# Sound Surroundings

Environmentally Generated Sound Installation

FINAL PROJECT

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BA Music Informatics

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2012

# Abstract

This project explores ideas and values derived from the concept of 'Acoustic Communication' through the creation of a system, which algorithmically generates a soundscape controlled primarily by environmental data. This is achieved through use of an Arduino with light and temperature sensors, a microphone and software written in the SuperCollider language. It is a qualitative study focusing on the experiences and perceptions of listeners.

# Declaration

The report is submitted as part requirement for the degree of BA Music Informatics at the University of Sussex. It is the product of my own labour except where indicated in the text. The report may be freely copied and distributed provided the source is acknowledged.

# Acknowledgements

The author would like to take this opportunity to express her gratitude towards a number of individuals who have provided endless amounts of support over the course of the degree. Nick Collins, for being an inspiring, encouraging and patient course tutor and project supervisor. Fellow course mates for being a group of fun, helpful and interesting people whom she has learnt a lot from. Acle Kahney, for the lending of equipment and generally being caring and encouraging. Her housemates, for putting up with the loud and strange noises despite working night shifts and finally her family, for always taking an interest and providing a wealth of support and guidance.

# Contents

## Chapter 1

# Introduction

Acoustic Communication is concerned with the relationships and processes involved in listening to a sound environment. The ‘Sound Surroundings’ project aims to provide a medium (through creation of a generative sound installation) to analyse ideas and values provided through acoustic communication in order to gain a greater understanding of the contemporary world.

Sound Surroundings practices methods of exploring communication with the environment from the area of Acoustic Ecology, in which data is collected from the environment and interpreted through sound. In analysing human perception of this sonified environmental data, the focus will be from a sociological human perspective. To achieve this it will be necessary to draw an understanding as to the sociological impacts that affect the listening process.

Exploration of electro-acoustic technology is a key theme throughout this report partly in assessing the positive and negative effects it has on communication and also its use as a medium to build and create the Sound Surroundings system.

This project aims to draw together ideas from a number of different areas including computer music (generative music, algorithmic composition, sonification, sound art, hardware and software implementation), Acoustic Communication (social and cultural issues, psychology, cognition and perception) and Acoustic Ecology (sensing environmental data) in order to gain understanding of sound from a human perspective.

The considerations of these different elements to inspire the design and implementation of the generative sound installation as well as a providing a basis for results analysis will be detailed in this report.

The report will provide an area review in Chapter 2 in order to contextualise the concept of the installation by giving an overview of both Acoustic Communication and Acoustic Ecology.  Chapter 3 regards the professional impacts of undertaking this project and how these professional requirements have been met. Chapter 4 provides an overview of the Installation design focusing on the planning, set up and equipment used. Chapter 5 covers software implementation of the program created to generate sound in the SuperCollider environment. Chapter 6 hosts an evaluation of the installation and discusses the results gathered. Chapter 7 gathers conclusions drawn from this project and provides thoughts as to the possibilities of potential extensions.

# Chapter 2

# 2.0 Area Review

### 2.1 Acoustic Communication

*"Communication studies, provides a useful framework and set of concepts for understanding a complex system such as the one that sound creates between people and the environment".*

*Barry Truax (1984)*

The following chapter gives an overview of what is meant by acoustic communication and will review a background of sound installation work with environmental themes as a preface to considering the 'Sound Surroundings' project in later chapters.

Barry Traux is a leading writer and researcher in the areas of acoustic communication and acoustic ecology. He was a member of The World Soundscape Project created by R. Murray Schaeffer in order to try and promote ideas of communicating with the surrounding environment through the medium of listening.

Traux uses 'Acoustic Communication' to describe sound from a human perspective. He feels that we as humans take sound and hearing for granted and that there is not enough emphasis on how sound connects us to the environment and its impact. The issues of how urbanization and technology effect and can be used to form these relationships are also important areas to explore.

The term ‘soundscape’ is seen as a simple term for acoustic communication as opposed to just being a synonym for the acoustic environment (Truax, 1984). The way in which people listen can be very sensitive or fairly passive, though both will help the mind to communicate with and interpret the acoustic environment to a varying degree.

Focusing on these listening habits helps to form a relationship between a person and the environment, which could be perceived as enjoyable and calming or frightening and oppressive.

Acoustic communication replaces energy/signals with information as the basic unit of its model (Truax, 1993). Listening is placed at the centre of the process as information results from cognitive activity.

In focusing on how sound can mediate a relationship between an individual and the surrounding environment it is important to note that that there can be influence from either side. A physical change in the surrounding environment or just a change in the listener’s perception can make a difference to the communicational situation. Context is another important element in studying acoustic communication because sound perception is based both on the physical sound produced and the context in which it is heard.

Put simply, Acoustic Communication focuses on relationships and processes in listening to a sound environment and aims to provide a medium through which we can explore and understand the contemporary world.

Music composer Brian Eno talks of his inspiration to write ambient music during a time of illness in which he was unable to leave his bed. His friend left a 17th century harp record playing after visiting. He realised the stereo was playing too quietly and one of the speakers was not working very well but he was unable to get up and change the music. He lay there for a while listening and became seduced by the listening experience. “*I realized what I wanted music to be- a place, a feeling, an all around tint to my sonic environment*” *(Eno, 1978).*

In general terms of communication, Eno feels that it begins with empathy. Empathy allows us to go beyond language and acts as a precondition for it. It is the ability to imagine what things look like from each other's eyes and it is this that connects us. Subconsciously we inhabit other worlds, minds and assumptions hundreds of times each day. Very subtle changes can make a huge amount of difference in our perceptions for example a slight change in the intonation of our voice can change the semantics of a sentence.

When we take part in cultural acts we rehearse the ability to step from one step of assumptions to another; changing our perspective and getting better and better at it (Eno, 1996). Eno believes this is why the world could be getting better. Fundamentalism wants people to accept one view of the world, therefore exercising the ability to move away from that school of thought by opening up and taking time to perceive the world in ways that we wouldn't usually, could really enhance our communicational skills and ability to emphasise all round.

### 2.1.1 Technology

Acoustic Communication explores the impact of electro-acoustic technology on communication. The negative and potentially harmful impacts of electro acoustic technology are blamed for causing deterioration in listening within the urbanized environment. Noise exposure, hearing loss, sleep disruption, physiological stress and generally dull and uninteresting sounds (for example the sound of a lorry reversing as opposed to birds singing) are all at fault and do not encourage sensitive listening.

This arises questions such as: what is it to put sound onto disk? What will the effect be on listening if sounds heard are likely to be repetitions of the original? The control of the music industry by multi million dollar companies may also have an effect on the way in which sound and music is generally presented.

Due to technological advances, music is now present in a greater amount of our every day lives than ever before, which causes a more general and widespread interest within psychology (North A, Hargreaves D, 2008). This presents the issue of 'purpose' and whether this applied purpose of music to so many elements of our daily lives has caused us to take listening for granted even further.

Despite these disadvantages to electro acoustic technology, acoustic communication tries to maintain a fairly balanced outlook on its uses. Acoustic communication assesses the benefits and the disadvantages of the new audio environments objectively. Often technology seems to work as a "zero sum" operation in that for every advance there seems to be a corresponding price (Truax,1984 ).

The prime justification of electro acoustic technology is that it does allows us for some very useful and powerful tools to extend communication through sound. Due to the development of recording technology, a whole variety of compositional possibilities that were fairly new to music were put into practice. Most of these were related to either the development of the sound's texture itself as a compositional focus or as the ability to create virtual electronic acoustic spaces that do not naturally exist (Eno, 1996). New devices to shape sounds were available on the market weekly and still are. When synthesizers made their debut people would sit playing with them for hours amazed and immersed in new sonic worlds. (Eno, 1996)

> "*And immersion was really the point; we were making music to swim in, to float in, to get lost inside*" (Eno, 1996).

Eno's experience of the emergence of electronic technology presents us with the fact that people were able to explore and create music that could really listen to and become absorbed in. A clear advantage of this technology is the freedom that it gives composers to create and express musical ideas in ways that were previously not possible.

### 2.1.2 Composition/Design Process

It is interesting to note how technology has allowed for a change to the way in which the actual process of the composition is designed. It enables a much greater deal of freedom and choice in methods employed to create music. Some examples include analogue and digital techniques, stochastic and deterministic methods, real time and non real time synthesis, memory storage and the use of complex algorithms (Truax, 1984) in order to build and control musical ideas.

The combination of these techniques with a vast increase in public accessibility to music technologies has impacted the divide between composer and performer, which was quite prominent in the 19$^{th}$ century. The same can be said in Western modern culture in terms of a shift between makers and consumers of culture. There is more of a demand for the ability to personalise and customise the way that culture is consumed. This could be anything from creating personal playlists on Spotify and sharing with friends to choosing which flavour syrup to have in a coffee.

We are constantly being given more choice, freedom and flexibility as to how we want to interact with culture. Hopefully this will have a positive impact on the ideas of acoustic communication and people will engage more actively with culture through the medium of listening due to a heightened integration of choice and engagement within society. In order to help encourage this, acoustic design aims to modify relationships within the listening environment. The listener must be included in the system so therefore part of the system design centers on modifying the listening and thinking habits of the audience.

Martindale's work 'A Clockwork Muse' presents a theory attempting to explain the development of creativity in all art forms including musical composition. He argues that musical composition is influenced by the audiences need for novelty (North, A, Hargreaves, D, 2008). He believes that the evolution of music over time has been made predictable by this need for novelty as if it ran like clockwork.

Martindale suggests that we only need a small about of novelty in music due to habituation. Habituation is a process in which we start to lose interest in things that we have experienced already. Composers insist on including some level of novelty in music so that it does not get boring for listeners. Our actual need for novelty is not really strong at all due to the fact that the society we live in needs a high level of predictability and order so that it is able to function. Martindale believes that high levels of novelty would lead to chaos and disorder.

From an acoustic design point of view it might be interesting to explore this theory as it may be possible to modify the listeners' thinking habits by presenting them with high levels of novelty through sound, which they do not 'need' in their every day lives.

However the design does not aim to be a manipulative process in which an "expert" imposes a pre determined criteria on an environment (Truax, 1984). It could just be that the listener chooses to modify and interpret the way in which sound creates a relationship with the environment. The focus is more centered on how the individual engages with the environment for their own personal discovery rather than trying to make them think or feel a set way.

### 2.1.3 Noise Levels

Acoustic communication seeks to encourage this engagement with the surrounding environment to increase a set of skills that are said to be deteriorating in technologised urban environments. Our auditory system changes in sensitivity depending on the average noise level of the surrounding environment; If we were sat in a quiet room and focused on hearing and listening we would experience a gradual dropping of the hearing threshold, the listener will start to notice minute sounds that they are unlikely to have noticed before (Truax, 1984). It takes around fifteen minutes for hearing to be at its most sensitive.  Therefore if more time is devoted to listening the more rewarded the listener is likely to be.

## 2.2 Acoustic Ecology

*"Ecology is the study of the relationship between living organisms and the environment. Acoustic ecology is therefore the study of sounds in relationship to life and society. This cannot be accomplished by remaining in*
*in the laboratory. This can only be accomplished by considering on location the effects of the acoustic environment on the creatures living in it"*

R. Murray Schaefer (1977)

Acoustic Ecology explores and presents information about the relationship between human beings and their environment through the medium of sound. It makes use of acoustic communication through actively exercising its theories and values in order to explore and understand this relationship to the environment.

Acoustic ecology focuses on listening. As humans we often tend to hear rather than actively listen. This section will present some examples of projects and installations created to study and research communication through acoustic ecology.

M.A.R.I.N stands for Media Arts Research Interdisciplinary Network. It holds various research programs, recently including 'Sensing the Baltic Sea' in June 2011. M.A.R.I.N advertises its programs to artists and developers who are work with environmental sensors and expects participants to have fairly experienced knowledge in the platforms of Arduino and Xbee. Interestingly M.A.R.I.N focuses on marine ecosystems and fieldwork at sea through the use of art, science and technology. Participants take residencies often living on boats for a few weeks and exploring the sea with sensors. In Sensing the Baltic Sea the main themes are how it is perceived via history, romantic or leisurely perception as well as how this can be juxtaposed via looking below the surface to understand the sea as an ecosystem (M.A.R.I.N online, 2011).

