DESIGINING VIRTUAL SPACES: REDEFINING RADIO ART THROUGH DIGITAL CONTROL

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Abstract

Radio Art is a composition practice that is constantly evolving. Artists share a commonality to redefine, reinvent, and repurpose analogue radio. It is an art that often bends to the will of antiqued technology, celebrating a wide pallet of found sounds. This research extends the boundaries of the art form by exploring Radio Art through sonic-centric lens and establishing a consistent and reproducible compositional framework. By shifting radio from a found object to an instrument, I have deconstructed its sonic aesthetics into two parallel materials for composition, gestural noise and broadcast signal. When tuning an analogue radio to a signal, relationships between these materials unfold. Contrast is a term found throughout my research. Contrast is embodied throughout radio and its history; radio is used as both a scientific communication device and for artistic expression. it is a symbol of democracy and oppression. Radio produces broadcast noise and signal, creating poetic reception, such as control and chaos, anxiety and ecstasy, distance and closeness. This research explores the characteristics of these forces and materials as a symbiotic relationship of unfolding radiophonic behaviours. A major focus of this research is the control of analogue radio through deconstruction and composition. I embarked on a twenty-four-month development period to build a Digital Audio Workstation called Radiophonic Environmental Designer, (RED). RED enables composers to create virtual radiophonic environments that are navigated by rotating the dial. Material is positioned along a horizon, and tuning behaviours sculpted. There is also a physical interface embedded into an analogue radio shell to control the virtual tuning, namely, Broadcast Link-up Environment, (BLUE). BLUE is an ad-on program offering an online digital platform for the diffusion of Radio Art. Using an internet connection and gyroscope technology that is built into most smart phones, a radiophonic environment is interacted through a purpose-built website. In my creative practice, analogue radio has been redesigned by adopting digital technological practices to control, edit and model it's unique sound. In doing so, I reflect upon relationships between analogue and digital design principles through an extensive study on virtual analogue software and interfaces.

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Table of Contents

Abbreviations:

AM: Amplitude Modulation

BBC: British Broadcasting Corporation

BLUE: Broadcast Link-Up Environment

CB: Citizen Band

CPU: Central Processing Unit

DAB: Digital Audio Broadcast

DAW: Digital Audio Workstation

EQ: Equalisation

FM: Frequency Modulation

FPR: Frequency Per Rotation

GUI: Graphical User Interface

ISM: Industrial Scientific and Medical

MCU: Micro Controller Unit

MIDI: Musical Instrument Digital Interface

MP3: Moving Picture Experts Group Layer-3 Audio

PLUS / +: Performance Link-Up System

RED: Radiophonic Environmental Designer

SW: Short Wave

UI: User Interface

WAV/WAVE: Waveform Audio File Format

Chapter 1: Introduction

> The rediscovery of the musical note in sound and speech, the welding of music and speech into a single material, is one of the greatest artistic tasks of the wireless. (Arnheim, 1986, p. 4).

Radio has always intrigued me. My early probing into radio as a sort of 'quasi-instrument' revealed an endless sound pallet of contrasting relationships. Each twist of the dial and a flick of the wrist produced a swelling of static, shortly dissipating into a tone. The blend from static to pitch is seamless, yet for me, dissecting the gesture revealed a multitude of processes: sweeping filters from high to low frequencies, volume crescendos, erratic stuttering, envelopes of granulation, all produced by one effortless motion. When rotating the dial, physical resistance is absent. However, as the tuner glides past the broadcast, something embodied within the auditory experience, makes my fingertips feel heaviness. It is like the broadcast stepped out or emerged from a background layer of static, and my actions feel directly connected to this movement. Art historian, Rudolf Arnheim, best describes this sensation: "[You] make countries tumble over each other by the twist of your hand and listen to events that sound as earthly as if you had them in your own room, and yet as impossible and far-away as if they had never been" (Ibid, p. 20). These contrasting sensations and forces are within the very nature of radio. It is used primarily as a mass communication device but lends itself to less mainstream experimental artistic practices. Radio became the force that propped up dictatorships, while also acting as a beacon of democracy. It produces static (cosmic noise or empty radio space), and broadcast signals (our earthly transmissions). A contrast of poetic polarities, therefore, categorises radiophonic sound within a broad framework of interchangeable scales: chaos and order, anxiety and ecstasy, passive and active, background and foreground. However, radio's sonic material is transient. The beautiful interplay between electromagnetic cracklings and fragmented musical tones, eventually dissipates back into the ether. They are unable to be replicated or recalled- an infinite number of unique sounds, repeatedly lost.

Those like myself, who incorporate radio within their artistic practice, contribute towards radio art. An art form influenced by radio technology. Radio's century-long history has seen radio art develop through a range of practices, from sampling and performing with radio receivers, to manipulating and interfering with its transmission. First, I must clarify that it is analogue radio and signals, rather than their digital counterparts, that I find most intriguing. My poetic descriptions of tuning/exploring the spaces within contrasting polarities, become lost in digital radio. Like many digital data transfer mediums (and their supported devices) there is a general goal of providing instantaneous or rapid access to media. With each new iteration, digital transmission and reception

becomes refined, to the point where loading times, interference, or the breakup of signals become eradicated. In digital radio sets and digital audio broadcasts (DAB), the dilution of static, the strive towards clarity, and the instantaneous flicker between broadcasts, amalgamating in the exclusion of the radio dial for digital station "pre-sets" via clickable buttons, erodes what I deem, interesting compositional potentials. It is these in between spaces that myself and many radio artists seek to explore. Compared to its digital counterpart, analogue radio is more expressive with a deep and contrasting sonic aesthetic:

> With an analogue radio, you can flick around, flick between. The effect your body has brushing up against the radio while you turn around, all these things change what you experience" (Carlyle, 2009).

While its rich sound pallet offers a multitude of compositional potential, materiality of radio is challenging to harness- a quality that makes it even more enjoyable. The journey from the transmission to reception is littered with electronic devices, often imprinting uncontrollable electromagnetic interference upon the radio signal. Although, these features become part of radio's sonic beauty that contributes to its transitory nature. Although, the process makes reproducing the desired phrase of radiophonic material inconsistent. Such polarity between harnessing radio's expressive sonic repertoire, and its unsteady reception form the core compositional philosophies of radio art: control and contrast. In the *The State of Research* chapter, I will define radio art through this philosophical lens, exploring how artists shift between analogue (chaotic, lively, tangible) and digital (accurate, reproducible, customisable) ideas. An extensive review of artists and academics such as Anna Friz, Ed Bear, Zach Poff, Lindsey Vickery and Magz Hall, will highlight a commonality to reinvent, repurpose and redefine the medium.

A complete definition of radio art is found in manifestoes by Robert Adrien and Tetso Kogawa. They position radio art within the found art/object practice.[1] As such, radio art is explored and defined using the concept, 'artist as chooser', rather than, 'artist as maker'. Its compositional framework expressed through the process of seeking and exploring. As described by Arnheim in my opening quote, through radio, we rediscover, "the musical note in sound and speech", and wield "music and speech into a single material" (Arnheim, 1986). The radio, therefore, becomes 'material' and interact as a found object. To conclude the chapter, I will offer an alternative definition. I shall pose the question, what are the compositional potentials for radio when

[1] Found art is an art form that is created with ordinary objects. Its purpose is to force viewers to question the meaning of art and what distinguishes 'art objects' from 'non-art objects'.

perceived as a musical instrument? Shifting the focus away from found art, I will develop a framework defined by identifying and harnessing solid compositional materials. Underpinning this chapter are the following questions: Are tensions between radio's analogue heritage and digital future fuelling artists to reconsider its very definition? Why is radio described as a found object, and what are the benefits of defining it as an instrument?

A significant focus of my research has been the result of frustrations experienced through my creative practice. As previously described, harnessing radiophonic material is problematic. Initially, I approached the radio as a found object, expressing my ideas through the process of discovery. Therefore, as I tuned into broadcast signals, twisting my hand in improvised patterns, I recorded a variety of sounds and arranged the fragments into phrases. At one point, as the tuner swiped through a cluster of radio frequencies, the result was an envelope of static that dissipated into a striking chordal texture (static unfolding into broadcasted music). As a composer, attempting to develop this phrase left me with several blockades. Repeating the dial rotation did little to recapture the sounds. With each twist, the chord irregularly changed notes, and after a while, the envelope's characteristics utterly changed. This experience led to the following questions that underpin an exploration of radio for its instrumental possibilities, rather than indeterminate and 'found' qualities: What kind of rhythmical variations are producible if I could consistently retune to a fixed signal? Conversely, what new phrases and musical possibilities are possible if I had the freedom to move signals around the frequency spectrum? Moreover, if I could insert my sounds into the radio spectrum, would I be able to compose custom radiophonic environments?

The following chapters aim to develop and realise a compositional framework, influenced by such questions. In *the Building a Framework for Radio Art Composition* chapter, I will demonstrate a methodology that broadens the musical scope of analogue radio into a medium that offers identifiable materials for composition. The radio will be analysed for its instrumental qualities. I will undertake experiments to deconstruct the radio frequency spectrum (a term I call radiophonic environment) into categorisations of its most common sonic elements, phrases, and behaviours.

As radiophonic material is produced by tuning motions, sounds often unfold or morph from one another. Therefore, my compositional language draws influence from Dennis Smalley and Curtis Road's research on identifying sonic morphologies. Using my terminologies and a custom-made graphic score toolset, I will offer an analytical model for understanding complex tuning envelopes and performance techniques. These gestures will be analysed, aiming to highlight a cyclical relationship between the dial's rotation, the produced sonic envelope and the user's perception of sound and movement. Through this process, I further intend to demystify a medium often

championed for its elusive and transitory nature. This new compositional language will form an outline for future radio art analysis. Therefore, in its creation, the following research questions shall be addressed: What are the instrumental characteristics of radio? How can sound be produced and manipulated? What kind of sonic material does it produce? Are there compositional limitations? As a medium like a sound sampler, which has 'no voice of its own', when viewing radio as an instrument, what levels of authorship do we need to consider?

The current efforts within music technology offer a unique landscape for my research. As a music producer and programmer for over ten years I have experienced a shift from analogue purity to virtual hardware and simulation. While this paper is not so much concerned with the long argued 'analogue vs digital debate', in today's technological landscape, musicians and composers work within this unique period of transition. In *the Software and Hardware Development* chapter*,* I will describe the creation of a set of radiophonic software and hardware to realise my compositional goals. Development is inspired by readdressing the question: If I could insert my sounds into the radio spectrum, would I be able to compose custom radiophonic environments? The answer came through the software design of, *Radiophonic Environmental Designer* (RED).

RED is a digital audio workstation (DAW), allowing composers to create virtual radiophonic environments. Its development was aided through the extensive analysis of radiophonic material, featured in Chapter Two. The workstation provides freedom for composers to transmit custom audio to a virtual radiophonic spectrum and craft the way one can tune into the material. It aims to simulate analogue radio's vast sonic pallet, with full compositional control over its interactivity.

