
- Okamoto, Akira. "Fig.15. Visualise Sound by Akira Okamoto" *Designboom*, 12 November 2014, <https://www.designboom.com/project/visualize-sound/>. Accessed 13 February 2023.
- Parker, Martin, and Robyn Thomas. "What is a critical journal?" *Organization*, vol. 18, no. 4, 2011, pp. 419-427, <https://doi.org/10.1177/1350508411403535>. Accessed 09 February 2022.
- RTD Conference, and Zoë Sadokierski. "Critical Journal / Contextual Portfolio: A Framework for documenting and disseminating RTD as scholarly research." 2019, <https://doi.org/10.6084/m9.figshare.7855829.v2>. Accessed 22 February 2022.
- Schine, Jennifer. "Movement, Memory & The Senses In Soundscape Studies." *Sensory Studies*, <https://www.sensorystudies.org/sensorial-investigations/movement-memory-the-senses-in-soundscap-e-studies/>. Accessed 08 October 2022.
- Schulz, Chris. "How Newton's Cradles Work | HowStuffWorks." *Science | HowStuffWorks*, 17 January 2012, <https://science.howstuffworks.com/innovation/inventions/newtons-cradle.htm>. Accessed 13 February 2023.

"Soundwalk." *Soundwalk*, <https://www.sfu.ca/sonic-studio-webdav/handbook/Soundwalk.html>. Accessed 30 January 2023.

Tharp, Bruce M., and Stephanie M. Tharp. "Background." *Discursive Design: Critical, Speculative, and Alternative Things*, MIT Press, 2019, pp. 31-71.

Tharp, Bruce M., and Stephanie M. Tharp. "Introduction." *Discursive Design: Critical, Speculative, and Alternative Things*, MIT Press, 2019, pp. 6-29.

"What is Cymatics? Science of Visible Sound Explained." *Journey of Curiosity*, <https://journeyofcuriosity.net/pages/what-is-cymatics-how-to-explained>. Accessed 13 February 2023.

"The World Soundscape Project." *Simon Fraser University*, <https://www.sfu.ca/sonic-studio-webdav/WSP/index.html>. Accessed 17 November 2022.

Appendix A

Reading resources

Koh, Ariel. "Reading resources and collected quotes from readers." *SoundCloud*, 17 January 2022, https://docs.google.com/spreadsheets/d/1BO8Q26ao_ciqtlVN429zhjflaiT6diqSeaJB4IZD-U/edit?usp=sharing. Accessed 11 February 2023.

Mind Maps

Koh, Ariel. "Ubiquitous nuisance Mind Maps." *Miro*, 17 January 2022, https://miro.com/app/board/uXjVPTQ1Vsl=/?share_link_id=367679325767. Accessed 11 February 2023.

Field Recording Device

"Tascam DR-100MKIII audio sound recorder used for field recordings." *Tascam*, <https://tascam.com/us/product/dr-100mkiii/top>. Accessed 11 February 2023.

Appendix B

Mixed Soundscapes Soundwalk

Summary of places I visited for mixed soundscapes

East	North-East	Central
Pasir Ris Coastal Park Pasir Ris Hawker Centre Tampines Hub	Nex Shopping Centre	Chinatown Singapore Botanical Gardens

Soundwalk recordings arranged by date:

Koh, Ariel. "2022-04-22-17-00-pasir-ris-park." *SoundCloud*, 22 April 2022,

https://soundcloud.com/ariel-koh-qing-wen/sets/2022-04-22-17-00-pasir-ris-park?si=3ab623d792904daa97cbd4822287d257&utm_source=clipboard&utm_medium=text&utm_campaign=social_sharing.

Accessed 11 February 2023.

Koh, Ariel. "2022-08-27-15-00-pasir-ris-hawker-centre." *SoundCloud*, 27 August 2022,

https://soundcloud.com/ariel-koh-qing-wen/sets/2022-08-27-15-00-pasir-ris-hawker-centre?si=7bd59473e12840a28ee735341a64a72d&utm_source=clipboard&utm_medium=text&utm_campaign=social_sharing. Accessed 11 February 2023.

Koh, Ariel. "2022-09-03-12-00-tampines-hub." *SoundCloud*, 3 September 2022,

https://soundcloud.com/ariel-koh-qing-wen/sets/2022-09-03-12-00-tampines-hub?si=539aa5360ef7421d87cfa1b27d88d1b5&utm_source=clipboard&utm_medium=text&utm_campaign=social_sharing.