It questions how environmental sensors can do more than just produce information. They can be used to explore how this research can be applied to alter perceptions of the marine environment. It investigates how common sense can be sensitised to change negative impacts on the environment and tries to find ways that the ecological and biological state of the Baltic Sea can be observed through sonification and other more 'abstract' tactics. In the last August residencies they focused on mapping marine biology as well as other every day sea practices such as farming, fishing, leisure and transport.

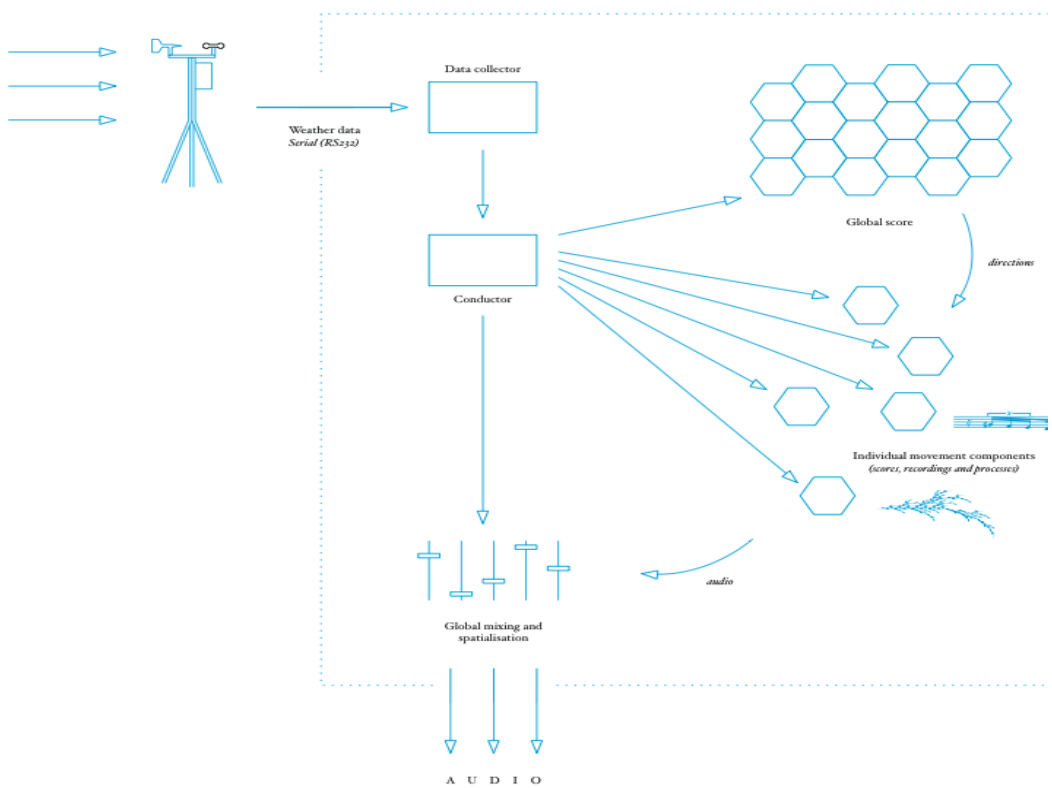



*Figure 1: System process overview diagram for James Bulley's 'Variable 4, (Bulley, 2011).*

'Variable 4: A Dynamical Composition From Weather Systems' focused on composing, through the use of environmental weather data. It was a sound installation created by James Bulley and Daniel Jones that transformed weather patterns into musical compositions said to be as ‘unpredictable as the weather itself’ (Bulley, 2011). Using meteorological sensors connected to a custom software environment developed by the artists, the weather conditions acted as a composer. Figures 1 and 2 indicate the stages of the process from data collection to composition and harmonic progressions, which are mapped in regards to the changes in position of the sun.

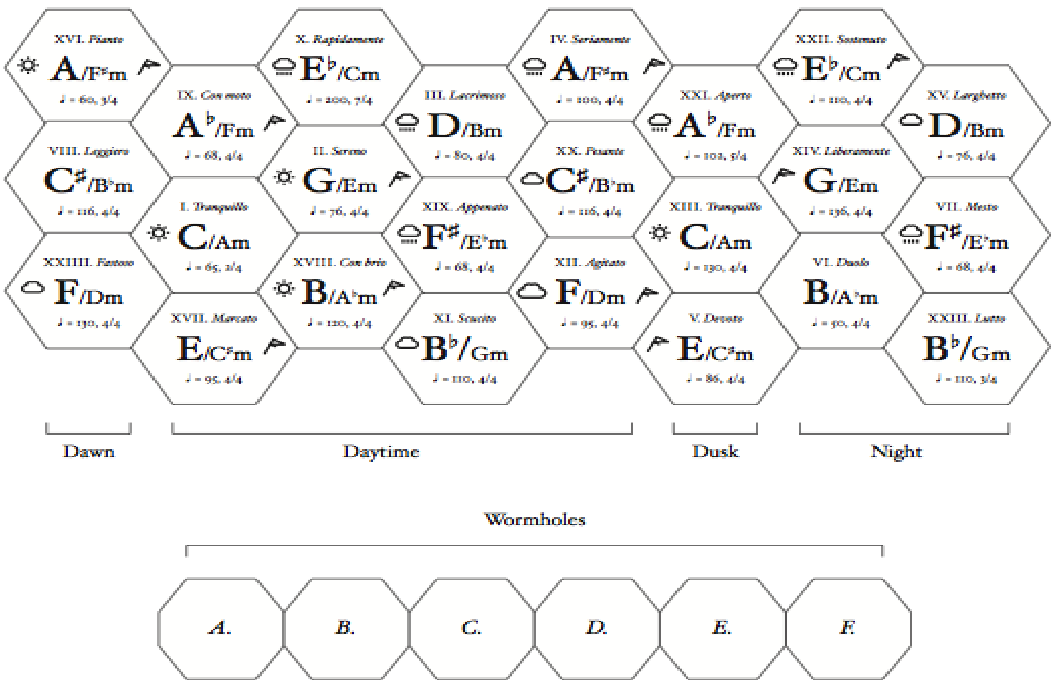



*Figure 2: Diagram showing harmonic progressions mapped in regards to changes in sun position (James Bulley, 2011).*

The sensor data is linked to carefully scored motifs. The sounds produced are influenced by the speed of the wind, amount of rainfall, solar radiation, tropospheric variance and temperature. In order to link together the sensor data and scored harmony and motifs a series of algorithmic processes are used. These algorithmic processes are also influenced by the natural world. They are modeled on information such as; tree growth, swarm theory and evolutionary development.

The performance lasted for 24 hours and was played through 8 loud speakers disguised to fit into the surrounding environment to look like rocks covered with leaves. This project gives a complex example of generated music from sensor data through algorithmic processes modeled on changes in environmental factors.

Other examples of turning environmental data into music are two projects called 'Flood Tide' and 'Hour Angle' created by John Eacott. Flood Tide is a live sonification of water flow and has been previously performed ten times, with the largest performance to date exhibited at the 'See Further' festival at London SouthBank by fourty Orchestral musicians, voices, taiko drummers and jazz soloists. The music of Hour Angle is generated based on the movement of the sun. The gradual change in the sun's declination (the north/south component) and hour angle (east/west component) is converted in realtime to musical notation and is performed by live performers. John Eacott converts the data into notation using a SuperCollider software package called LiveNotation.

John Eacott has also undertaken a sound installation project as part of his doctorial thesis entitled 'Contents May Vary: The Play and Behaviour of Generative Music Artefacts'. In September 2000 at University of Westminster he worked on a project with Ross Clement called 'The Street'. It was part of a research project to explore ways that permanent features (for example public buildings and spaces) could have interactive music incorporated into them.

The Street entailed an interactive ambient music system to enhance the Harrow campus entrance at the University or Westminster. This area is known as 'The Street' from which the installation takes its title. It creates music from the movement of users in the space (Eacott, 2007).

Originally they explored the idea of video tracking to detect movement but felt that it would not meet the demands within the scope of the project as they felt they could not write the video tracking software as well as music producing software in terms of the time available. They decided to use ultrasound transponders in order to detect movement of people leaving and entering the street.

They chose to map the intensity of the music to the amount of user activity. They originally looked into using a library of compositions in order to meet the level of musical requirements suitable for the task. However, they decided against this due to the amount of music a system would require in order to run up to 24 hours a day without excessive repetition.

They settled on creating a single composition in which enough variation could be achieved through using generative processes in combination with the use of interaction. They found that the advantages of using generative and synthesised music as opposed to audio recording and samples were that file sizes containing generative algorithms were smaller. This helped with the use of multi-channel sound as generative music doesn't need to be limited by duration. They also found that it allowed for greater variety and user flexibility.

John Eacott made sure he respected the needs of his audience when creating his installation 'The Street'. He made sure that the volume of the sound produced by the street was at an acceptable level for the users of the space. He specified that the musical content should be sensitive to tastes and cultures of a wide range of users. As well as students and academics there could have been administrative, technical and security staff to consider as well as visitors from a range of backgrounds and ages.

Figure 3 presents a flow diagram, which indicates the design structure of the 'The Street' to give a better idea as to how the different parts work together as a whole.

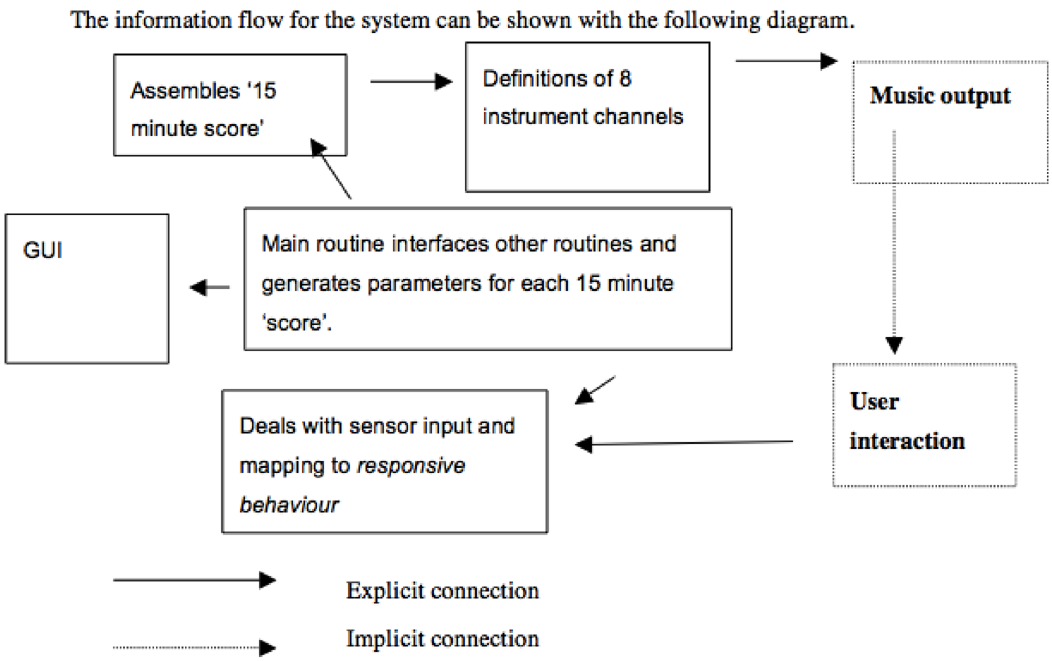



*Figure 3: Indicates the design structure of 'The Street', (Eacott, 2007).*

The World Listening Day was an event held on 18th July 2010 (Schaeffers birthday) by The World Listening Project and is affiliated with the World Forum for Acoustic Ecology, which was founded by a colleague of Barry Truax: Hildegard Westerkamp.