I find that RED offers exciting prospects to me as a composer, as it allows me to preserve and even further develop analogue radios pallet. This idea builds upon academic and radio artists Magz Hall's research, which poses the very real possibility of analogue signals being lost forever (Hall, 2018). In Norway, at 10:11AM GMT, January 1st, 2017, the analogue FM broadcasting system for the country's northernmost counties of Troms and Finnmark was shut down. Public broadcaster NRK and other commercial broadcasters switched over to the DAB. The transition from analogue to digital was justified due to DAB being more robust and using less power to operate. Norway's topography, with many small communities spread across mountains and valleys, was difficult to reach with FM radio. This loss of radio bands is not limited to Norway. In many European countries, AM frequencies are becoming empty. In the UK, DAB contributes towards 60% of all radio listening, and the big AM and FM "switch off" by UK broadcasting agency Ofcom, will soon be a reality in 2023 (Revoir, 2020). With many radio art works and performances reliant on such signals, which include historically important radio works such from John Cage and Robert

Rauschenberg, RED could provide a possible platform for their preservation. Each lost radio frequency, which is inevitable, dilutes the rich pallet that radio artists are so fond of. RED's ability to go beyond recording and achieving radio sounds, whilst simulating its subtle nuances and interactions, will contribute towards preservation for next generations.

Performers can navigate through RED based compositions, using the software's virtual dial or my physical tuning hardware, *Performance Interface Networking Kit* (PINK). As pink is a colour closely linked to red, it is an appropriate name for such an exclusive pairing. PINK features a twistable dial that transmits tuning data to RED via Bluetooth. Finally, to complete the trio, I created an online performance platform called, *Broadcast Link-Up System* (BLUE). The software is embedded into a website, transforming a user's smartphone into a gestural controller. As radio art is often limited to venue installations using radio technology at its core, BLUE attempts to provide a far more accessible experience.

Throughout Chapter Four, I have documented the trio's (RED, PINK, BLUE), intense two-year development period. Rather than provide a comprehensive step by step programming guide, I will include developmental milestones that have both refined and challenged my understanding of radiophonic material, radiophonic environments, and tuning behaviours. As a digital software package, there are various concerns exclusive to this medium. As such, this chapter will address the following questions unique to digital practices: What implications does software have on workflow? What effect does user interface design have on composition and performance? What is the best method for simulating the subtle characteristics of radio tuning? How are the negative aspects of digital performance, such as audience disconnect and stability issues, addressed? [2] The final question I will address, which has often raised when presenting my findings to other fellow radio artists, why would one want to control the radio in the first place?

In the *Portfolio of Compositions* chapter, I will document the creation of several radio art exhibitions and installations, exploring the instrumental and compositional potentials of digitised radio. Most importantly, I will demonstrate how I realised my compositional framework, exploring radio for its instrumental features. In my practice, I find that it is important to create new works, based on sonic pallets so clearly associated with the past. In fact, radio uniquely ties us to our past. When hearing static, we hear the energy left over from the hot primordial universe, the result of the Bing

[2] Digital practices such as laptop performances are criticised for their lack of theatrical gestures. Audience disconnect occurs when visual stimuli do not correspond to the produced sound. For example, when the micro-movements of a laptop performance create expansive and abstract soundscapes, audience disconnect may occur.

Bang, and the aftermath of burnt-out stars. To quote more poetic polarities, the static result is vast yet suffocating! My works that use live radio signals become a moment in time where we revel in the vastness of the cosmos, and directly interact with it- via our physical bodies and through our earthly broadcasts. I find that there are few other mediums that bridge these two forces (cosmos and humanity/static and broadcast signals) together and allow you to seamlessly traverse between them. The subtle and fluid transition from static to broadcast signals, triggered by performance and movement, remains radios most appealing and unique feature, and is at the forefront of many of my works.

Whilst I have some nostalgia to radio and understand the influential place radio sits within history and society today, I want to try and avoid limiting radios significance to my practice, to these reasons. I find that radio offers an insight and connection into spaces that surround me. Static, interference, distortions of all kinds, is the sonification of unseen space. As a composer, the seamless exploration of such spaces, is most intriguing. I find that these are unique contributions to sound art in general.

As I strove towards exploring and harnessing such forces, each piece reflects part of a personal developmental journey. For example, *94-108,* which was my first attempt at manipulating radiophonic material in a controlled environment. As a studio producer and acousmatic composer, manipulating live sound in a DAW seemed the first reasonable step. I recorded several improvisations, tuning an analogue radio to different broadcast frequencies. The radio produced audible pitches and rhythmical patterns, manipulated by my dial movements. Using the software, Logic Pro, these phrases were threaded and arranged into a realistic, yet virtuosic, tuning performance. I shaped these phrases using thematic devices such as silence, tension and dynamics. It would be impossible to replicate the intricate phrases and intensities, without such digital intervention. Although satisfied with the outcome, I felt an obvious frustration. Recording sessions seemed divorced from one another. The radiophonic material continuously changed, so developing ideas between recording sessions proved difficult. As previously mentioned, I encountered a striking sound, which enveloped into a chordal texture. However, once recorded, I was never able to replicate these sounds. Going forward, I wanted to explore radio's potential, pushing beyond the fixed playback of spliced radio sounds. I imagined the possibility of designing such intricate phrases and then performing the sounds using a radio set.

The next piece, entitled, *Tune-in, Zone-out*, is aimed to address, at least, some of above stated ambitions. The work is an exhibition featuring five analogue radios. The radios were modified

using a programable Micro Processing Unit (MPU), a servo device, and 3D printed parts. The components were concealed and attached to the radio's tuning mechanism, autonomously rotating the dial through carefully programmed servo movements. The dial's rotational speed, smoothness and tuning degree are variables I controlled to create the live collage. Through coding, the radiophonic ensemble accurately tunes between precise frequencies, cycling through preprogramed patterns. The dial movement can be repeated for multiple exhibitions. While I gained control over tuning gestures, the radiophonic material changed over time.

The bulk of the portfolio includes interactive works using my software and hardware trio. Each piece showcases the possibilities of radio art, when not solely bound to an analogue format. For example, the piece, *Quadrophonic Radio,* demonstrates RED's multichannel capabilities. I developed a module within RED that enables composers to shape radiophonic material within an array of up to twelve speaker outputs. As the user rotates the radio dial, their hand movements become projected, pushing sound around the room in a circular motion.

The piece, *Goodwin Sands Radiogram*, was a collaboration with award-winning podcaster, Ben Horner. He created a podcast series, documenting the lives of residences located within the South East area. At the performance, Horner triggered pre-recorded interviews, while the ensemble provided music and sound design. The goal was to create the illusion of a 1950s BBC or Pathe newsreel, broadcasting live from a rickety ship, anchored near the Southern coast of the UK. The performance included: electric guitar through a laptop, piano through spring reverb and an assortment of found objects. As part of the performance, an ex-BBC news presenter introduced each interview. My role was to compose a radiophonic environment of static noises and use my gestural interface (which I neatly hid inside a radio set), to weave interference throughout the piece. Moreover, I edited the hour and a half long performance to produce a ten miniate showcase. The piece demonstrates the live capabilities of the performance interface, PINK.

As part of a series of works using RED and BLUE, I have also created two interactive archives using recordings from *The Conet Project* and *The BBC Radiophonic Workshop*. They form an exhibition hosted through my online platform. Using archival material, I constructed a radiophonic environment, offering a consistent platform for recipients to interact. The participants can freely navigate through the piece. By rotating the dial interface, the user controls the evolution of the composition process and the arrangement of the material. The experience forms part of an improvised performance or an exploration of sound by an online exhibiter. Other works, such as *Fragments* and *Reimagining Imaginary Landscapes*, build upon these ideas.

My final piece is a reimagining John Cage's radio work, *Imaginary Landscape No. 4*. In 1951, Cage composed multiple pieces influenced by radio's intermediate nature. His piece uses an ensemble of twenty-four players, a conductor, and twelve radios. For this work, performers scan radio-stations by following his score. He wrote the tuning durations in conventional notation, relating to notes placed on a 5-line staff. Due to the ever-diminishing number of AM band stations, accurate performances as directed by the score have been increasingly comprised of static rather than a broadcast signal. I aimed to reimagine Cage's work as an online exhibition. Users connect their mobile phone to my website hosting a 1950s New York inspired radiophonic environment. As participants rotate the virtual dial, tuned material is produced by the website and amplified through the phone's audio output. This interpretation aims to reintroduce and celebrate historical radiophonic work while making it seamlessly accessible to modern audiences.

In my *Conclusion* chapter, I will look towards the future of radio art, focusing on its evolving relationship between analogue and digital mediums. I will highlight how my workstation could contribute to the current and future development of interface design and human-computer interaction. Throughout my creative practice and research, several questions have surfaced, which I will address in my conclusion: What is my identity as a composer? What is the medium I use? Is my practice radio art or a hybrid of live electronics, synthesis, coding, or laptop music? Finally, as part of my evaluation, I will endeavour to argue the next phase of radio arts' redefinition; an art form that can exist outside the paradigms of a particular technology; an art form that has a defined sound and shape, and an art form that looks towards the future, in order to understand its past.

Chapter 2: The State of Research

There is a scale of numbers. Numbers which indicate areas, towns, cities. An idea that a radio wave travels vast distances, that these numbers mean something, and are not arbitrarily placed. The distance is felt as the thumb strains against the dial from the upwards momentum. It starts with static, an amalgamation of every possible frequency, sonified through cold equations and physics. It unravels, bends and crunches into an unusual breadth, spanning the depth and diversity of all earthly life. Static and broadcast, chaos and control, earth, and the cosmos, near and far are interchangeable perceptions deeply rooted in the imagination. They are produced by a machine that sculpts a portrait of reality through an illusion of varying forces. Their potential differences are ethereal, but tangible, active and unseen. It is a constant shift between the illusion of reality, and the reality of illusion, to tune in, to zone out, and repeat the process, with a different result.

Radio is full of contrasts. "It proposes entry points into realms that surround us daily, but elude our unassisted perception" (Friz, 2009). Radio has been used for propaganda and revolution, for freedom, and control.[3] In our popular imagination, it represents music, from the classics to classical, live coverage from traffic updates to the world cup, talk shows and debates, political, sensational, all woven in-between the annoying jingle of 'webuyanycar.com'. As the band, Queen said in their song, *Radio Gaga*, "You had your time, you had the power, you have yet to have your finest hour" (Queen, 1984). Radio has one foot in the past, and one in the future. In a fast-evolving digitised world, it is an object encompassing tradition and obsolete technology. Contrast is prevalent within the radio's core functionality and characteristics. It generates a sound that transitions between two contrasting receptive forces. I relate these forces to the radiophonic materials as static and broadcast signal. Like consonance and dissonance in tonality, these perceptions are contrasting sensations that define radiophonic material as something tangible to compose and structure. They seem dualistic, dichotomist even, and as the organisation of western tonality, it offers navigation between these boundaries, like interwoven scales. On the one side, static is chaotic and granulated. On the other, broadcast embodies a controlled state with sonic clarity. By rotating the radio dial, one gradually shifts from one material to the other. However, as materials, these perceptive qualities also vary within themselves. For example, static may be

3 Control of people through subliminal messages. Moreover, the medium assisted revolutions and gave rise to a previously unheard entertainment. Such opposite extremes are entrenched in radios political history, being both the medium used by revolutionaries and dictatorships. It was heavily utilised during the Rwandan genocide with approximately 51,000 deaths caused by radio station broadcasts inciting ordinary citizens to take part in the massacres of their Tutsi and moderate Hutu neighbours. Radio as a propaganda device as also heavily used in Nazi Germany for national indoctrination and is currently controlled by the North Korea government for state propaganda. Revolutionaries smuggle radios into North Korea, modified to receive broadcasts by defectors and South Koreans promoting Western ideas and change.

chaotic, but it is also the representation of empty radio space. It can be cold and mysterious, yet when tuned to, it is solitary, unsurprising and non-developing. The broadcast signal is both intimate and distant, coherent, but also a bombardment of commercialism, a perception of overwhelming noise. Radio Artist Gregory Whitehead reveals a radiophonic space to encapsulate interchangeable moods; anxiety and ecstasy.