Accessed 11 February 2023.

Koh, Ariel. "2022-09-04-10-00-pasir-ris-park." *SoundCloud*, September, 4 September 2022,

https://soundcloud.com/ariel-koh-qing-wen/sets/2022-09-04-10-00-pasir-ris?si=83d7c4164cb44db3a523f1fed31da31f&utm_source=clipboard&utm_medium=text&utm_campaign=social_sharing.

Accessed 11 February 2023.

Koh, Ariel. "2022-09-16-15-30-NEX." *SoundCloud*, 16 September 2022,

https://soundcloud.com/ariel-koh-qing-wen/sets/2022-09-16-15-30-nex?si=284610f4ab3445bd90c662ecacaa0311&utm_source=clipboard&utm_medium=text&utm_campaign=social_sharing. Accessed 11

February 2023.

Koh, Ariel. "2022-09-17-13-15-Chinatown." *SoundCloud*, 17 September 2022,

https://soundcloud.com/ariel-koh-qing-wen/sets/2022-09-17-13-15-chinatown?si=e7f43ac8acdc414699affde42d6bd068&utm_source=clipboard&utm_medium=text&utm_campaign=social_sharing.

Accessed 11 February 2023.

Koh, Ariel. "2022-09-17-16-00-singapore-botanic-gardens." *SoundCloud*, 17 September 2022,

https://soundcloud.com/ariel-koh-qing-wen/sets/2022-09-17-16-00-singapore-botanic-gardens?si=59edb1ff7bb24e58afe8444784a9e85d&utm_source=clipboard&utm_medium=text&utm_campaign=social_sharing. Accessed 11 February 2023.

Public Parks Soundwalk

Summary of the two parks that I visited

Tampines Park	Pasir Ris Coastal Park
Timing 12 pm - 1 pm 5 pm - 6 pm Soundscape: Noisy soundscape because of a small neighbourhood park surrounded by a circular car park and residential homes.	Timing: 9 am - 10 am 5 pm - 6 pm Soundscape: Certain places are noisy because they are located near the main road and residential areas. Places such as the mangrove forest have fewer sources of urban noise because it is not located near the main road.

Soundwalk recordings arranged by date:

Koh, Ariel. "2022-10-29-tampines-park." *SoundCloud*, 29 October 2022,

https://soundcloud.com/ariel-koh-qing-wen/sets/2022-10-29-tampines-park?si=76c2bb517c104410a23b6647ed90a33c&utm_source=clipboard&utm_medium=text&utm_campaign=social_sharing.

Accessed 25 January 2023.

Koh, Ariel. "2022-11-21-22-pasir ris-coastal-park." *SoundCloud*, 21 November 2022,

https://soundcloud.com/ariel-koh-qing-wen/sets/2022-11-21-22-pasir-ris-coastal-park?si=19631f54f6e7473daf48d4691d78a07a&utm_source=clipboard&utm_medium=text&utm_campaign=social_sharing.

Accessed 11 February 2023.

Appendix C

Sound and Shape Experiment



Fig. 1. Big triangle shape.

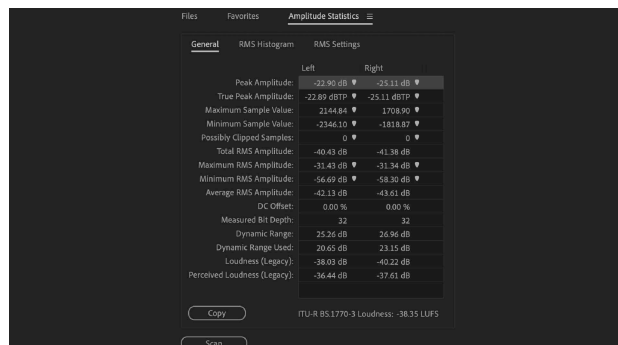


Fig. 2. Big triangle audio reading.

Koh, Ariel. "big-triangle." *Dropbox*, 24 September 2022,

<https://www.dropbox.com/s/aiisksqeg9nqy66/big-triangle.wav?dl=0>. Accessed 12 February 2023.



Fig. 3. Small triangle shape.