It aims to get a wider audience interested in listening to the world around them, promote environmental awareness and acoustic ecology and helps to design and implement initiatives which explore these concepts and practices (World listening project, online). Workshops and projects ran all over the world on this day in attempt to appeal to a wider audience.

Like the workshops and projects displayed as part of The World Listening Day, the Sound Surroundings project attempts to employ the values supplied through acoustic communication and acoustic ecology by creating a soundscape determined by the state of surrounding environmental factors to which the audience members are encouraged to exercise the skill of listening.

The remainder of this report will explain how the Sound Surroundings installation was created. Its weaknesses and successes will be discussed and evaluated through analysis of audience response and observation.

# Chapter 3

# 3.0 Professional Considerations

In developing Sound Surrounding I promise to abide by ethical standards, which govern the computing profession in Britain and are defined by the Code of Conduct and the Code of Practice published by the British Computer Society.

I would like to cover a few potential areas of concern:

I would like to state that although this projects involves creating a sound installation for members of the public to listen to. I will make sure I work in accordance to Part 1 of the code of conduct: Public Interest. Part 1a of the code states that:

“You shall: a. have due regard for public health, privacy, security and wellbeing of others and the environment.”

In order to abide to this I made sure the installation was held in a safe public environment. I worked with electrical equipment and therefore made sure I worked in a dry setting so as to prevent any damage that could be caused by electricity.  I worked with safe, low voltage equipment and made sure the visitors were well aware of any potential dangers that could arise. I ensured that noise was kept at a safe level so as not to cause any damage to hearing.

In accordance to section 3a of the code of conduct:

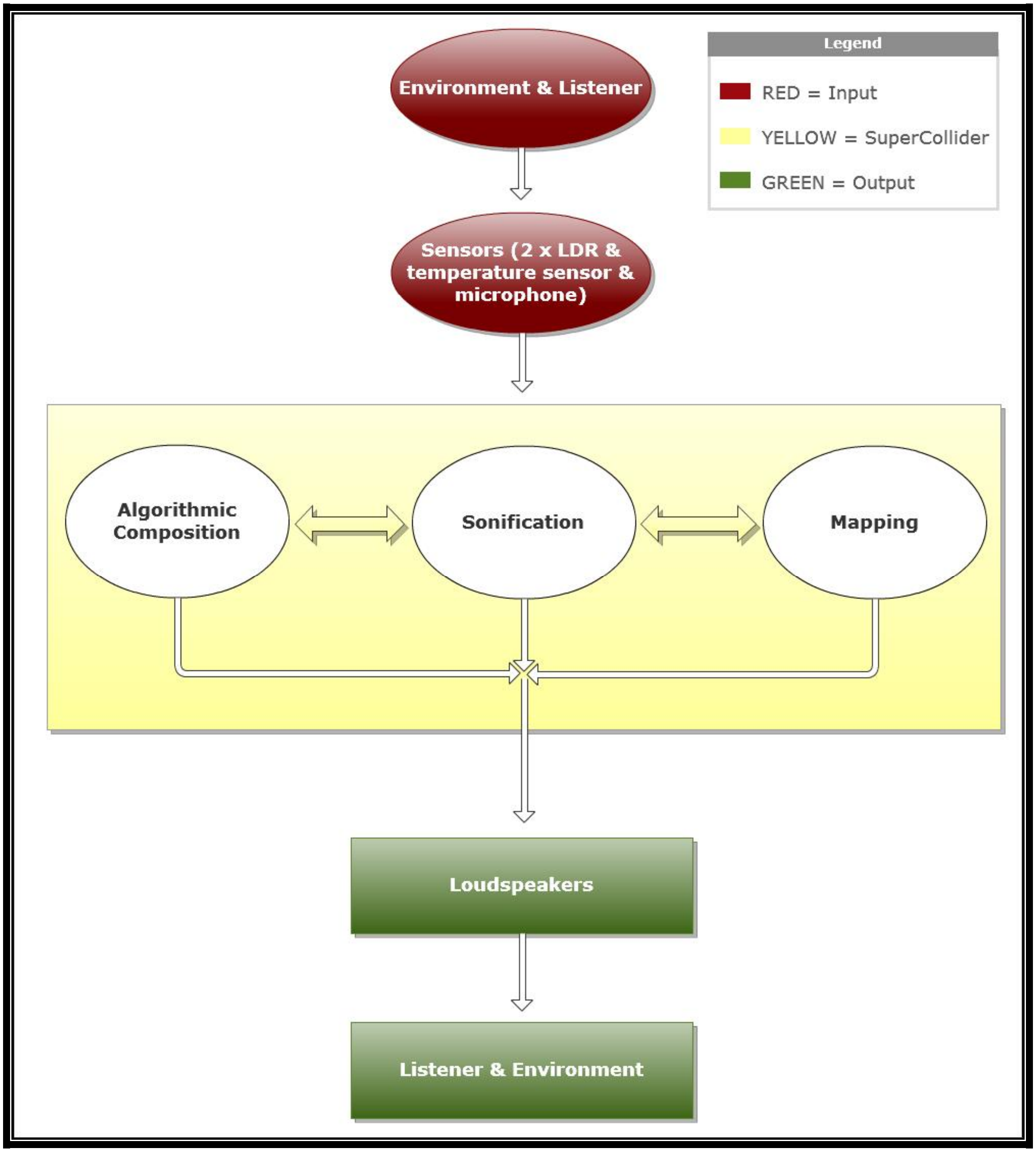
“You shall: 3a Carry out your professional responsibilities with due care and diligence in accordance with the Relevant Authority’s requirements whilst exercising your professional judgement at all times”.

I will make sure I follow the guidelines set by the Informatics department at the University of Sussex.

# Chapter 4

# 4.0 Installation Design

### 4.1 System Overview



The Sound Surroundings project was developed in wanting to explore the relationship between people and the environment through listening, a concept inspired by acoustic communication and acoustic ecology.

The outcome of the project was therefore a computer-generated soundscape controlled mostly by sensory data captured from the environment using an Arduino microcontroller device with sensors and a microphone. The environmental factors used to control the sound were light, temperature, sound and movement.

The program was created using the SuperCollider environment essentially to map the inputted data to a sound output. In designing this program the main focuses were working with mappings, sonification and algorithmic composition.

The installation ran for a fairly long period of time (6 hours) in order to allow the environmental factors to change over the course of the day.

This chapter will detail the planning and organisation of the installation giving an over view of the set up and equipment used. Chapter five will then go on to explain how the software program for the installation was implemented, bringing together design ideas from acoustic communication and accommodating for elements such as audience and equipment discussed in this chapter.

**4.2 Time and Location**

The installation was held in room Falmer 120, a music classroom at Sussex University. The original desired location to hold the installation was the upstairs of a building called the Meeting House which is often used for music performances at Sussex due to its resonate acoustics and calm, beautiful and tranquil environment created mostly by a variety of different coloured glass windows in the wall/ceiling of its dome shape. Use of the Meeting House was denied as it was reserved for prayer. Trying to locate the installation at the Meeting House would therefore contradict the intent of abiding to professional considerations.

The Head of the music department was emailed to enquire about the availability of room Falmer 120. The planned date to hold the installation was Monday April $2^{nd,}$ which was during the university Easter holiday. The space was needed from around 9am until 6pm to allow time to test and set up, for the environmental factors to change over the course of the day and time to dismantle the installation at the end. The Head of Music was very supportive and allowed for use of the room.

Despite this room not being the initial choice for location it in fact turned out to have many advantages. Using a room on a smaller scale meant that the microphone did not have to work as hard to get a good signal. The fact that the room was smaller meant that there was less opportunity for background noise to be integrated into the signal patch.

Room Falmer 120 would allow more direct sunlight into the room whereas the coloured glass windows in the Meeting House would have filtered away some light which would have lessened the desired effect of changes to natural light on the sounds produced. The room was at the front of campus and easy to direct guests to. Being at the front of campus also meant that there would be more potential visitors passing by that may have decided to drop in and attend.

A lot of acoustic ecology projects are held outdoors in order to explore a range of environmental relationships. Even though this installation was held indoors it is not felt that it is what Schaefer described as being ‘in the lab’. The environmental factors are controlled by elements from outdoors as well as inside. A primary reason for not holding the installation outside was due to the use of electrical equipment. With the unpredictability of the British weather it would be safer in terms of health and safety to hold the installation inside.

The room itself was fairly dull and uninspiring. This could be considered quite positive to what the aim was to achieve as the room gives a fairly placid, blank canvas, which doesn't impose too much of a predetermined point of reference. Therefore it is likely that it would be easier to focus attention on listening as opposed to for example, attractive decorations in the room. This may lead to an increase the listener's ability to be aware of subtle changes in the sound and environment and for connections to be made in regards to what is evoking them.

In order to try and get an idea of how the light levels would change throughout the day Falmer 120 was visited a few times the week previous to the installation to gather an idea of what the position of the sun would be during the day and how much natural light would be coming into the room. Figure 4 (shown below) provides a rough idea of the sun position in the sky in relation to the Arduino:

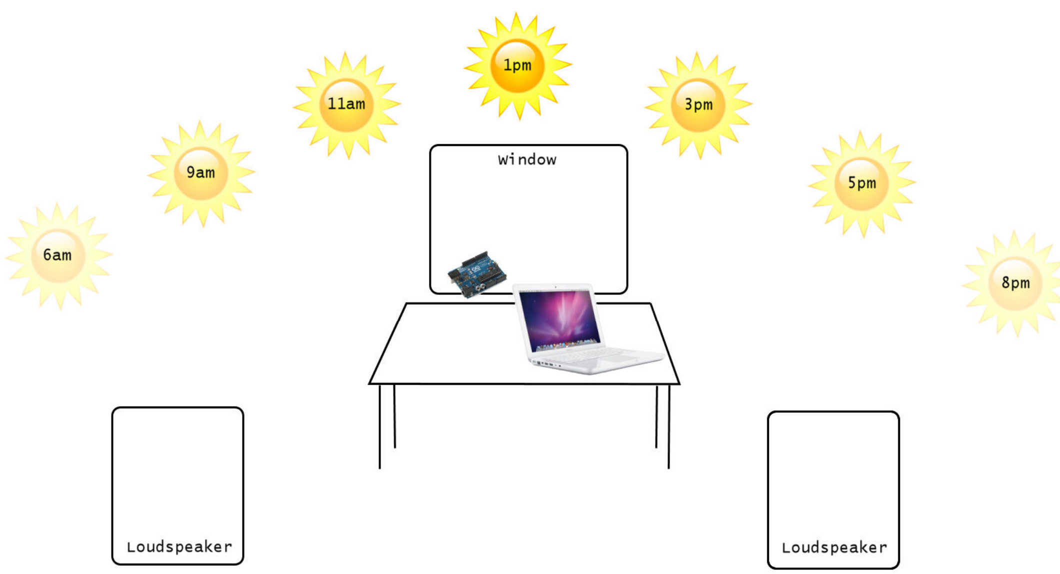



*Figure 4: Provides a rough indication of the sun position in the sky over the course of the day in relation to the Arduino and sensors.*

The windows in the room were not high in quantity and were not especially large so the sensors needed to be placed as close to a window as possible in order to register the maximum possible change in light over the day. It was fortunate that the window ledge was large enough to safely accommodate the Arduino and that there were power supplies located just below.