> Anxiety is at the beginning, and the end of radiophonic space hardwired deep in the nervous system of the electronic media. At root, it is the anxiety of the Twitching Finger, the finger that taps out code on the telegraph, S-O-S, the anxiety of the finger that makes a distress call uncertain of its destination… However, the ecstasy is there too, the ecstasy that marks the other rhythm of the twitching finger, a finger fully prepared to produce pleasure from a nobody out of nothingness, yet ubiquitous (Whitehead, 2005, p. 10).

Radio Artists have therefore created their language and terminology to describe this contrast. Serge Cardinal arranges radiophonic material as being a series of modes and internal forces- passive and active, affect and change. Whitehead further clarifies these qualities as:

> You have presence and absence, you have the living and the dead, you have infinity and proximity, you have intimacy and you have power (Whitehead, 2005, p. 10)

Zach Poff, a media artist and educator from New York, refers to static material, as "negative space" (Poff, 2016). Artist, Anna Friz, describes radio space consisting of existing radio stations and "inter-frequency" sounds (Friz, 2015, p. 5). Her description suggests a polarity between known 'points of interest' (frequencies that mark broadcasts), with parts of the radio spectrum that are unknown and in-between (inter-frequency). By tuning the radio and rotating the dial, we navigate between these distances. The idea of space and distance embodied within the sounds and shapes of radiophonic material is of interests to me. Distance in radio works as two different forces that shift between the near and far. As a listening device, there is a shifting distance between oneself and the radio speaker. Its sonic material manifests as a sonic blueprint, mapping the distance and proximity of radio transmitters, receivers and everything else in-between and around them. Dr Angus Carlyle shares distance as a listening strategy for radio:

> [We can] expose ourselves to the seven hours and ten minutes of Castro's speech to the third communist congress in Havana, and as a non-Spanish speaker, I think I would experience that, especially as a live broadcaster, [as] something which contains in it, the great distance of something that never came back to me as familiar or meaningful, or

> fixed. There is another notion of distance, when someone switches the radio on, starting to listen, not being sure what it is that your listening to, taking time for that meaning to settle down (Carlyle, 2009).

Carlyle's observation offers a different perspective. Unlike the closeness and stability attributed to broadcast material, he experiences Castro's speech with a great distance. Carlyle also describes an initial unfamiliarity when tuned to a broadcast signal. Although, through listening, the meaning becomes more precise. This relationship fits within a scale of varying intensities, rather than a binary movement or dichotomy. Interacting with radio's broad sonic pallet, therefore, becomes a relationship between the near and far, proximity and distance. The power to shift between these contrasting forces is part of the most excellent tool for expression in radio art composition. In *the Building a Framework for Radio Art Composition* chapter, I will explore these contrasting forces further, to create classifications of sonic materials, and create a robust framework for radio art composition.

2.1: Defining Radio Art

"Over the years, radio has been remixed and repurposed, stolen outright, left for dead and resurrected" (Friz, 2017). The current interest in radio by artists, suggest a period of summarisation, signalling the end radio as a compositional medium (Inges, 2015, p. 120). Predictions of radio's imminent demise have been recurring regularly, at least since the advent of video figuratively "killing the radio star".[4] Recent developments in podcasting, streaming and the internet, cast radio as a senile and dying media. However, nothing is further from the truth. Radio seems to be proving its resilience. The new wireless media, which appear to be instrumental in its death, have started to become an extension of radio. Such technological intervention is found within radio art practices, and form a central part of radio's economic future. Over the last decade, radio sets have become integrated with digital technology, allowing consumers to accurately tune to radio signals, instantly save and recall stations, connect to external speakers via Bluetooth transmission, and receive Digital Audio Broadcasting (DAB). Compare to its analogue counterpart, through DAB digital radios receive additional programming information. These include station/presenter name, slogans and the currently playing artist, band and song. Such information is often available on a scrolling LCD screen.

[4] *Video Killed the Radio Star,* is a popular song written by Trevor Horn in his band, *The Buggles* (1978). It features lyrics and videography, documenting the rise of television and the decline in popularity of radio sets, leading up to 1980.

The technological intervention was the focus of the *International Radio Summit* in 2015. A group of six industry experts contributed towards, *Radio Interactive: Radio of The Future Panel.* Their foremost goal was to answer the question: what is the future of radio? In his introduction, Jeff Smulyan firmly argues for radio's resilience: a medium that offers a far more profitable and competitive business model than other digital streaming services.[5]

> The cost of sending our over-air signal is $39,000 a year. That is our cost for electricity. If we were to take our transmitters down and just stream, our cost to reach our listeners in Southern California, would be a million dollars a year, [in data costs] … Not only that, there are no barriers to entry… anybody can stream and compete with me every day. In over-the-air ecosystem, I'm one of twenty-five broadcasters in Southern California (Smulyan, 2015).

From a consumer perspective, broadcaster, Gavin Mcgarry, reflects on the public perception of radio. He recalls a conversation with a friend, whose children are immersed in digital platforms:

> A friend of mine at Christmas gave his kids… radio boxes and said its free music. These kids went crazy, and he has videos up on his Facebook with the kids running around saying "it's free, its free!". They didn't know what radio was… All these kids out here don't know they can get free music [and] their all conscious about streaming costs. (Mcgarry 2015).

Sixty-one per cent of phones within the United States and Canada is data metered. This provides over the air broadcasting, which is free, a tremendous ability to compete with digital streaming devices. The primary revelation at this event was the development of a concept called *Next Radio.* It is a platform that connects to smartphones via an FM chip, which is available in modern smartphones. *Next Radio* aims to create a compelling ecosystem to modernise and enhance the consumer experience. Jeff Smulyan (2015) states that a person interacts with their smartphone on average, one-hundred and forty-five times a day, and *Next Radio* will be the only option for interactive streaming media at no cost to the consumer.

Radio has had a rich one-hundred-year history of being, 'with the people', and part of our everyday lives. *Next Radio* attempts to capitalise on its longevity, enhancing interactivity which up to now has been through radio promotions, contests, phone-ins, and music information. The integration

[5] Jeff Smulyan is CEO and Chairman of *Emmis Communications Corp,* with four decades worth of experience within broadcast marketing and innovation.

of digital technology reinvents radio as a visual and interactive format, simultaneously offering live information over the radio waves. The panel deconstructs this concept into three goals:

1. To changes listening habits: Compared to the average radio listening session, *Next Radio* boasts a twofold increase in listening times.

2. To offer interactive advertisement: Advertisements are carefully controlled, monitored and personalised.

3. Reinvent radio's image: As echoed by Mcgarry's story, radio has suffered tremendous brand erosion. One of the most critical factors in securing radio's future is its reinvention and redefinition as an innovative brand.

By creating a smartphone application, powered by the integrated FM chip, the following features highlight how digital technology can enhance and repurpose analogue radio:

- Users can interact with a live guide showing media 'on-air now' from radio stations, a similar process to digital television services or streaming media platforms such as YouTube and Twitch. Ability to tune to a program automated and presented in unique user interface formats that is current, universal, and easy to use. Such interaction allows the user to accurately tune to recently selected stations and organise programming through a range of styles and categories.

- One tap station feedback: *Next Radio* communicates retrievable programming information which enables the user to 'scroll' to view song related content. It includes a wide range of search classifications, a list of tracks currently being broadcasted, recommended playlists and artist details.

- Interactivity: The smartphone application breaks down radio's traditional one-way delivery system. It offers customisable and targeted advertisement, locational promotions through GPS and a direct communication point between the station and user for competitions.

The development of radio art parallels this momentum through a shared commonality of reinvention and redefinition. Like the *Next Radio*, composers are working on new and exciting technologies, to shape radio's future and create enhanced interaction and artistic control. In both examples, analogue and digital practices amalgamate into something new, where both mediums

provide their positive attributes. Radio artists are exploring this unique combination, creating innovative interactive experiences that make us rethink the delicate balance between the past and the future.

2.1.1 Redefining Analogue Radio through Digital Technology

Zach Poff, Ed Bear and Brett Ian Balogh fuse analogue radio with digital programming to democratise the listening experience. Poff's exhibition, *Radio Silence*, uses the silent moments of broadcasted speech, to compose an ongoing collaborative performance. He tunes eight radios to a variety of AM frequencies, such as local talk radio, public radio, religious broadcasting and weather reports. Each radio feeds its signal into software that detects the silent moments within a conversation or speech. Once detected, the software crosscuts to a different broadcast to fill the space. The movement from one station to another is based on the silence between words and phrases. The matching of the timbre of each voice results in crosscuts that share a similar aesthetic. The result creates a seamless stream of broadcasted voices, carefully threaded together through code. Any un-highlighted broadcasts are tuned to static or "negative space" (Poff, 2017).[6]

Radio Silence uses digital programming to imitate and extend the dissecting and reconstructive properties of radio tuning. On an analogue radio, as one erratically tunes through the radio spectrum, small segments of broadcasts become threaded together. Through code, Poff controls and rebuilds the radio space into a new narrative. He also offers a platform to challenge our tuning behaviours and offer a new way of listening to the radio through digital automation. Poff explains:

> A pause in conversation might indicate the end of a thought or an opportunity for reflection and response. A pause in a radio broadcast offers different potentials: As radio listeners, we cannot respond, but we might exercise our only form of interactivity: changing the station. On commercial radio, moments of silence are minimised to avoid losing listeners… In Radio Silence, pauses are treated as opportunities to probe the neighbouring airwaves in search of other conversations. Over time, it surveys the spectrum of viewpoints currently on the air, weaving them together through the intersections of a shared linguistic device (Poff, 2010).