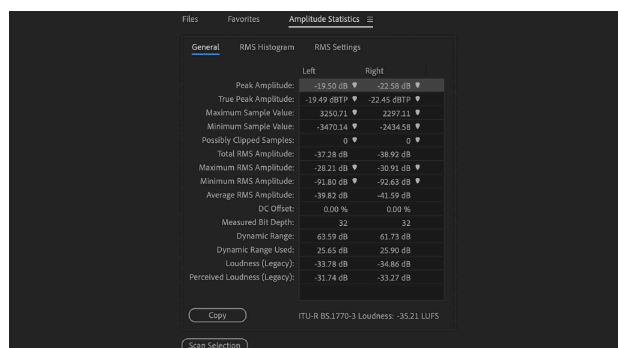


Fig. 4. Small triangle shape audio reading.

Koh, Ariel. "small-triangle." *Dropbox*, 24 September 2022,

<https://www.dropbox.com/s/xq5f4a4qxly3n5g/small-triangle.wav?dl=0>. Accessed 12 February 2023.



Fig. 5. Cube shape.

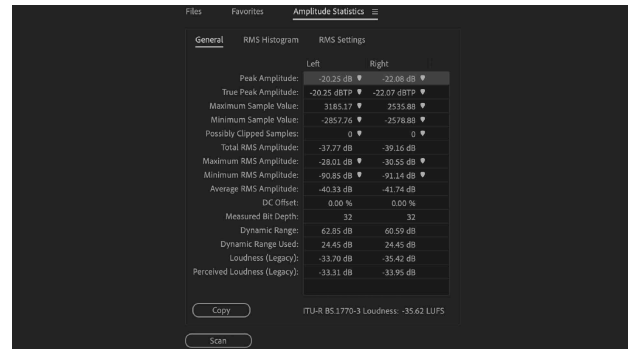


Fig. 6. Cube audio reading.

Koh, Ariel. "cube." *Dropbox*, 24 September 2022,

<https://www.dropbox.com/s/zl1py3ewfi5xd2u/cube.wav?dl=0>. Accessed 12 February 2023.



Fig. 7. Long tube shape.

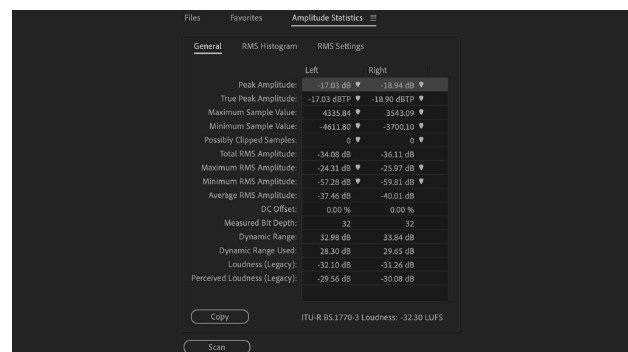


Fig. 8. Long tube shape audio reading.

Koh, Ariel. "long-tube." *Dropbox*, 24 September 2022,

<https://www.dropbox.com/s/uz45ei3ftozq700/long-tube.wav?dl=0>. Accessed 12 February 2023.



Fig. 9. Short tube shape.

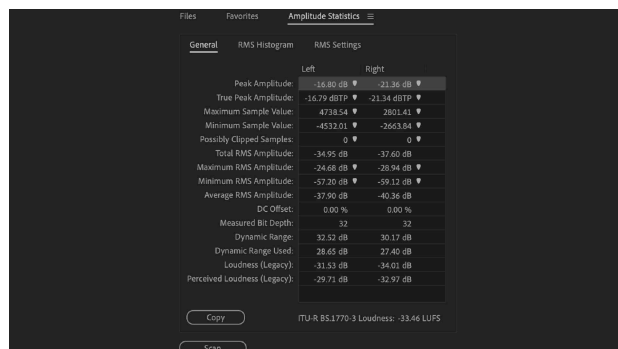


Fig. 10. Short tube shape audio reading.

Koh, Ariel short-tube." *Dropbox*, 24 September 2022,

<https://www.dropbox.com/s/jlsxbbhugijepuf/short-tube.wav?dl=0>. Accessed 12 February 2023.

Electric Paint Sensor Experiment

Koh, Ariel. "Electric paint sensor experiment." *YouTube*, 26 October 2022, https://youtu.be/fWI56_rOnxI.

Accessed 12 February 2023.

Conductive Sensor Experiment

Koh, Ariel. "Conductive sensor experiment." *YouTube*, 27 November 2022, https://youtu.be/E0JGPd_ykj8.

Accessed 12 February 2023.

P5.js Sound Generative Graphics Experiment

Koh, Ariel. "P5.js experiment 01." *P5.js*, 10 August 2022, <https://editor.p5js.org/ariel.koh/full/lvc6LqWYU>.