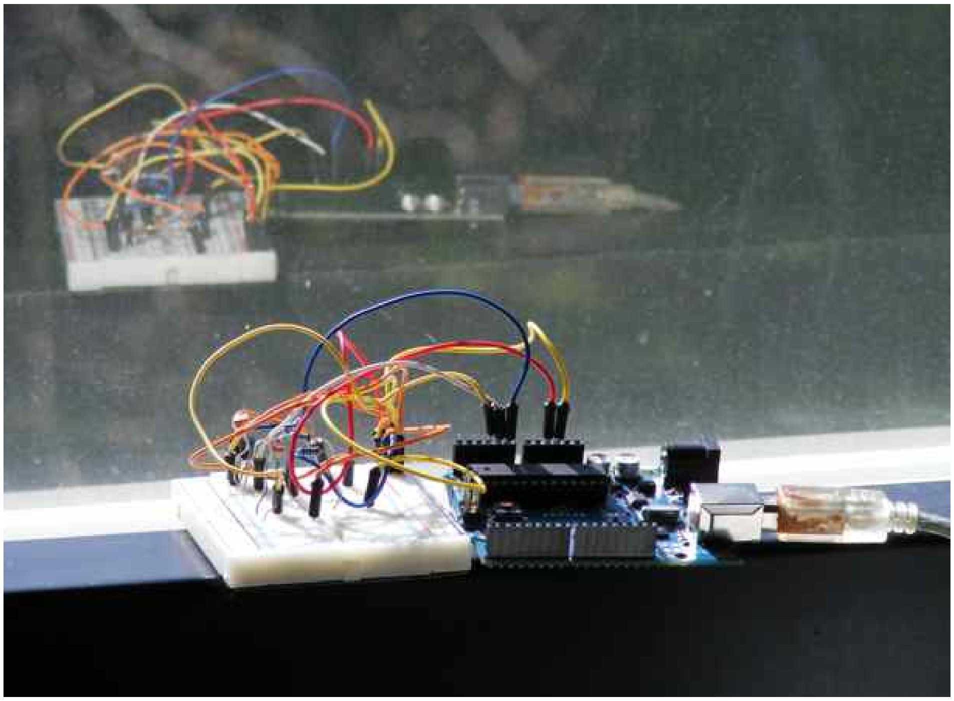


*Figure 5: Image showing placement of Arudino and sensors on window ledge, it is being reflected in the glass.*

Changes in room temperature were not predicted to be very dramatic (unless there were extreme weather conditions on 2nd April) but it was possible for slight change during the day due to changes in sunlight and amount of activity in the room.

In listening to the natural sounds produced by the surrounding environment (when alone in the room) it seemed the room was fairly quiet, the main extraneous noises being from people shutting doors outside, seagulls, quick segments of passers by talking and faint road noise from cars driving slowly on a road parallel.

**4.3 Audience**

By holding the installation on Sussex University campus it would be expected that university students and staff would be most likely to attend. The installation was however open to the general public so it was anticipated that its demographic could include any from any age range, gender or race. The fact that the installation was held during university holidays meant that it would not be expected that as many passers by would attend than potentially would have attended if it had been held in term time. On the other hand a lot of students especially in final year were likely to be on campus over this period in order to work towards deadlines set for after the Easter break.

In order to make sure that people were aware of my installation it was promoted through email, social media and putting up posters on the day. The Sussex University Music Informatics mailing list was emailed in regards to attendance to try and appeal to course mates to attend. This was because it is more likely that people would be to be motivated to come if they had some interest in the subject area. It was therefore assumed that in this context the audience would be fairly well educated with varying degrees of knowledge on the subject area. It was hoped that this target audience would be able to give constructive feedback, gain some or further knowledge about the subject from this project and possibly appreciate the musical outcome.

An event was also created on Facebook in order to promote the installation. The Facebook event was an effective way of quickly reaching a large number of people. The event was public so anyone could view it but people were specifically invited if it was thought that they would have an interest in coming.

The main aim of this project was to try and get people to communicate with their surroundings through the medium of listening. It was important that the project aim was clear to the audience so that they could understand why the installation was running and what they were required to do whilst visiting it. When promoting the installation through email and Facebook it was made sure that potential visitors were given a clear summary of the project aims and what they would be asked to do on the day.

For example the installation ran for 6 hours but it was understood that the majority of people would not be able to come for long periods of time. They were therefore advised to come for a short period of time in the morning and then asked to return again later in they day if they were available, to see if they could hear much of a change in the soundscape.

They were also informed that they would need to fill out a questionnaire about their listening experience. It was very important that listeners filled out a questionnaire as it allowed a way to collect qualitative data, which could later be analysed and evaluated to draw conclusions from. Open-ended questions were used so that the listener had to think more deeply about their answer and hopefully listen more thoroughly. As well as being evocative the questionnaire was constrained to two sheets of paper so that it did not seem daunting or too much like a chore to the visitors. A blank copy of the questionnaire will be included in the appendices of this report and a summary of the responses will be contained in the evaluation section.

Handouts were given to each visitor to introduce and explain what the installation entailed. Each visitor was greeted with a handout and informed as to how the installation had been put together and the context behind it.

*Figure 6: Introducing visitors to the installation.*

*Figure 7: Introducing some more visitors to the installation*

### 4.4 Equipment

*Figure 8: shows the set up of the equipment on the day of the installation.*

The list of equipment needed to created the installation:

- Macbook with the SuperCollider program written to sonify environmental data.
- Arduino.
- Light Dependant Resistors.
- Temperature Sensor.
- USB cable.
- Edirol 24bit, 96 kHz USB Audio Capture UA-25 audio interface.
- Neumann TLM 193 Microphone.
- XLR cable.
- Microphone stand.
- KRK VXT 6 monitors.
- 2 x monitor stands.
- 2x Stereo 1/4" to Stereo 1/4" cables.

### 4.5 Inputs and outputs

In order to turn environmental data into music the data must be received from the outside world and fed to the computer before it can be mapped musically. Sensors allow the environmental data to be turned into an electrical signal. This problem of turning outside data in to a signal that can be processed by a computer has been tackled for some time in terms of sound recording. For pressure waves in the air, a microphone gives intermediate conversion to an analogue electrical signal, and then conversion by an ADC into samples (Collins N, 2008).

For Sound Surroundings a Neumann TLM 193 microphone was used to capture audio data. This was used to detect both sound and movement. In choosing a microphone an Sm57 and an SE2000 were also tested to get an idea of the level of difference an alternative choice in microphone would make. The Neumann was considerably more sensitive and therefore more effective for detecting subtle changes in the sound environment. This is predominantly a studio microphone suited to less spontaneous work meaning it possesses precise and heightened sensitivity. The Neumann has a large diaphragm with a cardioid pick up pattern. Frequency response is relatively flat down to 20Hz therefore very low bass frequencies are reproduced without coloration (Neumann.com). Transduction of lower frequencies of sonic events through the dense material of the building structure meant the Neumann was able to pick up very small details such as footsteps from the other side of the room and the doors from other rooms closing.

The microphone was placed in front of the monitors to try and avoid any loud and unpleasant feedback noises. This was also achieved due to the microphones' unidirectional cardioid pick up pattern. The average unidirectional microphones tend to have around 20-30 db greater sensitivity to sound waves approaching from the front than behind (Ballou, Ciaudelli, Schmitt, 2009).

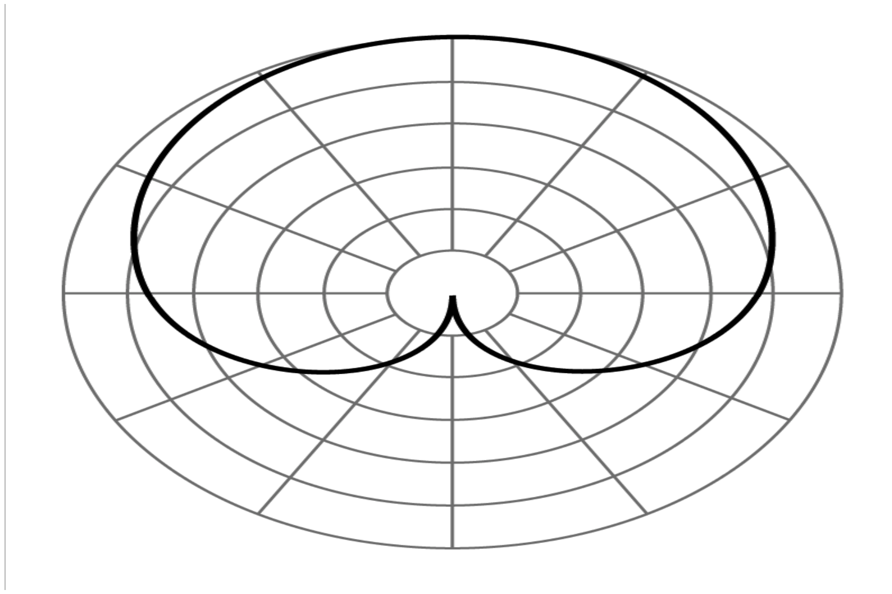


*Figure 9: Representation of a cardioid pick up pattern. (Leo Cuomo, 2011)*

This was beneficial to Sound Surroundings, again to try and reduce the amount of feedback captured from the monitors.

The Neumann was connected to the Edirol audio interface via XLR cable from which it was supplied phantom power. The analogue to digital conversion was also made and sent to the laptop via USB cable. The gain levels on the interface were increased to add to the microphone's sensitivity. The direct monitoring level was turned all the way down so that the sounds captured by the microphone were not amplified, the sounds that were amplified were those produced by the program, which were affected by the sounds captured from the environment. The environmental factor of movement affected sound parameters as the sensitive nature of the microphone meant it was able to pick up changes in pressure on the ground as people moved around the room mostly through vibrations travelling through the microphone stand.

The KRK monitors were positioned in a stereo set up and were used in order to convert electrical energy into acoustic energy to amplify sound. They were placed approximately 2 metres apart. The stereo set up is traditionally used in mixing to try and spatially replicate how sound is heard through natural listening. This is better achieved through the use of headphones where each ear only receives one signal channel. If the 'optimum' listening position were achieved in which the positioning of the listener to the speakers resembled the points on an equilateral triangle, the listener would receive sounds from both monitors. The sound from the left speaker will reach the left ear first followed by the sounds from the right speaker and vice versa (McCorick & Rumsey, 2009).

Chairs were spaced out across the majority of the room facing in different directions shown in the images below:

*Figure 10: Indicates set out of chairs and guests listening.*

People could sit wherever they wanted or could walk around if they preferred. This was explained to them on the handout they were given when they entered. Encouraging people to listen from different positions around the room aimed to get them to try and notice whether the sound was different from varying perspectives. Being further away from the speakers would make the sound slightly quieter to the listener with very slight differences in delay. The time taken for sound to travel the extra distance from perhaps the left speaker to the right ear would also change depending on position in space.

Differences in phase, leading to the cancellations of certain frequencies could mean that sounds are heard differently from other areas of the room.

*Figure 11: Indicates set out of chairs closer to the equipment set up and guests listening.*

It must therefore be expressed that through use of the stereo monitor set up the aim was not to try and reproduce a perfect representation of how the sounds should be heard by the ears. Working with sound can be as much of an art as a science and the impression of space; source position, size and depth are all factors that were used to explore the ways in which they effected people's perceptions rather than concentrating on replicating sound field accuracy.

The monitors were positioned so that they were close to a wall. This helped to make use of 'room gain' in which the low frequencies are reinforced. When exerting low frequencies the speaker is virtually omnidirectional, transmitting sound fairly equally in all directions. The sound omitted behind and to the side of the monitors reflects off of the walls, which adds to the bass. There was some elimination to high frequency splash due to the brick walls. The walls were parallel though which can cause a great deal of reflections of high frequencies, The curved ceilings help to curb this as the frequencies are reflected in a scatter pattern making it less noticeable.

Light sensors and a temperature sensor were used to obtain real time environmental data.