Ed Bear is an artist that also fuses analogue radio with digital programming. He repurposes and 'up-cycles' obsolete radio technology and electronic waste (e-waste). "I work a lot with found and reused electronics, e-waste as its commonly thrown about, or things that are going to become e-

[6] Negative Space is a term by Zach Poff, describing part of a radio spectrum devoid of broadcast signals.

waste" (Bear, 2017). In July 2015, Bear built an array of sixty micro radio transmitters as part of a multichannel synthesiser with one hundred and eighty voices, transmitting to any and every station across the commercial FM spectrum. Each radio transmitter is a hacked-apart device called an *I-trip*, "intensely obsolete" and disposable technology (Bear 2017). The *I-trip* uses a micro transmitter, allowing users to broadcast custom audio through the devices input connection. Its initial purpose was to wirelessly transmit music from a phone to a car stereo via the radio. As most modern smartphones are equipped with Bluetooth connectivity, the *I-trip* became obsolete.

Moreover, the device only works with a discontinued old generation iPod. However, through digital intervention, Bear has highjacked the *I-trip's* transmission circuit. By flicking to a radio station two hundred times per second, he has repurposed the system to produce its modulation and synthesis. Through the marriage of analogue radio and digital programming, he has repurposed this obsolete technology into a radiophonic quasi-instrument.

Brett Balogh is a Chicago-based artist that utilises radio signals and digital technology to reimagine traditional notions of space and our placement within it. At a time when we increasingly rely on wireless technologies, he draws attention to the personal, private and political aspects of our wireless world. Central to his thinking is the intersection of objects, sounds and spaces. Balogh's concept is engaging as radio space forms stochastic web signals that continuously surround us, yet we are unable to perceive them. Many of his works draw attention to phenomena that are often invisible and overlooked, such as radio space. By doing so, he aims to broaden our understanding of the thousands of signals that surround us through digital imagining. Between the years 2015-2016, Balogh has worked on a project with the *UIC Electronic Visualization Lab*, to visualise wide-band radio-frequency data (Balogh 2017).

> Humans are sensitive to only a narrow region of the electromagnetic spectrum; a region known as visible light. In order to experience electromagnetic energies of different frequencies, it is necessary to use a device that can translate them into a form we can perceive (Balogh, 2017).

The scope of the project was to develop a code and user interface to create preliminary visualisations of radio space. Like Poff's and Bear's exhibits, Balogh has developed a compositional practice that uses digital intervention to manipulate and control radio space with high precision and accuracy. In Balogh's work, the software becomes an integral part of radio's redefinition, repurposing the radio frequency spectrum into a visual format.

2.1.2 Shifting Between Reality and Illusion

The notion of extended or expanded radio beyond its identity as a mass medium has inspired artists to reimagine radio for the twenty-first century. These include creating interactive installations, sound walks, transmission performances and radio parties. For example, Canadian radio artist and media studies academic, Anna Friz, creates self-reflexive radio for broadcast, installation and performance, where the radio is the source, subject, and medium of her work. Friz reflects on a future of radio, as imagined by the past:

> Spiritualists and scientists ardently hoped radio would allow access to realms of the uncanny; some believed that the radio would provide a connection with the dead or other ethereal spirits (Friz 2009).

Instead, Friz focuses on the present, filled with reports of the dead (for example, casualties of war and street violence), and wonders what communication we might be missing from those living around us.

> What nearly inaudible signals, transmitted in moments of intensity or crisis, might we hear if the radio was tuned to hear? What do people seek to transmit, in a moment between the intake of breath and the breath held, waiting, in tension? In listening for and imagining these signals, I seek to hear the desire for contact and witnessing in such liminal moments (Friz, 2009).

Friz aims to provide a contrasting environment; we feel the sounds both near and far. She achieves this through multichannel speaker set-up using radio receivers, individually tuned to the FM frequency of material she broadcasts. Instead of offering solutions to the unstable nature of analogue radio, Friz celebrates and even enhances the radio.

> I seek not to occupy the airwaves, however temporarily, but rather to collaborate with them, and in so doing achieve less rather than more control. The composed sounds may, at times, become almost obliterated by the sounds generated by the volatile radio environment (ibid).

As the audience move among the radios, their bodies cause sudden eruptions of static and signal. It is a miniaturised reflection of real-world radiophonic interaction: radio signals transmitted over vast miles, diffusing by a city worth of electromagnetic interference.

In her works, *For Respire* (2008-2009), and *You Are Far From Us* (2008), Friz recorded and transmitted breathing and other bodily exclamations, such as non-verbal utterances and fragmented text. These sounds are typically absent from regular radio programming. The relationship between Friz's source material, from the realistic (recordings of breathing) to the hyper-realistic (accordion, harmonica and theremin that imitates the human breath and detuned radio landscape), is echoed in the very nature of the radio space. Radio space allows for a productive slippage between the real and the imaginary: a mixture of earthly transmissions that feel intimate and talk directly to you, yet intangible, fleeting and far-away, as if they had never existed. Friz further clarifies this unique radiophonic experience, referring to her work as embodying, "a continuous, available, fluctuating intersection of transmission ecology" (ibid).

Radio Art practices, especially in the case of Anna Friz's installations, shift between these metaphors- illusion of reality (memetic space), and reality of illusion (a virtual space in which everything is possible). A unique characteristic of radio is its ability to seamlessly shift between these receptive layers by the type of source material received, and by the characteristic of radio space itself. Radio can be recorded and performed as concrete sound, but also manipulated to be imaginary, endowing a higher capacity to alienate. Quite a considerable amount of radio art fashioned from the viewpoint of taking the popular and familiar medium of radio to create something unfamiliar sounding. Like sound walks, radio art creates new narratives and relationships with spaces that surround us; "radio becomes not only a mediation technique but also a popular art, a way to rebuild an image of our world and a way to forge a deeper relationship to it" (Arnheim, 1984)

Crafting an illusionary space to redefine or repurpose a physical space, is a practice championed by composer Tetsuo Kogawa. Kogawa is a highly respected Japanese micro-radio pioneer and activist. He adopts radio technology to liberate the radio space that is dominated by commercial entities. Using ethereal technology, Kogawa's ideology closely matches Zack Poff's democratisation of radio space. He poses the question, "why don't you go to a radio station just as you [go] to theatres?" (Kogawa, 2017) According to Kogawa, through low watt transmitters (like the transmitter inside the *I-trip*), "micro radio theatre could be possible" (Ibid). For him, performance areas, installation spaces, indoor or outdoor, are ideal venues for transformation. Micro transmitters offer radio artists a departure from radio's historical definition as a global medium for communication. As a tool to democratise radio space, they become an antidote to mass media control, whose reach covers the globe with qualitatively patterned information. At its core, the 'micro' element of radio transmitters goes far beyond its transmitting power. Kogawa

defines micro transmitters as diverse, multiple, and polymorphous, not necessarily small in physical size. In his micro transmitter manifesto, he states:

> We have to use a kind of "phenomenological bracketing" to perceive what things are. Given the age of various global means such as satellite communications and the internet, micro Radio can concentrate on its more authentic territory: tiny airwave space (ibid).

Kogawa demonstrates the liberating and communicative potential of micro radio through his 'radio parties'. A radio party is an opportunity for people to come together and converse, tell stories, play music, and more notably, take part in impromptu radio plays. It allows the possibility of adding a second layer of private sound or reality to any place and situation. As such, it transforms, enhances and redefines the spatial experience. Speeches, poetry and musical extracts broadcasted via low watt transmitters, often received only within the surrounding area. Their free-form sound and participatory nature characterise these informal, irregular radio events. Unlike independently licensed stations, for which the programming grid serves as the central organisational paradigm, 'home-brew' micro radio can be as interactive as the participant's desire. The micro-radio party is not about diffusion, but communication. It is a medium for people to listen to and make Radio together, with transmissions mostly taking place face-to-face. Kogawa has built the foundations for radio as a potential space for his term "micro radio theatre" (ibid).

British academic and radio artist, Magz Hall, has realised Kogawa's vision. Hall's body of works, under the collective title, *Switch Off,* is a collection of eight fictive stations that fit the description of Kogawa's 'micro radio theatre'. Hall imagines a future without the FM radio. Such a semi-dystopian future has routes in our recent past. In 2017, Norway discontinued its FM spectrum, replacing it DAB. Hall engages creatively and speculatively, the loss and potential of such an action. Her body of work, *Switch Off,* recalls radio's past uses, to speculate upon its future.

> It takes its overarching theme, (the imagined future of FM analogue radio) when abandoned by sanctioned broadcasters, presenting future sonic possibilities of analogue FM radio after the 'digital switchover' proposed (and indefinitely postponed), by Ofcom (Hall, 2015, p. 102).

Hall comments on the potential of the "vacated FM spectrum… a speculative space within which to reimagine the utopian potentiality of radio as revealed as its apparent point of obsolescence." (Ibid p.109) Hall's portfolio forms a sequence of divergent works, where fragments of familiar,

strange, overlooked and unheard sounds coalesce with experimental drama, radio art and sound poetry. These fictional stations represent different aspects of how FM radio interacts with in the future. Each composition functions as an abstract and self-contained narrative, as well as forming part of an overall portfolio.

For example, the work, *Spiritual Radio* (2014), unites two old media forms: radio and books. In doing so, Hall conveys the resilience of such mediums while reflecting on the advantages and disadvantages of their digital counterparts (e-book, Digital Radio).

> Both media have been able quickly to move to digital forms, and both and gained and lost from this move. For me, the loss is when you look at a screen or listen to an mp3, the physicality of both is affected. The sound quality of an mp3 is weaker, and the book loses its personality. On DAB radio, you lose the hiss and static, as there is no tuning or bleeding between stations (ibid, p. 200).

For her piece, Hall built a micro FM transmitter with copper pins, wires, capacitors, resistors, and transistors, soldered together to form a circuit. The transmitter circuit remains visible on the front cover, and the contents of the book hollowed out to conceal the battery source. The source material within this piece is a collage of analogue radio sounds and voice. The spoken text is from the book *Spiritual Radio*, initially published in 1925, transmitted on a loop via the concealed transmitter.[7] It is an interactive piece where the recipient tunes into the book's carrier frequency to hear the words. As such, the physical book, which itself is the only substantial part of the exhibition, is an illusion, with the text-only accessible by entering radio space. Like Friz's creative philosophy, part of a running theme throughout the *Switch Off* Project is an exploration of the future, via its documented past. In doing do, Hall builds upon a commonality shared by Bear and Kogawa, where radio space has liberated, democratised and thus, redefined.

Hall's work, entitled, *Numbers* (2012), connects with the long history of political activists embracing and experimenting with radio since its inception. As the internet becomes ever more subject to surveillance and pre-emptive policing, activists considered radical offline communication schemes. In this piece, Hall's interest lies in the re-appropriation of terrestrial radio, making communication covert, highly visible, yet hidden in plain sight. Hall's concern over internet surveillance echoes more so today, with the previous UK prime minister, Theresa May's, response to the London

[7] Spiritual Radio by Archbishop F.H. du Vernet is a vision of the nascent technology as a spiritually charged electrical force capable of mediating human sensibilities, and the transcendent will of God in a text that is by turns visionary and often absurd in the bathetic disjuncture between spiritual promise and quotidian reality.

Bridge terror attack: "we need to work with allied democratic governments to reach an international agreement that regulate cyberspace" (May, 2017).