Accessed 13 February 2023.

Koh, Ariel. "P5.js experiment 02." *P5.js*, 10 August 2022, <https://editor.p5js.org/ariel.koh/full/u7EC2WqFo>.

Accessed 13 February 2023.

Koh, Ariel. "P5.js experiment 03." *p5.js*, 10 August 2022, <https://editor.p5js.org/ariel.koh/full/BtvJx4JDI>.

Accessed 13 February 2023.

TouchDesigner Sound Generative Graphics Experiment



Fig. 11. Park photo from Tampines Park.

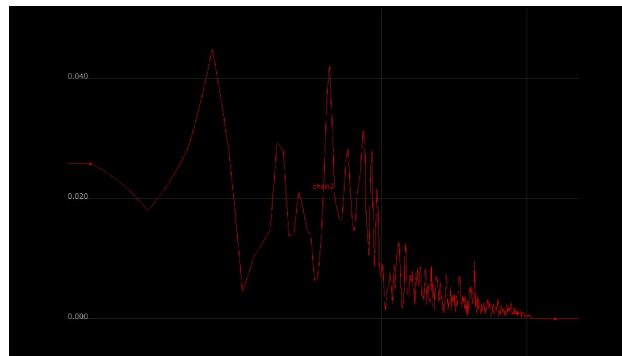


Fig. 12. Grass-cutting audio channel 2 waveform.



Fig. 13. TouchDesigner nodes structure.

Version 01

Koh, Ariel. "Grass Cutting Audio Generative Graphics Version 01." *Google Drive*, 12 January 2023,

<https://drive.google.com/file/d/1k6-qozp0jFB50bf2f5LXKhqOOmD6KlQK/view?usp=sharing>.

Accessed 13 February 2023.

Koh, Ariel. "Grass Cutting Audio Final Composition Version 01." *Google Drive*, 12 January 2023,

https://drive.google.com/file/d/17_tN-fNfUL3PmQgbtcRuEzTMhX70jaSn/view?usp=sharing.

Accessed 13 February 2023.

Version 02

Koh, Ariel. "Grass Cutting Audio Generative Graphics Version 02." *Google Drive*, 12 January 2023,
https://drive.google.com/file/d/12v0QbaNqvHs_e-R4xUktW8UrWusjWI26/view?usp=sharing.

Accessed 13 February 2023.

Koh, Ariel. "Grass Cutting Audio Final Composition Version 02." *Google Drive*, 12 January 2023,
https://drive.google.com/file/d/1_j2c5iOCn2EJ_QZ9RFSz6VPLQilu3wtI/view?usp=sharing.

Accessed 13 February 2023.

Appendix D

Play Kit Set Prototype

Koh, Ariel. "Play kit set prototype." *YouTube*, 7 February 2023, <https://youtu.be/TGGgS92Wk3o>.

Accessed 13 February 2023.

Textile Noise Maker

Different Material Experiment

Koh, Ariel. "Chalkboard with chalk." *YouTube*, 19 January 2023, <https://youtu.be/2jdBGZ8HViQ>.

Accessed 13 February 2023.

Koh, Ariel. "Chalkboard with scraper." *YouTube*, 19 January 2023, https://youtu.be/ln0zNI_deDs.

Accessed 13 February 2023.

Koh, Ariel. "Grater." *YouTube*, 19 January 2023, <https://youtu.be/lrORXqD2hXY>.

Accessed 13 February 2023.

Koh, Ariel. "Sandpaper." *YouTube*, 19 January 2023, <https://youtu.be/khWT6Uz4NjA>.

Accessed 13 February 2023.

Koh, Ariel. "Styrofoam." *YouTube*, 19 January 2023, https://youtu.be/6a_FjY4Nc.

Accessed 13 February 2023.

Koh, Ariel. "Whiteboard." *YouTube*, 19 January 2023, <https://youtu.be/IDMFU-F7p48>.

Accessed 13 February 2023.

Prototype Videos

Koh, Ariel. "Textile noise maker prototype." 19 January 2023, https://youtu.be/ekg_vweSx1o.

Accessed 13 February 2023.

Koh, Ariel. "Textile noise maker piezo prototype." *YouTube*, 9 February 2023,

<https://youtu.be/yT1i0H-ICsc>. Accessed 13 February 2023.

Moss Carpet Prototype

Koh, Ariel. "Moss carpet prototype." *YouTube*, 8 February 2023, <https://youtu.be/hMKVEeqfgB0>.

Accessed 13 February 2023.