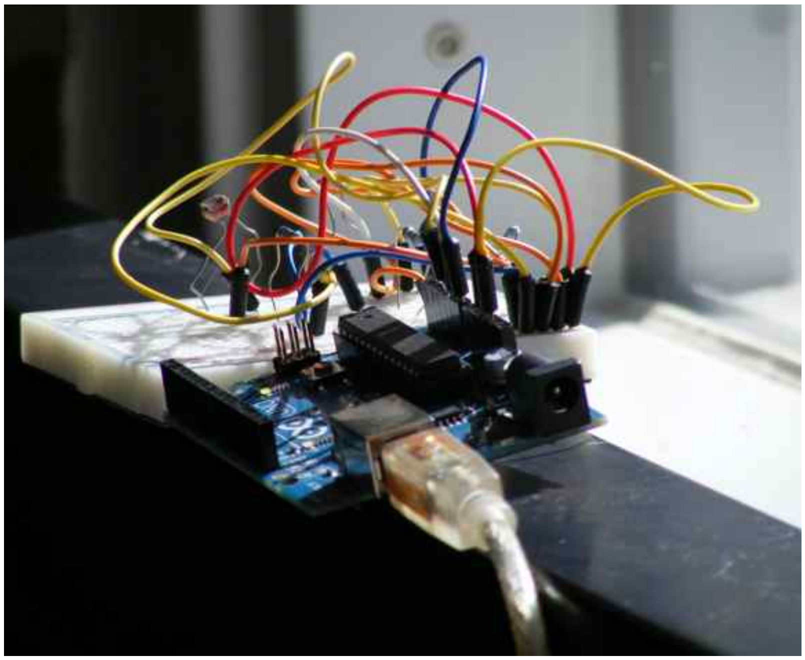


*Figure 12: Showing the sensors wired to the Arduino.*

The model of Arduino used was an Arduino Uno. This is a reference version of Arduino and therefore a simple but reliable model that fulfilled the needs of the Sound Surroundings project. It has fourteen digital outputs as well as six analogue outputs. Sound Surroundings makes use of three analogue outputs: one for each sensor.

There is a second microcontroller on the board to handle all USB communication. This is the small surface mount chip (the Atmega8U2) located near the board's USB socket (Margolis M & Veldin N R, 2012). The Arduino uses the USB connection as a method, which enables it to be powered by 5 volts of the laptop's (in this case) power.

The board is only able to control and respond to electricity. Components must therefore be attached to it to enable interaction with the environment. For this project the components used are sensors that convert aspects of the physical world (light and temperature) so that the board can sense them (Margolis M & Veldin N R, 2012).

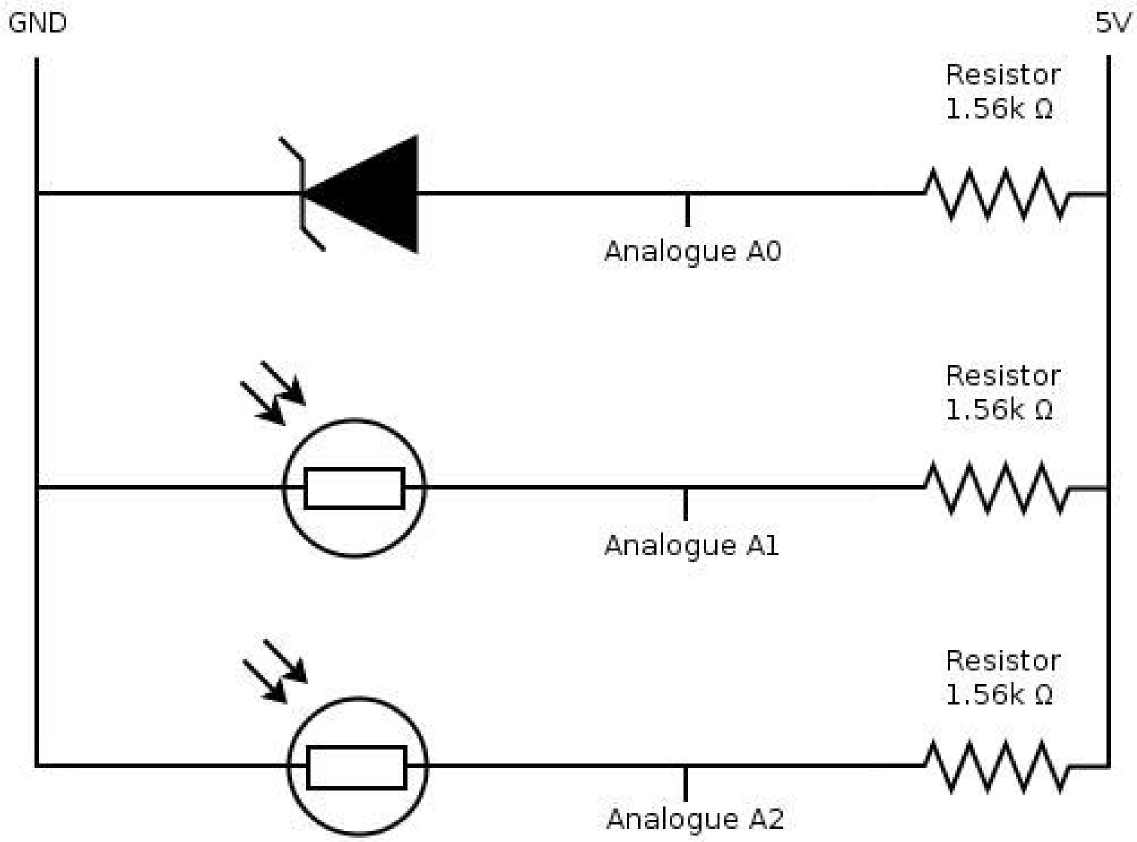



*Figure 13: A circuit diagram representing the circuit used in Sound Surroundings.*

A solderless breadboard is therefore used to host the circuit needed to connect the electrical information to the Arduino. Light is sensed using two photocells also known as light dependant resistors (LDRs). They give a variable resistance that changes according to the light. This is then read by the Arduino as an analogue value.

These photocells are cheap, hardwearing, and do not take up much power. Photocells are non-polarised so they can be connected both ways around making them very simple to connect. The disadvantage to them is that they are not highly accurate and it is possible for 2 different light sensors to differ slightly. They are therefore better for determining basic change in light level as opposed to getting a being used to measure precise levels of millicadela/lux (Fried, 2011). When put into practice it was found that they responded immediately to changes in light and it was felt they would be sensitive enough to be used to measure light for the scope of this project.

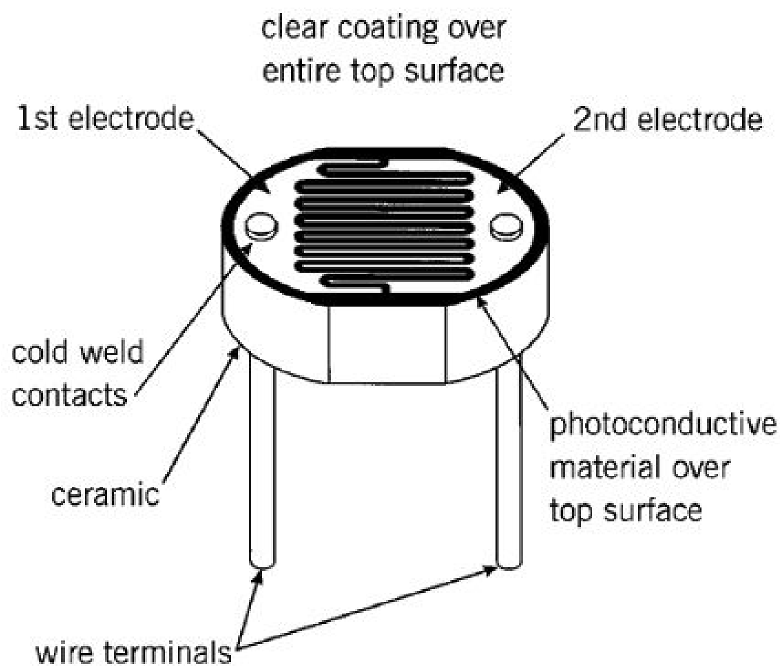



*Figure 14: Diagram showing different parts of a plastic coated photocell. (Fried L, 2011)*

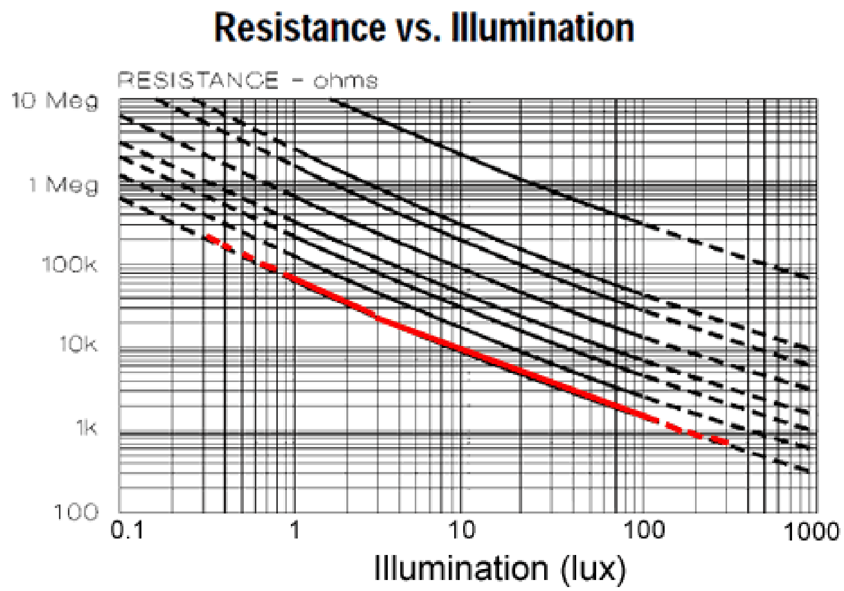



*Figure 15: Graph displaying resistance in relation to illumination of a photocell. (Fried L, 2011)*

The resistance of the photocell changes depending on the amount of light exerted onto it. In the dark the resistance is high (up to 10MΩ). The lighter it becomes the more the resistance increases. The graph above gives an approximation of what the resistance of the sensor would be at different light levels.

The Temperature sensor model used was an LM336 developed my STMicroelectronics. It is a precision 2.5v regulator diode with a low temperature coefficient, which ensures for temperature stability.

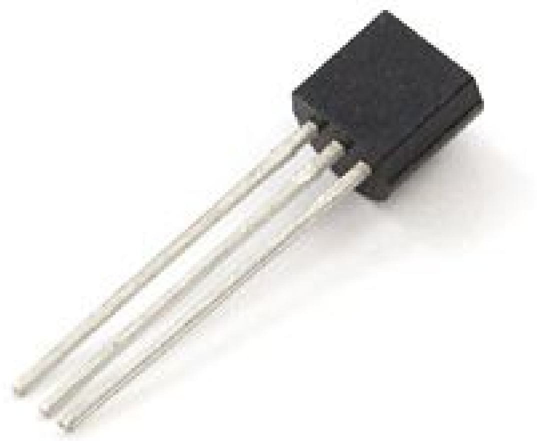


*Figure 16: Image of a temperature sensor (Fried L, 2011)*

It is used to sense ambient room temperature. As the temperature increases the voltage diode also increases at a known rate. An analogue signal is generated which is proportional to temperature by precisely amplifying the voltage change (Fried L, 2011). The advantage to using this type of temperature sensor is that they are consistent between sensors and readings meaning they are easy to replace if needed. They are robust and work in a range of environmental conditions.

The method used to convert temperature into voltage is as follows:

Temp in °C = [(Vout in mV) - 500] / 10

However for this project it was the change in temperature that was of importance rather than getting an accurate reading of what the exact temperature was at different parts of the day.

Wires were used to connect the sensors into a circuit. They allowed for an unimpeded flow of electricity from one component to another (Arduino.cc, 2012). Stranded wires were used for flexibility and the ability to quickly rewire. Resistors were used in order to resist the flow of the current on to the sensor components.

A solderless breadboard was used for the circuit to be constructed on. Electrical contact is made to metal strips inside the breadboard. Soldering is not necessary in order to hold the components in place.

## Chapter 5

# 5.0 Software Implementation

Between the input being received via the sensors and the sound outputted by the speakers a program written in SuperCollider was used in order to structure, map and sonify the data. This section will focus on explaining how this was achieved.

### 5.1 Arduino

The first stage was to get the Arduino to communicate with the SuperCollider software. Communication to the Arduino is available as a Quark using the Arduino class. This provides an abstraction of the serial connection, which allows for reading from and writing to a program running on the Arduino board using pluggable protocol parsers (Baalman M, Boverman T, Kersten S, 2011). The SMS (SimpleMessageSystem) is a prebuilt protocol, which provides an Arduino extension providing an ASCII-based way of data exchange.