Numbers pays homage to the shortwave 'number-stations' which have remained on air since the Cold War.[8] Hall's approach is to place a series of micro FM transmitters to broadcast encrypted messages taken from 'tweets,' originating within the Occupy Movement. Twelve radios receive the messages. Numbers was first diffused as a surround-sound, micro broadcast installation. At the start of the project, it used six micro transmitters and twelve solar-powered FM/DAB radios. Ed Bear's, Anna Friz's, and Magz Hall's research demonstrate radio transmitters and receivers offer an alternative to multichannel speaker systems. FM transmitters have at least two-hundred-and-five separate channels for wireless sound reception. These are easy to set up, with some featuring pre-set frequencies that enable the user to change the channel of the input effortlessly. With the increase in voltage power, its range becomes far broader than alternative devices such as Bluetooth connected systems.

2.2. Redefining Radio Art:

The roots of radio art embody several philosophical contradictions; an artistic expression that navigates between the obsolete and the innovative, chance and design, analogue and digital, static and broadcast. As I have demonstrated, contrast is evident as artists have both one foot in the past, and another firmly set in the future. In this chapter, I have reviewed a selection of artists who are contributing to the state of research within radio art practices. An art form defined by a deep desire to control and manipulate radio into expressive compositions while paying homage to the sounds and aesthetics of this unsteady medium. I have explored a commonality in descriptive language amongst composers who seek to redefine, reinvent, repurpose and reimagine radio through a range of creative practices. However, while artists share conceptual interests, a definition of radio art is still not clear. When referring to the name of the genre, a range of spellings used within the radio art community which suggest more than just semantics.[9]

In my definition of radio art, contrasting forces shapes its essence. Radio art is defined by taking the familiar medium of radio and creating something unfamiliar sounding. It is a communicative

[8] A number station is an SW radio transmission, which broadcasts encrypted messages as numbers. These stations have been used since WWI and have continued to be in use during the Cold War.

[9] For example, Radio Art. radioart. radio-art.

strategy that forces the listener to question their conventional approach to the decoding of messages supplied by the medium. The radio artist, therefore, establishes the boundary of this duality. The boundary includes a spectrum or scale between narrowcast and broadcast, concrete and imaginary, chaos and order, analogue and digital, or the past and the future. Through performance or interaction, the composed radio space is navigated, continually shifting between these contrasts.

Radio is also capable of creating an entire world within its perception. Therefore, through radio art, we evaluate its capacity to arouse the empathy and participation of our senses, separated by its power to test the boundaries of hearing.

There are two further receptive focuses, although not mutually exclusive, that defines radio art. An example such as Anna Friz's illusionary radio spaces, Tetsuo Kogawa's radio parties, Magz Hall's 'micro radio theatre' and Zach Poff's, Radio Silence, focus on the communicative messages sent by radio processes, 'art on the radio'. This concept contributed to the initial understanding of radio art as a compositional medium. From the late 1920s in America and 1930 in the UK and Europe, experimental radio birthed radio art traditions. These works were in the style of radio dramas and used 'audio art' techniques such as sound effects, tape manipulation and dialogue arrangements:

> Give 'em the right sound effects and music, and their imaginations will work for you. A man in his armchair can picture all kinds of fantastic scenes: a fly crawling up the Empire State Building, scenes of outer space, or under the sea. These are things radio can do best- better than the movies (Alen, 1954).

In contrast, artists such as Ed Bare, Todd Merrell and Patrick Jordon, use radio as an instrument to perform and produce sonic material. The receptive focus is very much the concrete sound of radio transmission: 'radio as the art'.

2.2.1 Radio as a Found Object:

The found art methodology involves a complete framework for composing with radio. It builds upon the definition, 'radio as the art'. Radio, and its role within radio art, is often described as a found object. The term, from a French phrase, 'objet trouvé', describes everyday objects and materials seen as works of art in themselves as well as providing inspiration to the artist. Found objects are also modifiable. The term, found object, was developed from Marcel Duchamp's 'readymades'. In New York, 1917, Duchamp made his most notorious readymade, *Fountain*: a

men's urinal signed by the artist with the false name, 'Mr Mutt'. Duchamp's later 'readymades' were more elaborate and was referred by him as 'assisted readymades'. For his works, he deliberately chose ordinary, functional, and rather dull objects. His reasoning was "based on a reaction of visual indifference, with at the same time, a total absence of good or bad taste" (Durchamp, 1961).

The term 'readymades', has since been applied more generally to artworks made from manufactured objects and built the foundation for 'found objects/art'. The theory behind the practice explained in an anonymous editorial published in May 1917, in the avant-garde magazine, The Blind Man:

> Whether Mr Mutt, with his own hands, made the fountain or not has no importance. He CHOSE it. He took an ordinary article of life, and placed it so that its useful significance disappeared under the new title and point of view – created a new thought for that object. (Anonymous, 1917).

In his article, *From Trashed to Treasured: A Grounded Theory Analysis of Found Object*, Paul Camic, (2010) explains why and how people use found objects, and how they are appreciated through an overarching course of action. The start of this process might occur after, by chance, from finding an object, or by a more active process of searching and seeking objects (Camic, 2010, p. 88). There are three actions related to found art, that can help define radio art practices. Firstly, the choice of object is itself a creative act; the principle that the artist defines art. The move from 'artist-as-maker' to 'artist-as-chooser' viewed as the beginning of the 'found object'. Secondarily, removing the function of the object makes it 'art', and its presentation in the gallery gives it a new meaning. Finally, the presentation and addition of a title redefines the object as 'a new thought', or 'a new meaning'.

There is a vast selection of radio compositions and radio artists that are classified using the 'found' terminology. For example, Magz Hall describes the production of Ferdinand Kriwt's, *Hörtexts* - Radio Texts, as "found sound" assemblages of recorded actualities from the 1960s and 1970s, edited together in ironic and unusual ways (Hall, 2015, p. 44). The radio pieces feature recorded noise, sound bites, and samples:

> *Apollo Amerika* (1969), [is] a collage made for German stations Westdeutscher Rundfunk (WDR), Bayerischer Rundfunk (BR) and Südwestrundfunk (SWR) of the media reaction to the Apollo moon launch… Kriwet's works are an attempt at

> communicating an idea of listening to something that always surrounds us on short, medium and longwave frequencies (ibid).

In *The Improvisor: The International Journal on Free Improvisation*, a review by Glenn Engstrand of Eric Leonardson's piece, *Radio Reverie in the Waiting Place*, includes radio sounds (amongst many other instruments and samples) and is described as 'a found-sound collage' providing a 'theatrical flavour' (Engstrand, 2003). Furthermore, curator and researcher, Doreen Mende, clarifies the relationship between found art concept and radio art as follows:

> By removing sound from its original context as an objet trouvé and doubly recontextualising it—that is, as material in artwork and as radio art in an unspecified everyday situation—every sound played on the radio is institutionalised (Mende, 2008, p. 158).

Both Robert Adrien and Tetsuo Kogawa have also contributed lengthy manifestos to definitively define radio art. They both agree that radio is the central focus of radio art, and their frameworks have many parallels to the object being the central focus of found art. Adrien's manifesto defines radio art as:

> 1. Radio art is the use of radio as a medium for art
> 2. Radio happens in the place it is heard and not in the production studio.
> 3. Sound quality is secondary to conceptual originality.
> 4. Radio is almost always heard combined with other sounds - domestic, traffic, tv, phone calls, and playing children.
> 5. Radio art is not sound art - nor is it music. Radio art is radio.
> 8. Radio art is composed of sound objects experienced in radio space.
> 9. The radio of every listener determines the sound quality of radio work.
> 10. Each listener hears their final version of a work for radio combined with the ambient sound of their own space.
> 11. The radio artist knows that there is no way to control the experience of radio work (Adrien, 2011).

Nevertheless, for radio art performances the transitory and haphazard nature of radio's 'found' signals are potentially problematic. Australian academic, Lindsey Vickery, has provided a starting point to explore solutions to this problem. In doing so, radio art could potentially shift away from its 'found' qualities. There are also interesting parallels between the research areas of Magz Hall

and Lindsey Vickery. Like Hall, whose compositional theme centres around the reimagining of Radio once FM has switched to DAB, Vickery explores the convenient switch over that has already happened, from AM to FM. From a performance perspective, Vickery offers practical reasons why radio needs reinventing.

In her paper, *Adapting John Cage's Radio Music for a Digital Score Player*, she argues that new frequency channels, FM and DAB, threaten AM centric radio art. Vickery offers an example of John Cage's work, *Imaginary Landscape No. 4*, composed in 1951. The piece was initially written and performed using twelve AM radios. Two performers operate each radio, one scanning AM radio stations, and the other controlling amplitude and timbre. Following Cage's score, performers tune to predetermined AM radio frequencies. Although, the score begs the question: How do we perform a composition such as this, utilising its original score, when the radiophonic environment has changed so drastically since the score's inception? Vickery offers three solutions:

1. to "embrace" the realities of evolving technology and realise the work principally with the majority of the AM signals comprising of noise and static;

2. to "transpose" the work into a frequency band such as FM which is still relatively populated with Radio stations

3. to "narrowcast" internet radio stations in the vicinity of the performance (Vickery, 2012, p. 23)

Embracing the realities of radio reception and transposing the work from AM to FM, positions radio as a found object follows Adrien's manifesto. Vickery compares the performance of Baroque music on modern instruments with the transposition of AM frequencies to FM found in Cage's score directions. The latter is less noisy than AM, but still provides many of the outcomes found in the original performance, such as compositional structure, noise between stations, and tuning gestures. However, Vickery's narrowcast approach is sophisticated, requiring multiple digital receivers and transmitters. Remarkably, it affords the possibility for the reconstruction of an AM radio space, replicating the works original sonic environment. Intrinsically, a digitised radiophonic environment using broadcasts from the 1950s is achievable.

Such digitised radiophonic environment begs the question, would Cage object to contemporary performances of his piece, if the result were overall, filled with AM static or non-randomised sound? Cage stated that his radio works make, "available something which you're already in. You

are bathed in radio waves… radio simply makes audible something that you thought was inaudible" (Cage, 1966-1967). Had he only intended to make this point, he might have permitted the performers to freely explore the AM band, or even provided specific timing markers on the score. Many of Cage's works from this period explore this intention.[10] In Cage's radio pieces, he specifies specific frequencies rather than durations, suggesting a structure. The proportion of different frequencies and the possibilities for temporal relationships with one another are valuable communication tools for a radio art composer. Although it is not possible to speculate clearly on Cage's intentions, we can emphasise the value of such observations to address the problems associated with AM centric radio art preservation and performance. Yet, the challenge is not exclusive to Cage. For example, Todd Merrell and Patrick Jordon have experienced the same dilemma in their work. They have been performing SW (Short Wave) works since 1991. Using an SW radio receiver, the duo performs by searching the airwaves for exciting noises and transforms these electromagnetic signals into an immersive musical soundscape. In *P-Form Magazine*, Lou Mallozzi wrote a review of Merrell and Jordan's performance. The duo performed an original radio art composition, *SWR*:

> It soon becomes clear that the focus of the work is not on achieving any musical moment, but on the ephemerality of sonic transformation itself. Unlike compositions that utilise radio in part for its referential or signifying qualities, SWR is more in the minimalist tradition of relying on the primacy of the material itself. The work is a celebration of the radio as material and of the belief that minutiae and limited systems can yield rich results. But it is also a celebration of the rich, rugged, unstable thickness of analogue sound in a world anesthetised by the crisp and clean precision of digital audio (Mallozzi, 1998).

Mallozzi's review focuses on the work's wide variety of radiophonic sounds. He appreciates the intricate structural relationships between static and broadcast signals. As such, the work exhibits a sonic-centric appreciation of analogue radio, which exposes a problem for radio art performances, practically when posed as a found art. Despite the analogue radio's rich sound pallet, its sounds are transient. Such an output is problematic for some composers, as performances are inconsistent. Mallozzi's review of Merrell and Jordon's performance, observes the celebration of radios rich material., In the light of fewer SW stations, if exhibited today, would the performance feature such substantive content? The answer is, no. Electromagnetic interference and cosmic static are forever

[10] For example: 4" 33" (1952), 59 1/2" for a String Player (1953), 34' 46.776" for a Pianist (1954), 31' 57.9864" for a Pianist (1954) and 26' 1/1499" for a String Player (1995).

changing, producing exciting sounds for a composer to harness, but unavoidably, contributing towards the temporary nature of radio's pallet. The same actions in different instances be able to produce unpredictable results. Magz Hall encountered the same obstacles in her exhibition of *Numbers*. She explains:

> The frequency stayed fixed for the full three weeks, unlike in Barcelona where… the FM band was so packed I had to keep moving the FM installation frequencies because they were subject to constant interference (Hall, 2015, p. 170).

To summarise radio's found qualities, the ties between these practices helps us to define radio art, or at least describe the interaction between artists, analogue radio, and sonic material. I have narrowed the process down to four steps, which relate to the practices of many artists explored throughout this chapter. I have based the following categorisations on Paul Camic's (2010) found art course of action:

1. Discovery and engagement through the adventure of seeking:

The purpose of building an analogue radio is to 'discover' artist's attempt to 'seek' a range of sounds from static and sonic blemishes to spoken text and music. Many radio art pieces such as Todd Merrell's and Patrick Jordon's performance of SW, and Cage's radio music are composed based upon the said premise. Each performance becomes a live improvisation: an adventure exploring a vast spectrum, with each frequency band offering a new landscape to travel too. In a similar course, Ed Bear is interested in finding unexpected material. However, in his work, *Radio Silence,* this process was carried out by a digital programme, rather than a performer. Moreover, it is important to note that the radio spectrum is organised into frequencies or 'segments', so the location of the discovery is important. As part of this unearthing act, we need to consider the physical movement of the operator's fingers and hand. In most radios, this is part of a dial mechanism that visually displays the location of these frequencies.

2. The symbolic and functional object by capturing something elusive:

Brett Ian Balogh's visualisation of radio space is an excellent example of not only capturing the elusive nature of radio but in transforming it into a visual format.

3. History and time passed by triggering personal memories:

The act of recording radio embodies a specific time and history. There are many radiophonic archives used in radio art, such as *The Conet Project*, and the *BBC Radiophonic Workshop*. Radio broadcasts provide a snapshot into the current trends, cultures, news and politics. Interestingly, the transient nature of radiophonic material introduces questions regarding cyclical levels of authorship, a concept I shall explore in the next chapter.

4. Ecological affirmation by environmental concerns and transforming rubbish:

Ed Bear views radio through this unique 'found' lens, describing his transmitters as electronic waste. His experiments have repurposed obsolete radio technology into an electronic organ-like instrument. In his radio art manifesto, Tetso Kogawa sees the airwaves as a post-modern material, or "garbage":

> For newspaper, for instance, the paper is a medium for communication. So plastic and liquid crystal display (LCD) can be substituted for it. How and when paper becomes an art? It is when the material of "paper" changes itself into a different material. Whatever you write and draw on a sheet of paper, it remains a medium. Therefore, such attempts create not paper art but the art on the paper.
>
> Moreover, when you crumple up it, it becomes garbage. Adorno argued that "all post-Auschwitz culture, including its urgent critiques, is garbage". This "garbage" is, however, not a worthless thing but a new material of art in Adorno's critical perspective. In my interpretation, post-modern arts… starts with Adorno's "garbage". His argument advocated "trash art". Nevertheless, considering his critiques against the electronic mass medium such as radio and television, we can argue that the most post-modern material as "garbage" would be airwaves (Kogawa, 2008).

2.2.2 Radio as an Instrument

In my opinion, numerous artists attempted to explore radio as a found object, found art, found sound, or even found radio. This perception forms a popular framework and research area for radio art. Instead, in the next chapter, I will consider the possibilities when casting radio as an instrument. Once shifting the focus from 'artist as seeker', to 'artist as maker', the resultant options invite a theoretical discussion that cements radiophonic sound as a pallet of solid materials that

can be performed and structured. What is the advantage of analysing a device such as the radio like an instrument? David Moulton addresses this question in his research on, *The Loudspeaker as Musical Instrument: An Examination of the Issues Surrounding Loudspeaker Performance of Music in Typical Rooms*:

> When we think of the loudspeaker from such perspective, we can think about it "playing music," in fulfilment of all of the artistic premises and aesthetic principles that are present in musical performance in general. This turns out to be extremely useful and also quite revealing. We can consider the timbral behaviour of the loudspeaker, …to examine the aesthetic qualities of "loudspeaker music," and to examine the differences between that particular instrumental genre and other instrumental genres (Moulton, 2003, p. 4).

When discussing the radio as an instrument, the work of Lev Sergeyevich Theremin, the inventor of the theremin, an electronic instrument developed using radio technology, is an excellent place to start. Theremin has had a long history of working and experimenting with high-frequency isolators and electromagnetic waves. For his radiophonic instrument (theremin) to produce sound, he utilised two high-frequency oscillators, each producing the same note far beyond human hearing (one remaining fixed while the other was variable). The latter is attached to an antenna sticking vertically out of the box in which the circuit is built. When a hand moved closer to the antenna, the body's natural capacitance transfers more capacitance to the circuit, thus reducing the frequency of the variable oscillator to a pitch lower than the fixed one. Both frequencies would then become 'in-phase', producing a pitch within the human hearing range.[11] By moving and varying the hand distance from the antenna, the frequency shape changes. The closer the hand is to the aerial, the higher the pitch; the further away the hand, the lower the pitch. When the hand leaves the electromagnetic field, the pitch returns to its neutral state- the result emitting no sound.

The theremin was a result of a scientific project. Leon Theremin's training as both a classical cellist and radio operator in WW1 contributed directly to his curiosity and interest in developing an electronic musical instrument. His classical training greatly influenced how he subsequently built and designed the instrument. The tone, pitch range, and gestural interaction made the instrument an uncanny double for the violin or the human voice, found within the chamber and orchestral music of his day. When Theremin toured the Soviet Union, giving demonstrations of the instrument, he played pieces from his cello repertoire. He also included works such as Jules

[11] Phase refers to the relationship between two identical or similar sign waves. If both signals are at their highest peak at the same time, they are in phase, and the sound overlaps. If one signal is at its lowest peak and out of time with the first signal, it is out of phase and sounds modulated or slightly delayed.

Massenet's *Elegy* (Friz, 2009). The electromagnetic field generated by the high-frequency oscillators could detect minimal capacitance changes, thus making a subtle control interface possible, naturally based on a changing field of proximity rather than by touch. The sound of the instrument characterised by glissando; a continuous slide up and down in pitch between notes. Glissando is a feature of fretless instruments such as the violin and cello. Theremin added a volume aerial (which functioned according to the same principle as the pitch aerial) to give control over the attack and release of the note. The feature allowed the playing of individual notes despite the glissando effect. The three-to-four octave, touch-less instrument, made its public debut in 1920 in the Soviet Union, and eventually introduced by Theremin to the West during his visit to New York City in 1928 (Glinsky, 2000, p. 26).

The development of the theremin is similar to Ed Bears's micro transmitter organ. Both composers used their knowledge of electronics and performance techniques to repurpose radio technology into a more conventional instrument that produced identifiable notes and scales. I have detailed this obscure, yet captivating moment in history, as I particularly want to emphasise the embodied nature of Theremin's inquiry into radio waves. It involves the curious mixture of innovation and conventionality, both of which have important implications for building a composition framework, and exploration into radio's instrumental possibilities. However, both instruments function far from an original radio and lack its unique sonic range and aesthetics. They are perceived through a process of signal feedback and human expression, realising the musical play of radio waves through performance. I propose a radically different trajectory for radio's instrumental characteristics. In my theses, radio's sound production and performance will embody the shape of broadcast signals and the vast pallet of radiophonic noise.

I content that radio as an instrument is a vehicle for testing the possibilities of movement and intensities. It is capable of giving birth to a new compositional framework. Analysing radio in such light highlights many of its unique features: disembodiment of the voice, schizophrenic editing of music and words, the coupling of a recorded past with an over-amplification of the present, all manifested within scales and phrases of musical contrast. The main characteristic of the method, is the chromatic rise in intensity, pitch and strength. They underpin a new musical language that we can develop and analyse when casting radio as an instrument.

Chapter 3: Building a Framework for Radio Art Composition

> Time passes most perceptibly; nothing of what has just been is left the next moment; only the course of the single line of melody exists; all the action is pure movement. [...] If the piece is adagio, then the whole world is adagio (Arnheim, 1986, p. 15)

I once performed a piece where I was on stage with an ensemble of improvisers. The venue advertised itself as a kind of 'artsy' bar, but there was no denying, it was more of a coffee shop. If you could not smell the aroma of the beans, you could undoubtedly see the circular stains of coffee cups, a thousand times imprinted into the tables. We had an unorthodox line-up of amplified piano through spring reverb, electric guitar processed via laptop, a well-spoken elderly gentleman who was a BBC radio presenter in nineteen seventies and eighties, and me as the 'radio operator'. The performance piece featured recordings of interviews, triggered by the conductor, Ben Horner. As improvisers, our role was to follow a script that transcribed the interviews and interpret the words and themes through our parts. The ex-BBC presenter introduced different sections of the piece. Horner directed us through body gestures and performance cards. As he held up a paper sign, the pianist suddenly tore parts of the score, scrunched the pieces of paper into balls and volleyed them into the acoustic chamber of the piano. A full commentary of the said work is available in my portfolio chapter. However, throughout the soundcheck, I kept hearing loud static noises, spontaneously erupting in the direction of the left PA speaker. Each sound lasted around four to five seconds, then dissipated into the chatter of the audience. This 'malfunction' struck within the quiet sections of the piece. I vividly remember the conductor forcefully gesturing towards my direction, with a universal sign to stop. After the performance, and to my surprise, the sound returned! It transpired that the sound came from the bar's coffee machine; steam fizzling and whistling through various valves and tubes and echoing throughout the venue. In my head, questions arose: What made both the conductor and I think the coffee machine sounded like my radio? Does radio have an identifiable sound or material? Are these pliable materials? And, why was I even presented as 'radio operator', rather than a 'radio performer'?