The `ArduinoSMS` class is an abstraction for communication to the board via SMS and is used in the same way as its Arduino base class. The constructor contains two arguments, the serial device identifier `portName` and a serial baud rate. These should be the same for the device selected during its serial device initialisation.

This initialisation code is used at the start of the Sound Surroundings programme to allow for communication from the program to the Arduino. The sounds used to sonify the data are then mapped to sensors using an `ArduinoSMS` reading loop, which writes and compiles to the board's flash memory.

## 5.2 SuperCollider Program

### 5.2.1 Algorithmic Composition

This programme produces a generative soundscape controlled mostly by surrounding environmental factors light, temperature, sound and movement. Generative music is another term given to real-time algorithmic composition (Collins, 2010). The environmental factors interact with the algorithms in order to change different parameters within the sounds.

In designing the control structure of the soundscape it was important to keep the audience in careful consideration. The installation was for people to focus on communication through the medium of listening. The parameters of the sound were controlled primarily by environmental factors using sensors. Two loops were also included which made random change to amplitude and frequency of sounds once every 90 (`amplitude`) and 50 seconds (`freqeffect`). This was to add in more variation to the soundscape and to give the audience an evolving range of sound and texture to listen to. It could be argued that the soundscape is not controlled completely by environmental factors, but once the changes made by the `changestate` loops have been applied this then outputted into the environment. This was then fed back into the system as an environmental factor.

When designing the scheduling of these sounds it was felt that the times specified in these loops allowed enough time for subtle changes to happen and evolve before the next change. It was hoped that the changes would intrigue people and help them to keep focused on listening if attention did start to waver.

The boolean funtion `.coin` added an element of probability through making subtle changes to the frequency of selected sounds which again helps to add variation to the soundscape. Structure was controlled through use of global variables ~. This helps to enhance code flexibility as they allow for global storage and are easily recalled (d'Escrivan J, Wilson S, 2011). They help determine structure in that all the sounds are played continuously. The texture of the sound changes over the course of the day. At some parts of the day some sounds will be only just noticeable and the texture will be very thick and lively at others. Structure refers to when and how things happen. Microstructure in this piece refers to different synthesised sounds used and macrostructure refers to connecting the different blocks of sound together and creating a composition, most of which is done through control via global variables.

### 5.2.2 Sonification

Sonification can be described as the perceptualisation of data by sound (Bovermann T, de Campo A, Frauenberger C, Rohrhuber J, 2011). It expresses data into the auditory domain in order to use the ear to determine its properties (Collins, 2010). It is a way of musically expressing data usually through synthesis. "In neural terms the temporary resolution of the ear is higher than that of the eye, and the ear may arguably be better developed to cope with simultaneous streams of information"(Chion, 1994; Fitch and Kramer, 1994 in Collins 2008). In this project, sonification is used to explore this as it aims to enhance the ability to communicate and interact by focusing on listening as opposed to through other senses.

In The SuperCollider Book Auditory Display is defined as "the rendering of data and/or information into sound designed for human listening" (Bovermann T, de Campo A, Frauenberger C, Rohrhuber J, 2011). The two branches of this are Auditory Information Display, which is used to render common knowledge information into sound designed for communication with human beings.  Some examples of this are alarms and auditory feedback sounds on computers.  The other is Sonification: "the rendering of (typically scientific) data into (typically nonspeech) sound designed for human auditory perception". Sound Surroundings makes use of the latter.

There are many scientific uses for sonification. Medical applications of it are thought to date back even past the stethoscope's invention in 1819. (Collins N, 2008) A well-known scientific use of sonification is that of sonar, in which underwater sound reflections are listened to in order to determine the distance of potential mines or ships. They could also be used to identify passing whales of fish swarms (Bovermann T, de Campo A, Frauenberger C, Rohrhuber J, 2011).

Sonification does not need to be used for a strictly scientific purpose and the data provides composers with material in which to discover a new medium to create music that could result in unexpected structures and results. In terms of this project the main focus is on listening to which sonification can provide new perspectives.

To the listener sonification can provide an interest into what the sounds represent, how listening to them is impacting on their moods, why they are concentrating on listening to these sounds, whether they are absorbed by listening to the sounds and if it has changed any of their perspectives.

Choosing and creating immersive and provocative sounds for Sound Surroundings was challenging. The aim was to develop an interesting and evolving texture, which allowed for lots of subtle changes that the listener would start to notice if they concentrated on listening intently. Getting a balance between something that was interactive, exciting, stimulating and engaging without sounding messy and 'noisy' was important. A variation in the sound and mood created by the music would add more interest and contrast to the soundscape. There was not one particular enforced mood that the soundscape was set to create, rather the sound was supposed to produce a variation in which people could interpret how they wished.

The sounds were assigned to separate global variables to enable mapping later on. The first sound created (`~sound1`) was mapped to the microphone. The environmental sound captured is used to manipulate the amplitude of a band limited impulse generator. The `freqadjust` argument was added in order to add some variation often in the form of interesting drone like bursts. Overall the sound had a fairly drone like quality, which sounded almost hypnotic at times as it panned back and forth between the monitors. This patch was particularly responsive and probably the most immediate mapping for the audience to identify as talking close to the microphone or even walking past it would have an obvious effect on the sound.

`Sounds ~2-5` were created using a patch adapted from an example in the SuperCollider 'Control' help file. It creates a `SynthDef` used to form a bank of fixed frequency resonators in which each mode is provided with a ring time. This resulted in 4 ambient sounding tones which when mapped were divided so that there were two on each light sensor. An amplitude argument was added as well as changes to the `decayscale.` The different frequencies were assigned to different global variables and `ControlSpecs` were applied (which will be explained in the mapping section below). Using these ambient tones helped to create a background layer that gave off a relaxing feel in contrast to the drone of the microphone. The amplitudes of these tones changed depending on the amount of light received by the LDRs. The darker the light levels the higher the amplitude level.

`~Sound6` also used the microphone as an input. This sound was adapted from an example found in the SuperCollider 2 Examples folder, which synthesises a reverberated sine percussion sound. The original sound was considered a bit too ominous and it was felt along with the microphone drone that it would impose too much of an eerie/un-nerving sense to the installation. When listening to it, it conjured up images of either being alone on the moon or walking around late at night not feeling safe. The fact that it somehow had this effect of stimulating images in the composer's mind made it seem like it could have the same effect on listeners at the installation.

The sound was applied to the microphone input and given an amplitude argument so that the louder the environment, the louder the amplitude and more of these reverberated sine sounds would be heard due to there being more delays. By increasing the resonant frequency the sounds became higher in pitch, which caused them to sound almost like twinkling sounds. The use of `rand` meant that differing sounds were continuously being produced which gave a sense of the sounds constantly changing and evolving in terms of amplitude, frequency and delays which helped create an interesting new dimension for the listener without being too overpowering.

`~Sound7` used a variation of the reverberated sine percussion patch used in `~sound6`. The sound was mapped to the temperature sensor, which was unlikely to change very dramatically. It was difficult to get the balance between the mappings using tones as it ended up being too sensitive and moving between two tones too much which sounded out of place.

On adjusting mappings it was found it could also not be sensitive enough and thus there were not enough changes to the tones. The reverberated sine percussion sound was a more suitable option. Changing this sound by adding subtle probabilistic and random elements and setting it into a routine in which it looped every 60 seconds helped to make the most out of the subtle change in sensory data.

`~Sound8` added to the texture and subtle changes occurring in the soundscape. This patch builds new synths every two seconds in which the amplitude changes randomly anytime between 5 and 20 seconds. This amplitude of the sound is also determined by an LDR and the `freqadjust` argument is added to it which is controlled through use of a coin and the `changestate` loop discussed in the above algorithmic composition section.

Finally `~sound9` was added just to give a little more depth to the texture and was given an amplitude argument which was contolled by a LDR. It was taken from the `Klang.ar` documentation and provides a bank of fixed frequency sine oscillators. It chooses randomly from an array of filter frequencies, which again adds more subtle variety to the soundscape.

### 5.2.3 Mappings

Sensory data from the microphone and Arduino was inputted into SuperCollider where sound material to sonify the data was created. Parameters of these sounds were mapped to the sensor values using the ControlSpec class. The parameter affected by the sensors is amplitude, therefore the sensor values need to be converted so that they worked in the amplitude range of 0-1. The ControlSpec class takes care of this through use of its map and unmap methods. The minimum and maximum values posted from the sensors are provided and the ControlSpec maps this to usable values between 0-1, which can then be sent to the SynthDef. The ranges set in the ControlSpec help to influence how simple it is for listeners to understand the sonification design (Baalman M, Boverman T and Kersten S, 2011). In order to achieve effective mappings the sensor values were carefully observed under different light levels at different times of day to make sure the minimum and maximum values were correct.

# Chapter 6

# 6.0 Evaluation

### 6.1 Testing

In order to test out the installation before its exhibition, it was arranged for 3 guests to come and listen to it. This was held in the authour's room in a shared house mostly for the purpose of convenience to both the listeners (the author's housemates) and to diminish the need to move the equipment to a different location from where it was set up when being developed. Two of the listeners did not have any formal musical training. They were given an explanatory outline of the concept and were told what to expect at the actual installation at room Falmer 120.

The guests listened to the soundscape for 15 minutes. They listened mostly in silence as they were told this would probably help them to focus on their listening experiences. They did say a few words to each other mostly when there was a change to the sound they were not expecting. This helped with consideration to whether guests would be instructed to be silent when listening. It was decided that this wouldn't be the case as other people in the room could be asking questions or new people could enter and be spoken to when given handouts and explanations about the installation. Silence would have been too imposed and difficult/unfair to enforce.

Rather than filling out questionnaires, an informal discussion was held after the 15 minutes of listening were over in which they were asked the questions that were being considered for the questionnaire. This posed very useful in modifying the questionnaire as it reinforced the need for use of open questions in order to provoke discussion. It was also helpful to get an idea of the kind of questions visitors would ask and the levels of understanding already possessed regarding sound installation work. In this case two of the guests did not have much experience of sound installation work but one did have a keen interest in acting and theatre so the fact she was making association to moods and memories through sound made her think about how this was achieved in theatre through the acting, scenery, light and music. She felt she had never realised how much concentrating on the medium of sound alone could create a strong connection to thoughts and feelings.

The other listener who had no formal music training seemed to be very interested in understanding how different sounds were being changed by the environmental factors. This was shown through a want to physically interact with the sensors. Originally it had been planned that the interaction with the sound would be through listening rather than taking a HCI approach therefore people would be told not to purposefully cover the sensors to change the light or talk directly into the microphone.

After testing the installation it seemed that the listening experience was enhanced/made more interesting if people were able to get a better understanding as to which elements were changing sounds. It was decided that under supervision (so as not to damage the circuit) visitors would be allowed to obstruct light from reaching the sensors (most likely by putting their hands above them) and talking into the microphone to understand how the installation interacted with the environment.

Separately to the user testing, the installation was left to run for around 3 hours at home with no visitors present in order to test that the set up would cope without crashing or overloading and to get an idea how much sound would change. The installation ran without any problems. The changes to the sound were fairly slow in evolving as the changes in environmental factors were not so vast but changes were still noticeable.

### 6.2 The Installation

The installation was open to the public from 11.30-5.30 2nd April as planned. The installation was tested from 9 am in order to check that the set up was running smoothly. It was a very warm, bright and sunny day all day, which contrasted to previous visits to Falmer 120 in which the weather has been rainy and dull. The ControlSpecs were altered for the sounds mapped to the light sensors as the high levels of light meant that they were not heard at all in comparison to testing at home where the sound had been quiet but still audible during periods of light. These were simple to adjust and by doing this sounds were not completely lost due to vast quantities of sunshine, instead they were heard faintly.

About twelve posters were put up, mostly with arrows directing visitors to the room. The room was positioned at the top of a staircase. Two doors were to be walked through in order to get to the room. The first one was wedged wide open and the second closed. This was in the hope that passers by would hear the soundscape and decide to drop in. It also helped for directional purposes. In total there were seventeen visitors to the installation, twenty questionnaires were completed in total as three people returned to complete one for a second time.