As far back as the First World War, the Earth's atmosphere has crackled with the noise of communication: "not just the dots and dashes of Morse code, but brief bursts of talking and music" (Hendy, 2013, p. 282). For the handful of people who had the equipment to pluck these faint murmurings from the ether, it was like witnessing magic:

> Mysterious music and voices in the air have puzzled hundreds of persons in England this Christmastide. From the silence of the night, there have been wafted scraps of melody and tantalising fragments of conversation… Instead of regular beats upon the eardrum, there have come harmonic chords and short, unmissable records of the human voice (Anonymous, 1912).

For the past one-hundred years, such descriptions of radio have eluded its sonic potential. In this chapter, I will develop a framework to dissect, analyse, and classify radiophonic sound. Although, as a found medium, its lack of a coherent conceptual framework has made it difficult to distinguish an independent space and achieve a satisfying dialogue. It is therefore essential to establish a musical language unique to composing with radio. Although, the task is compounded because of the diverse design of commercial radio sets, manufactured in various shapes, sizes, and some with unique features. Also, radio's reception is also a personal interaction of body, space, interference, location, and environment. As such, creating a unified framework pose a challenging task.

Media lecturer, Richard Thorn, shares this need to categorise experimental radio through unified perception:

> …we should seek to loosen the straitjacket of general cultural premises which privilege sight over sound and have largely denied us conceptual frameworks or a language comparable to those of the visual arts (Thorn, 1992).

Canadian artist and writer, Dan Lander, also reflects upon the ongoing dialogue about the very issue. Lander notes a critical factor that has contributed towards radio art's theoretical underdevelopment since the 1990s. In the article, *An Overview of Spatialised Broadcasting Experiments with a Focus on Radio Art Practices*, Lander argues that music's dominance in the field of audio has stunted the growth of radio art methodologies conceptually. He states:

> [t]he imposition of a borrowed musical discourse applied to all sound phenomena, stripping away any social and/or cultural referentiality, thus creating a situation in which aurality in general is perceived as music as if the origin, context and phenomenology of any given sound or noise can be measured only by its contribution to a renovation of western art music (Lander, 1994, p. 13).

Lander calls for the continuation of research, pursued through further theoretical and practical interrogation. Following his observation, Lander suggests we should concentrate on radio art at its point of signification:

> …not a literal rendering which will collapse into cliché, but sensitivity to how meaning in sound circulates, dissipates and re-emerges. The development of an autonomous body of theory and practice regarding aural referentiality… will contribute to a better understanding of the role that radio art plays in the articulation of social and cultural ideas (Ibid, p. 12).

I find Lander's assertion problematic. He offers a widespread perception of a radio art (a complex layering of cultural and social articulations), better suited to theoretical discussions around found art. Such reasoning is apparent in *Radio Play is no Place: A Conversation between Jerome Noetinger and Gregory Whitehead* published in the journal TDR Vol. 40, No 3, *Experimental Sound and Radio* (1996), Whitehead remarks:

> Radio happens in sound, obviously, but the sound is not the material, any more then images are the material of video art. In electronic media, the material is rooted in relationships: living and dead, present and removed, outcast and audience… While sounds can be controlled, these underlying relationships are volatile, and sometimes you just have to give in to what they want to do…. Obviously, it's great if you have a bunch of cool sounds, but unless you can animate the other layers of relationships, nothing happens (Whitehead, 1969).

My aim, however, is to release radio art from this found art pigeonhole, by developing a framework that focuses on the literal rendering of radio (the deconstruction of radiophonic material). As a compositional framework, it is an interesting prospect to uncover the cyclical forces of healthy circulation, dissipation, and re-emergence of sound. As stated in Chapter 2, it allows us to discover the musical potential of radio as an instrument, rather than a found object. My objective further includes an exploration of material, playing techniques and style.

As a starting point, radio artist, Sabine Breitsameter, describes stylistic differences between radio artists from Chicago and Germany. She evaluated such differences based on harnessability of the radiophonic material. Breitsameter's statement forms a compelling analytical framework to take forward:

> The first characteristic of Chicago audio or radio artists is that they are, in my opinion, working very close to music, a particular type of music… They very much like dealing with loud, and reliable, and technical noises, and they like to use noises actively- let us say, in a not very elegant way, but in a way where you really can feel the strength and aesthetic ambivalence of these mechanical noises physically… [In Germany] you would

> not find so many composers using these types of sounds in that way. Sometimes when I listen to the pieces of your artists, I found that you do not make these sounds nice. You use them as brutally as they are, at the border where you cannot bear them. Furthermore, unconsciously you have to decide, "do I want to listen to this now, or not." It starts a process of thinking, and you can feel that the artist is reflecting that process (Breitsameter, 2015).

Breitsameter's comments echo instrumentalists' interpretations of a performance and the musical scores. For example, a trill, vibrato, or crescendo, can be interpreted to sound different between multiple performers. A professional musician has knowledge of the standard or conventional interpretations contained in the work's musical style, although the information is absent within the score. It is knowledge learned from experience and preference, which change over time and between musical genres, instruments, regions, and performers. Therefore, when casting radio as an instrument, is it possible to be performed in different styles? Can performers utilise performance expressions, like vibrato, glissando and dynamics?

In the development of my framework and musical language, I will continue to deconstruct radio into a set of solid materials for composition. Along the way, I shall compare a range of radios to document sonic and gestural idiosyncrasies within the sound production, performance, and composition. I will position the radio as an instrument and test the viability of my premise. Along the way, I intent to reference electroacoustic analytical concepts such as Dennis Smalley's *'Spectromorphology'*, and Curtis Roads', '*Cloud Formations*.' I shall further experiment on a range of analogue radios to further my understanding of the sounds, textures, and shape of radiophonic material. In doing so, I shall attempt to address the following questions: What kind of sonic material does radio produce? How does a broadcast fit into the concept of compositional material when any sound can be transmitted? How can the radio be performed consistently? Do performance techniques influence the characteristics of radiophonic material or vice versa?

3.1 Characteristics of Analogue Radio

With a domestic radio, tune into an AM frequency until you hear only static. Hold a nine-volt battery near the radio's antenna and join the two battery terminals by tapping a coin onto them. With each coin connection, the crude circuit becomes complete, releasing electromagnetic pulses from the battery. The result is a crackling sound received by radio and caused by the connection

and disconnection of the circuit. In its purest form, this is radio transmission and reception in practice. The circuit created by the battery and coin acts as a radio transmitter, emitting radio waves (electromagnetic signals). By tapping Morse Code using the coin, one hears the crackling message received through a radio within several inches. As one moves the radio away from the battery, the Morse Code becomes fainter and distorted. In commercial radio, broadcast stations expand this process. They use much higher voltages to send transmissions over vast distances.

In my above battery and coin example, I transmitted an empty signal. Broadcast stations transmit audio information using similar signals. Building upon an earlier example, each battery connection generates a voltage. A square wave signal is produced by rapidly changing the electrical current from On to Off, fluctuating from 0 to 9 volts.

Figure 1: Square Wave

Smooth voltage fluctuation is generated by removing the coin and connecting specialised circuitry such as a capacitor, inductor, and transistor. The signal is a sine wave which is commonly used to transmit audio.

Figure 2: Sine Wave

Broadcast stations modulate sign waves to encode information. Pulse Modulation (PM) is a similar signal produced by my battery and coin example. It is a sine wave that turns on and off, a commonality in Morse Code and radio-controlled clocks.

Figure 3: Pulse Modulation

Amplitude Modulation (AM), is used in AM radio broadcasts. The audio signal is overlaid onto the transmitted sine wave to vary its amplitude.

Figure 4: Amplitude Modulation

FM radio stations use Frequency Modulation. Unlike AM, the amplitude remains constant. Instead, the frequency of the transmitted sine wave is modulated, encoding the audio signal into the transmitted sine wave.

Figure 5: Frequency Modulation

Radio reception is a process that involves decoding (demodulating) the information transmitted through a sine wave. The radio antenna receives multiple sine waves at once. A tuner device separates the signals. It operates through a principle called resonance to 'resonate' and amplify one frequency at a time. It is a similar process to the audio production technique, 'filtering,' or setting an audio EQ. to amplify a specific frequency. The frequency of a sine wave is the number of times it oscillates up and down per second. In AM reception, the radio tunes to a sine wave with a frequency range of 1,000,000 kHz (hundreds of cycles per second). For example, the AM frequency 530 kHz, oscillates at 530,000 hertz. FM transmissions operate within the environs of 1000,000,000 hertz (millions of cycles per second), so the frequency 104.5 MHz, receives a sine wave oscillating at 104,500,000 hertz.

In the UK, an FM broadcast band ranges from 87.5-108.0 MHz. Most countries use this frequency range. However, in the USA, FM ranges from 88-108 MHz, and in Japan, 76-95 MHz. For AM frequencies, the standard range is from 535-1700 KHz. Multiple wireless technologies reserve part of the radio spectrum for transmission and reception. For example, Citizens Band (CB) radio is a system of typically 40 short-distance radio communication channels. In the UK, CB radio operates within 26.965 to 27.405 MHz. The UK government initially licenced the 27MHz band to radio-controlled model aircraft hobbyists and then offered alternative frequencies within the AM and FM spectrum. Other devices include wireless garage door and alarm systems (40 MHz): radio-

controlled cars (75 MHz): air traffic controller radar (1,227 and 1,575 MHz): and deep-space radio communications (2290 – 2300 MHz).

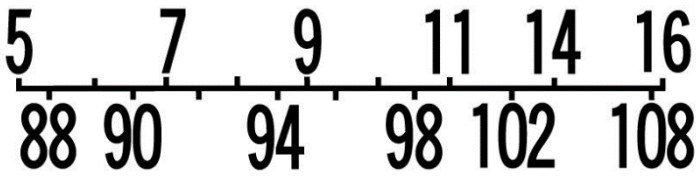


Figure 6: Frequency band design- Example 1

Figure 7: Frequency band design- Example 2

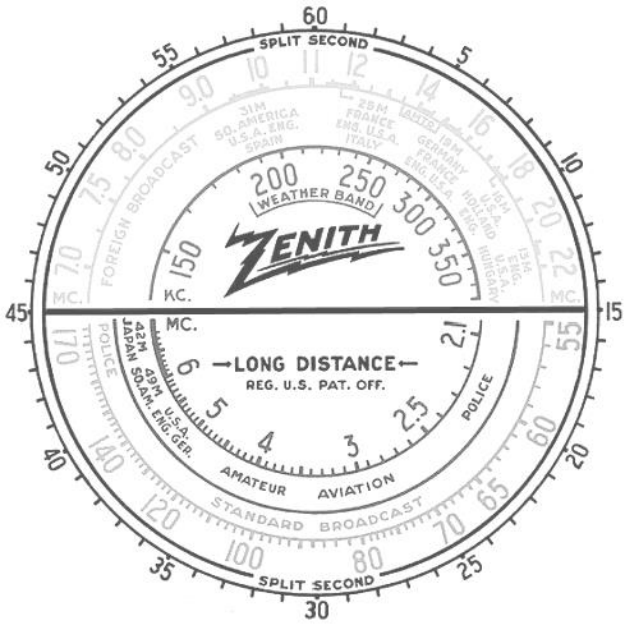


Figure 8: Frequency band design- Example 3

From a compositional perspective, question begs: is there a difference in sonic profile between AM and FM transmission and reception? When comparing fidelity and capture effect, FM and AM reception produce considerably different results. For instance, in FM, the more robust transmission eliminates the weaker one, creating artefacts at the point of transition. However, when receiving AM signals, the broadcasts overlap like polyphonic textures, forming a foreground of robust transmission, and a background for the weaker ones. Furthermore, in both spectrums, the tuning distance between each frequency is not even.