This seemed like a reasonable amount of attendees considering the installation was held during university Easter holidays. Although it would have been preferred if more people had returned it was felt that seventeen people was a successful turn out as it allowed for enough qualitative data to be collected in order to analyse. There was a fairly steady flow of people, which made it simpler to introduce the visitors to the installation and explain the set up and concept. The fact that it was held during the Easter break meant that classes of students that could have potentially been nearby were not disturbed and despite the installation volume being fairly loud at times there were no complaints.

### 6.3 Results

Results were obtained using qualitative data collected from visitors to the installation through the use of questionnaires as well as observations from the author. Qualitative data was preferred as the project aim focuses on the listening experience of the user (sound from a human perspective), therefore it seemed the most effective way to receive feedback was through first hand responses provided by the listeners. The questionnaires were anonymous as people were being asked to write about memories and emotions so it was decided that they would feel more confident in being open in their answers if they were not easily identifiable. As well as questionnaires photos and videos were taken at different points over the day to document listener behaviour.

The pie chart below shows the duration that people spent listening to the installation, which they specified in the questionnaire:

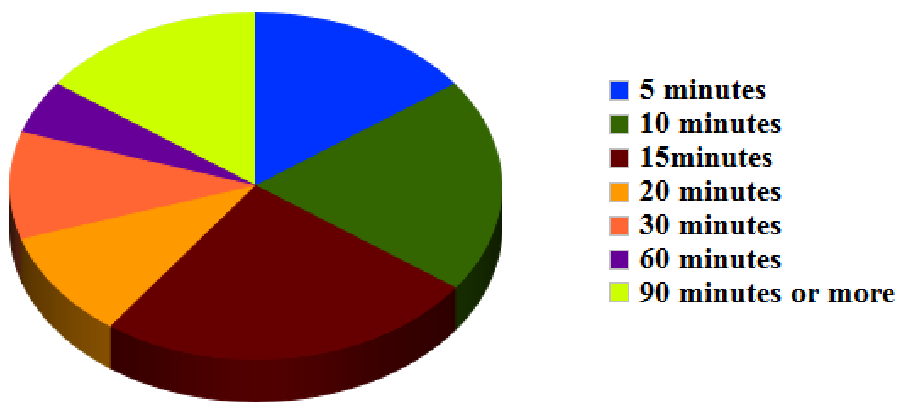



*Figure 17: Pie chart showing duration of time visitors listened to the installation.*

It can be seen that the majority of people stayed for 15 minutes. This should be the point at which the threshold of hearing drops. From the questionnaires it could be seen that people who spent 15 minutes or more listening to the installation gave more insight into what the soundscape caused them to think and feel. It could be argued that people who stayed for less time could have been in a rush and unable to spend as much time filling out the questionnaire which seemed to be the case for some people. Overall it was clear from responses and observation that the more time was invested in listening, the more impacted the listener.

At the start of the questionnaire the visitors were asked whether it was their first visit or if they were returning, the time of arrival and an approximate time that they had stayed and listened to the installation.

They were then asked if any differences had been noticed in the soundscape over the period of time they had visited. This was to help stimulate listening by giving them changes to look for. Overall everyone was able to notice some kind of change. They seemed to notice different elements as opposed to all noticing one main change, which helps to back up the aim of creating a variety of changes within the soundscape. Some examples of changes noticed were that "Certain elements became louder", "Crystalline raindrops increased in presence", "Sudden periods of calm', "Drone sound completely removed" and "At first it sounded like an ominous, deep sort of vibration which reduced and more sounds like tinkly bells came in which sounded more happy and ethereal".

They were asked 'In what ways have you noticed a relationship between the sounds produced and the surrounding environment?' This question aimed to encourage awareness of the surrounding environment and how it affected the sounds. A lot of people were able to make the connection between light and the sound changing ("Light changes mix", "Reacted to changes in light", "Sound changes when we talk louder or when there are clouds outside") but they didn't give much detail as to how the sound had changed.

Change to sound captured by the microphone was the most obvious change ("Vibrations from footsteps generate changes in tones", "Movement on the floor makes changes to sound produced and produces new sounds"). Somebody commented that the relationship was that it "Makes visitors part of the installation" which portrays an understanding that people in the installation helped to change the outcome of the soundscape. On the other hand someone commented that the "Environment hasn't changed noticeably" this could mean they didn't understand the question or it could mean that they didn't make a connection between sound changing and the environment. It seems that the vast majority of people were able to make some sort of connection between the two.

The next question 'How has listening to the soundscape altered your mood since first entering the room?' was used to decipher how much power listening to this soundscape had to influence mood. Nearly everyone commented that they felt calmer or more relaxed

("The monotonous bass wave has a trance like effect, and the high pitched notes are calming"). It was interesting that some people felt a contrast in their mood over the listening period ("It was nice at first, now it sounds like horror film sounds" and "It was very tranquil, hypnotic and relaxing until the pitch changed"). The intention was that the sonification used to create the soundscape would allow for a range of moods to be interpreted so this seemed to have been successful.

Visitors were then asked which sorts of thoughts, ideas or memories were evoked whilst listening to the soundscape. This was to get them to become more absorbed in the soundscape and to help them make connections and possibly empathise through listening. Some examples of responses were: "Found my mind emptying of thoughts and concentrating on sounds", "Rain drops, industrial machinery, colours", "Caves, water, calm", "Being on holiday somewhere sunny", "Horror movie, meditation", "Dreaming in a mossy cave", "Waterfall". Most people associated experiences (either real or imaginary) to the soundscape.

They were then explicitly asked if the installation had effected their perception of the environment in this space. As hoped, most people experienced a change in perception as a result of the installation. Some people felt a change in their perception to the size of the space ("Makes space appear larger - changes from loud/quiet create illusions of space changing", "I'm aware of how much space there is in the room – I do not feel claustrophobic").

Others felt their attention was focused on a certain area of the room ("I am paying attention to the lit/shaded areas of the room", "I have found that my interest in this space has been mainly revolving around the area with the speakers"). One person felt more aware of other people in the environment ("Made me focus on people around me and how they move and how loud they talk"). The non descript connotations of the room were also considered ("I liked that the environment wasn't distracting from the sounds. Once I really listened in I didn't really notice the surroundings"). It could potentially be interpreted that through not noticing their surroundings this person was unable to communicate with the surroundings through listening. On the other hand the fact that the environment was non-descript did not provide the listener with much novelty. This could be perceived to enhance the concentration on listening as a distraction was not imposed.

Another person felt that the soundscape had transformed their perception of the room (“The installation is reshaping the classroom environment to a tranquil, reflective space”). Only one person commented that they did not feel their perception was effected (“Just the same”).

Listeners were then asked to consider whether the soundscape had entertained or interested them? In acoustic communication the main focus generally isn’t on whether the audience like or dislike the sound material, rather whether they have engaged in it enough to make this decision. This question was included as it seems well known that if someone wants to listen to music it is usually because they enjoy that particular music. Through finding out which elements people enjoyed it may have been possible to enhance these elements or to work on less well received aspects in order to gain ideas in how to improve the soundscape and listening experience.

Some people commented that they were intrigued by the soundscape as it was something they had never experienced before. (“Never seen anything, heard of anything like it before”, “ Nice to sit down and listen to something new”). Some people commented that they liked trying to depict why sounds were changing (“It is changing but it is hard to pin point how and why exactly, This is a subtle mystery! Feels like time itself is slowing down”, “Interesting in the way sounds suddenly drop in and out. Twinkling sounds ensure that constant engaging material occurs. Many layers are only noticeable when you really listen”). Most other people commented that they liked the sounds used, the shift in mood and the fact they were able to relax from their otherwise busy lives.

Visitors were asked what they did whilst they listened to the installation. This was to help get an idea of when people actively and passively listened. From observation it seemed that most people sat down for the majority of the listening period. This was mostly influenced by the fact that this was the most comfortable way to fill out the questionnaire.

Some people did purposefully interact with the Arduino and microphone to change sound ("Walked around to trigger changes, played with Arduino. Sat and reflected on soundscape").

Finally visitors were asked how often they focused on listening in this way. Nearly all responses were along the lines of 'rarely' or 'hardly ever'. Some commented that they did occasionally to music they liked ("A couple of times a week or when I get a new song but it is usually about the words"). This definitely proves Barry Truax's point that we as humans take sound and hearing for granted and that there is not enough emphasis on how sound connects us to the environment and how this impacts human behaviour.

People were asked to provide any general feedback. Some commented that they would be interested in seeing how the installation was perceived in different spaces to the room it was held in. Some showed appreciation for the sounds created and the balance between them. Some felt that it could have been broadened ("The mood it generates is nice and displaying the Arduino as opposed to hiding it is good. The timbral and rhythmic characteristics could be broadened, although it's a difficult balance to strike between active enough for a listener to hear an interesting range, but not so active to prevent a sense of environment and state").

From the responses it seemed that people were surprised by how much of an effect listening to the soundscape had on them as it allowed them to open up to interpret and really think about what they were hearing and why thus drawing a relationship to the environment mediated by sound.

# Chapter 7

# 7.0 Conclusion

Generally the installation was well received and exceeded original expectations in terms of how much the visitors seemed to take away from it. It was taken seriously and visitors allowed themselves to sit and carefully listen to the soundscape for 15 minutes on average. A few people seemed to find understanding the questions difficult at first (mostly people without musical background) but this posed a challenge to them and once they started listening carefully they were able to calm down, start thinking and open up and start writing.

Brian Eno gave an example of something his friend Robert Wyatt said to him regarding pretension (attempting to do something critics believe you have no right to even try). This was that we are always in the condition of children. We are often faced with things we don't understand and therefore need to guess and improvise. Pretending is what children do and how they learn (Eno, 1996 ). The medium of listening seemed to enhance this ability to learn and pretend which got listeners to start thinking deeply and engaging with the sounds and environment.

The listeners' ability to make observations as to the changes in the soundscape and how this was changing due to environmental factors was overall fairly good. Different people perceived different changes as opposed to a majority of people noticing a specific change. It was exciting to see how people were communicating with and interpreting the environment in their own ways much like how we engage with culture as acquired to our own tastes (hence choosing to follow different fashions or going to certain restaurants).

The majority of listeners commented that listening to the soundscape did affect their mood. Most people commented that they felt relaxed, though some people felt a significant change in mood corresponding with changes in the soundscape. The power that listening has to change the way a person feels makes it an important medium of communication as it allows for greater empathy with the surroundings. People visiting the installation are likely to be students or university staff who live in a city environment leading busy lives. Taking the time to listen intently to the soundscape gave them a chance to sit down and immerse themselves in the sound. This lead some people into an almost meditative state, allowing for emptying of stressed and tired minds. This may have resulted in giving them some calm, clarity and focus, which could enhance communication when they return to their daily lives.

Thoughts, ideas and memories were also evoked in the minds of most listeners. These associations could improve communication as people are referencing back to memories or images, which help to enable them to understand and identify with the environment. Investing more time into listening might help people see situations they remember in a new light or could improve ability to interact through making connections derived from past associations.

In terms of changes to the perception of the environment, most people recognised that their perception had changed. Some felt that the soundscape caused them to concentrate on the environmental factors that helped to produce changes. Others felt that the soundscape completely changed the space from a dull classroom to a tranquil and reflective space. The result of the last point may seem fairly obvious as holding the installation would have made a change to the room. The interesting point to draw from it is that people were able to forget the dull surroundings and become engaged and moved through listening alone.

All of the guests that visited the installation claimed to be interested by the sounds produced. The fact that they found it engaging reflects positively on the choice of sound design as an interesting and evolving soundscape was achieved which aimed to stimulate the listening experience and therefore provide more resources for communication through listening.

All of the enthusiasm and intrigue exerted by guests does lead to wondering as to why listening does not explicitly tend to be exercised in order to improve our communicational skills and improve our environmental awareness. This is especially as nearly every visitor responded to the question 'How often do you focus on listening in this way?' with "Hardly ever".

Barry Truax explains that a primary reason for this neglect of listening is due to how immediate and habitual listening has become for us.  We possess a psychological reaction to the degree of repetitiveness in a message, which to an extent, corresponds to the predictability of information (conformity and associations with past experiences) (Truax, 1984). The amount of detail in any acoustic situation is very large and the differences the brain can detect are often very small. This means that some 'screening' of information will have to take place to reduce the amount of data in order to depict what may be significant (Truax, 1984).

It goes to show that the active listening encouraged at the Sound Surroundings installation would have focused the mind to interpret sounds more attentively, which is unlike what it has become programmed to do in day to day life. This allowed people to think more intensely about the links being created in the mind to past experiences, which served to enhance the way they communicated with and interpreted the environment.

In terms of technology it is obvious that it was an essential and primary factor in the running and development of the installation. Technological impacts to the urban environment can be viewed negatively however, due to factors such as hearing damage and physiological stress caused by noise pollution.

The development of electro-acoustic technology has meant that sound no longer has to be closely bound to its source and heard only in a fairly small proximity to it. The ability for sound to be heard over a greater distance thanks to technology immediately enhances its communicational uses (Truax, 1984). Before electro acoustic technology no sound had ever been heard twice exactly the same. These exact representations of sound make information processing easier for the brain, as it is easier to match with a stored pattern. This therefore makes it easier to ignore un-needed information causing the brain to take on a 'background listening' attitude.

It is then likely that the visitor's minds are not used to listening and forming new ideas and concepts and are in a sense focused on matching sound to templates. It is hoped that in Sound Surroundings, as well as thinking about links created due to past experiences, new or not often explored imagery was also generated in their minds when listening to the soundscape to try and broaden their communicative abilities.

Repetitions of sound, encouraged by electro-acoustic technology especially when exploited in the commercial sense of modern culture (for example jingles in adverts) do not encourage sensitive listening. However electro-acoustic technology does have many advantages. It allows for sound to be taken out of its original context, which gives for a whole range of interesting possibilities for sounds to be perceived in different contexts.

As proved in Sound Surroundings this can completely change the way in which people perceive an environment as it was commented that the sound turned the classroom into a tranquil and reflective space. It is hoped that the installation added positive value to electro-acoustic technology as it demonstrated a way to make people think about their perceptions of the world thereby enhancing patterns of communication.

The installation gave an example of how technology could shape the compositional and design process. It created a split between performer and listener as the environment, which was to an extent affected by the listener was used as a controlling factor for sound parameters within the soundscape. The soundscape did not follow connotations derived from $19^{th}$ century music in which music serves to isolate itself to the privileged preserve of a talented few, without relation to other forms of human activity (Truax, 1984).

The use of technology within the installation was used to mediate between humans and their environment but the focus of communicational activity was on the communicational patterns generated by human minds, which is something technology is unable to do. Technology was therefore used to stimulate the listeners own knowledge and to hopefully leave them thinking about how they could try and exercise these practices in their every day lives. To achieve this they need to encourage themselves to listen beyond the repetitive modern soundscape provided so heavily within the urban environment, Sound Surroundings has proven that this could enrich their learning experiences and help them understand and question their patterns of consumerism.

**7.1 Achievement of Objectives**

From this analysis of the subject it is possible to conclude that the objective of creating a system to generate a soundscape that would enable people to communicate with the surrounding environment was achieved through the Sound Surroundings installation. Ultimately true achievement of the objective would have been if this had a lasting impact on the listening habits when they returned to their daily lives. It is hoped that guests were able to understand the benefits of actively concentrating on listening but maybe it would have been interesting to contact certain guests a few days later to learn the extent of the project's impact.

**7.2 Potential Solutions/Extensions**

There are a wealth of possibilities in terms of extensions that could be made to improve this system. The programme itself could be made a lot more complex in the sense that more subtle changes could be created possibly through stochastic processes in order to generate different processes of sound generation. Adding complexity to the program could generate more sonic processes for the listener to interact with though care must be taken to not overload the listener with information.

A greater range of sensors could be used in order to better capture environmental data. Computer vision techniques to track motion and then map to sound could have been interesting though potentially not useful in a large room as this would exceed the range of the camera. Passive infrared sensors could also be used to track movement. This works when an infrared source that is detected with a certain temperature (for example a human) passes in front of another infrared source with a different temperature. The moving object breaks the field of what the infrared sensor saw as the normal state. There had been plans to attach infrared sensors to the door frame and other points around the room but problems were experienced when trying to implement this.

It may be interesting to apply different mapped sounds to the Arduino to see how much of an effect the timbre of the soundscape had on the communicational process. Experimenting with the level of human interaction in regards to listening could be achieved through adding more ways for people to change the sound (for example through use of Wii motes or reactive surfaces) though this would have not been overly suitable for the Sound Surrondings project as the emphasis was that the primary interface between people and sound way through listening.

Some visitors commented that they thought it would be interesting to see how the installation would be perceived if it was set up in different locations. This would be of interest as the context and environmental factors of the sound would be changed. The lack of mobility of the system makes this fairly difficult.

It would be interesting if an environmentally reactive smart phone app version of Sound Surroundings were to be created as this mobility would allow for a whole range of contexts and changes to the sounds to happen. On an Iphone, the temperature would be fairly difficult to accurately measure though it could be provided through GPS. Light and motion could be detected through the camera and accelerometer and sound through the microphone. The app could then use the same principles of algorithmically mapping data based on data from the surrounding environment. This would result in an augmented reality style app similar to the Inception and RJDJ apps created by Michael Breidenbruecker, which generate a 'Soundtrack to your life'. In the Inception app this is achieved by manipulating surrounding environmental sounds to create a dream like sound scape.

# Chapter 8

# 8.0 Bibliography


Arduino Online: http://arduino.cc/playground/Main/Components#Wire, *retrieved 11th April 2012*

Baalman M, Boverman T and Kersten S (2011) “Ins and Outs: SuperCollider and External Devices” in “The SuperCollider Book”, Cambridge Massachussets, MIT Press

Ballou G, Ciaudelli J and Schmitt V (2009) “Electroacoustic Devices Microphones and Loudspeakers”, Oxford, Elsevier

Bovermann T, de Campo A, Frauenberger C,and Rohrhuber J (2011) “Sonification and Auditory Display in SuperCollider” in “The SuperCollider Book”, Cambridge Massachusetts, MIT Press

Brittish Computer Society Code of Good Conduct for BCS Members. BCS, online: http://www.bcs.org/upload/pdf/conduct.pdf, *retrieved 16th November 2011*

James Bulley Online: http://jamesjbulley.com/works.html, *retrieved 16th November 2011*

Collins, Nick (2010) “Introduction to Computer Music”, Chichester, John Wiley and Sons

Cuomo, Leo (2011) Online: http://audiophilesablog.blogspot.co.uk/2011_06_01_archive.html, *retrieved 10th April 2012*

d’Escrivan J, Wilson S (2011) “Composition with SuperCollider” in ‘The SuperCollider Book”, Cambridge Massachussets, MIT Press

Eacott, John (2007) Contents May Vary, PHD, University of Westminster, England

Eno, Brian (1978) “Ambient Music” in “A Year With Swollen Apendices”, Great Britain, Faber and Faber LTD

Eno, Brian (1996) A Year With Swollen Apendices, Great Britain, Faber and Faber LTD

Fried, Limor (2011) Online: http://www.ladyada.net/learn/sensors/cds.html, *retrieved 10th April 2012*

Hargreaves, D and North, A (2008) “The Social and Applied Psychology of Music”, Oxford University Press, Oxford

Margolis M and Veldin N (2012) “Arduino Cookbook”, USA, O’Reilly Media

M.A.R.I.N online: http://marin.cc/residency/2011-programme/ , Copyright 2011-all rights reserved,WordPress & Atahualpa, *retrieved 16th November 2011*

McCormick T and Rumsey F (2009) “Sound and Recording” (Sixth edition), Oxford, Elsevier

Neumann Online: http://www.neumann.com/?lang=en&id=current_microphones&cid=tlm193_description, *retrieved 5th April 2012*

Murray Schaeffer, R (1977) “The Soundscape: Our Sonic Environment and the Soundscape of the Tuning World”, New York, Knopf

Truax, Barry (1984) “Acoustic Communication”, USA, Ablex Publishing Corporation

Truax, Barry, (1993) “Acoustic Communication” in “Soundscape Newsletter No. 05” [Online] Available at: http://wfae.proscenia.net/library/newsletter/SNL5.PDF, *Accessed 8th April 2012*

World Listening Project Online: http://www.worldlisteningproject.org/?p=667, *retrieved 16th November 2011*

# 9.0 Appendix 1

## Project Logs

**October 2011:**

- First meeting with project supervisor Nick Collins who recommended books by: R Murray Schaeffer, John R Pierce, Hildagard Westerkamp and to look into Acoustic Ecology.
- He also recommended I start by experimenting with the SoundIn UGen in SuperCollider.
- Wrote a project proposal.

**November 2011**

- Nick leant me the Arduino Uno with sensors, resistors and a dial to take home and experiment with.
- He tells me to look at Ardunio.scd and use the serial port class to list all devices to give the pathname to my Arduino.
- He Explains how to install the Arduino Quark and to look at the Arduino website.
- Wrote the interim report.

**December 2011**

- Started reading Acoustic Ecology by Barry Truax.
- Learnt how to map sounds to the Ardunio sensors in SuperCollider.

January 2012

- Focused on sonifying data and creating a soundscape.
- Concentrating on developing ambience and texture.

February 2012

- Organised and booked a venue to hold the installation.

    - Borrowed the interface, microphone and monitors and set up at home.
- Gave sounds amplitude arguments.
- Starting thinking about questions to ask in questionnaire/ researching into aims and what wanted to draw from ideas of Acoustic Ecology.

March 2012

- Handed in draft report.
- Used ControlSpec to map data to sensors.
- Worked on the algorithmic composition elements to structure and generate the sounds.
- Packages up/neatened code.
- Checked Sun position and acoustics of venue.
- Tested the installation.
- Promoted the installation to potential visitors.
- Created handouts and finished questionnaires.

April 2012

- Held the installation on April 2nd.
- Finalised commenting code.
- Evaluated results.
- Completed the project report.

# Appendix 2

## Sound Surroundings Questionnaire

Thank you for coming to the Sound Surroundings project installation. Please take a few minutes to fill out this questionnaire with some feedback in regards to your visit.

1. **Is this your first visit to the installation (or are you returning)?**

2. **What time did you arrive?**

3. **Approximately how long have you stayed and listened to the installation so far?**

4. **What differences have you noticed in the soundscape over the period of time you have visited?**

5. **In what ways have you noticed a relationship between the sounds produced and the surrounding environment?**

6. **How has listening to the soundscape altered your mood since first entering the room and in what way?**

**7. What sorts of thoughts, ideas or memories were evoked whilst listening to the soundscape?**

**8. How has this installation effected your perception of the environment in this space?**

**9. In what way has the soundscape entertained or interested you?**

**10. Describe what you did whilst you listened to the installation:**

**11. How often do you focus on listening in this way?**

**12. If you have any general feedback please include here and on reverse:**

# Appendix 3

## Sound Surroundings Installation Information

Hello and thank you for coming to my 'Sound Surroundings' sound installation. This installation is being held as part of my third year project. The project aims to create a sound installation, which is reactive to some of the changes in the surrounding environment: sound, temperature, light and movement. This installation also aims to explore elements of 'Acoustic Communication' through the medium of listening.

The installation will run from 11.30 am until 5.30pm in order to allow the environmental factors (light, temperature etc) to change throughout the course of the day.

You are invited to come in and out at any time whilst the installation is running. I would recommend to try and come back again later in the day so you can hear how the music generated has changed.

Please feel free to stay as long as you wish. The main emphasis of this installation is on your listening experience and the concept of communication through listening.

The installation will be a generative piece created using a program I have written in SuperCollider, a microphone and environmental sensors connected to an arduino.

I will be on hand all day to answer any questions and to talk through the set up.

Please make sure that you fill out a questionnaire about your experience before leaving the installation. If you are returning please fill out a second questionnaire so I can see if your experience has contrasted the previous.

Thank you for coming!

Rosa Fox