Since its invention in the late 19th century to the present time, radio has undergone various changes and styles. Today, we may purchase range of radios including pocket receivers (credit card-sized radios with a recessed dial and a headphone output), interior design pieces (bespoke, antique, or refurbished vintage radios), playback devices (radios that feature Bluetooth speakers and inputs to playback stored music such as an SD card and USB slot), or novelty items (radios built into furniture or shaped as other objects such as the infamous cola bottle shaped radio and the 1960s radio hats for women). To set the parameters of my compositional framework, I will explore the idiosyncrasies shared between consumer radios.[12] For my comparisons, I have selected a range of analogue radios, all featuring a speaker and headphone output to diffuse the sound. The majority of analogue radios tuned to a radio frequency by scanning through empty areas of the radio spectrum. Most analogue radios use a dial for tuning, and digital radios use buttons for changing stations and setting frequency presets. As such, I am drawn towards the expressive potential of analogue radios, as navigating through empty radio space can create a range of varied compositional materials. Furthermore, when using a dial compared to a digital button, there is the possibility of heightened interaction and performance techniques. I will explore this sensation throughout this chapter.

A notable characteristic of the radio speaker is that it obtains optimum performance in a single direction with a constrained frequency range that often loses its lower frequencies. A joint facet between currently available consumer-level radio sets is their relatively portable sizes and wireless operation through the usage of a battery power. It allows the user to easily transport the radio set while continuing to receive radio signals. Although they predominantly feature an antenna to

[12] Consumer radio: It is a commercially available radio that only receives broadcasted signals.

receive radio waves, styles may vary. Antennas are mostly built as a metallic telescopic tube, protruding from the top of the radio. Other styles include a flexible wire attached to the back of the radio or an antenna encased in a solid material.

Located on most analogue radios is a visual marker. When rotating the dial, the marker moves up and down the frequency bands, conveying information that proves useful for performance and composition. The marker represents the tuned frequency and its position within multiple bands. I have developed a set of ratios to analyse and compare the compositional potential of different radio sets. The ratio mirrors the amount of sonic detail produced by the radio when tuning. It involves counting how many frequencies are within a dial rotation and the size of the dial. As such, I call this method, 'Frequencies Per Rotation' (FPR). A radio's FPR reflects its internal mechanical processes. In an analogue radio, the dial is connected to a potentiometer, a voltage resistor with a sliding contact. The voltage passing through the potentiometer is measured and resisted. The higher the resistance, the higher the tuned radio frequency value. There are several interface variations for potentiometers, including dials and sliders. Standard potentiometers use a dial and have a rotation of 270 degrees. While there are potentiometers with new or continuous revolutions, in analogue radio, it is more common to fix the component.

Figure 9: Fixed potentiometer rotation diagram

A full rotation of the internal potentiometer will always scan through the entire frequency band, from 87.5-108 MHz in 0.10 intervals on FM, and 535-1605 kHz in 1 kHz intervals on AM. However, the relationship between the radio's external dial (rotated by the user), and the internal potentiometer is not always equal. A combination of pulleys or gears allows the external dial to rotate multiple times, slowing down the internal potentiometer revolution, to accuracy tune to the 0.10 frequency intervals.

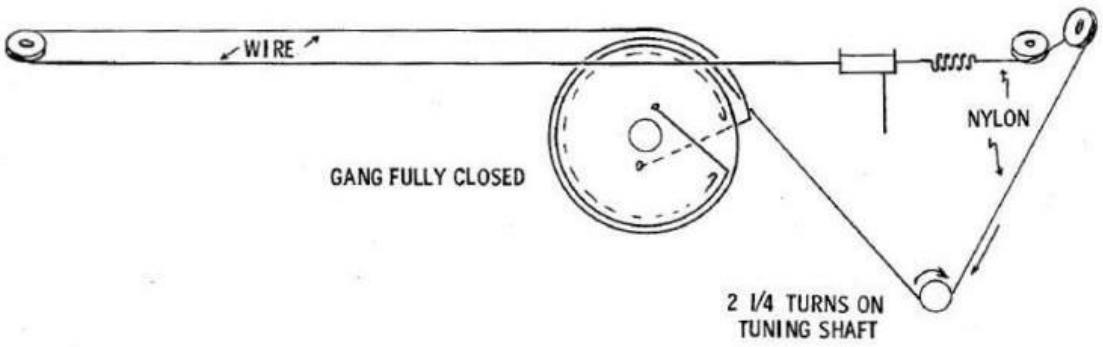


Figure 10: 2 ¼ rotations on this radio dial fully rotates the potentiometer

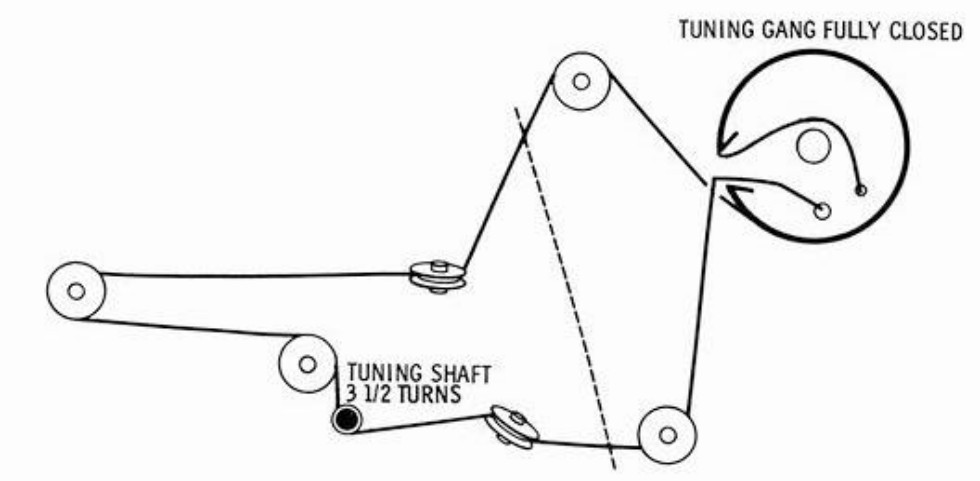


Figure 11: 3 ½ rotations on this radio dial fully rotates the potentiometer.

My FPR ratio requires two values which are determined without deconstructing the radio set or viewing internal schematics. The first value represents the radio's frequency range, and the second the rotational degree of the dial. For instance, a radio that scans five frequencies per 180-degree dial rotation will have greater tuning detail than one that scans twenty. In my methodology, FPR is transcribed in the following format: 5:180 (5 frequencies per 180-degree rotation). Therefore, the more we tune frequencies in a rotation movement, the slower the potentiometer will rotate, creating considerably more tuning detail and sonic variation. A radio's FPR calculation is central to our understanding of radio's sonic potential. Although a range of frequencies and rotational values are testable, my recommendation for accuracy and consistency is to test radio's FPR by counting the range of frequencies within a half or full dial rotation (the degree of the dial rotation for half and the entire radio band). As the distance within the frequency spectrum is not equal, each calculation must start from the lowest frequency value or 88 MHz on the FM spectrum. Both UK and US radios can support this value.

The following FPR examples are arranged from the lowest tuning quality to the highest. Each calculation maps the FPR for 180-degree dial rotations: Philips: FPR 2:180[13], Clearclick: FPR 3:180[14], Robert: FPR 4:180[15], Sony ICF506: FPR 6:180[16], Sainsbury's FM/MW/LW Analogue Radio: FPR 20:180[17].

3.2 Terminology for Radio's Sonic Pallet as an Instrument

It is challenging to categorise radiophonic material. Any description relies on poetics, such as dualistic characterisations, 'anxiety and ecstasy', 'chaos and order', (as discussed in my previous chapter). Poetics give us little in the way of clarification as such terms are interchangeable and subjective. Furthermore, any sound is broadcatable, including noise. My categorisation splits radiophonic material into two forces. The first is *the broadcast signal*; any sound that has been intentionally broadcast, but most importantly, one that evolves like most traditional radio programming. The second force is *broadcast noise*.[18] Unlike signal, it is static in characteristic, and unlike signal, it requires gesture (from the dial), to evolve and change shape. Additionally, noise and signal also intertwine with one another. As the dial rotates, noise unfolds, into a broadcast signal. I call this process a *radiophonic behaviour*. Each type of broadcast material affects listener's perception. Noise is static, or a perceptual loop, and gives no sonic indicators of time passing. The broadcast signal is the opposite, pushing forward at different perceptual speeds, due to its constant evolution. However, by tuning the dial and creating radiophonic behaviours, noise acquires motion, while the broadcast fragments into transient individual tones.

In the following pages, I will deconstruct and analyse radio's sonic aesthetics, characteristics, and shape. These materials are building blocks that populate a *radiophonic environment*. A radiophonic environment is a term I use to describe a radio band, such as the AM or FM frequency spectrum. Anna Friz and Tetsuo Kogawa have named such environment as 'radio space', while Richard Kostelanetz describes the spectrum like a "city portrait" (Kostelanetz, 2017, p. 134). I refer the

[13] Philips radio 2.180 FPR video demonstration: https://blocki.co.uk/hilmi/1.mp4

[14] Clearclick radio, 3.180 FPR video demonstration: https://blocki.co.uk/hilmi/2.mp4

[15] Robert radio 4.180 FPR video demonstration: https://blocki.co.uk/hilmi/3.mp4

[16] Sony radio 6:180 FPR video demonstration: https://blocki.co.uk/hilmi/4.mp4

[17] Sainsbury's radio 20:180 FPR video demonstration: https://blocki.co.uk/hilmi/5.mp4

[18] I also use the short form terms *signal* and *noise* about broadcast signal and broadcast noise.

marked frequency scale that forms the radio dial, *radiophonic scale* (as in a radio marking FM frequency sequence: 88, 92, 96, 100, 104, 108). They form visual pivot points that aid the composer in evaluating the tuning distance between different radio frequencies.[19]

I propose an analysis of radiophonic materials and environments, influenced by electroacoustic, acousmatic and studio production practices. I find links between Sabine Breitsameter's radio art descriptions and acousmatic compositional practices. Breitsameter argued that radio art should adopt the electroacoustic methodology, where for the composer, all elements are the same materials to harness.

> RadioArt is an electroacoustic genre, which fluctuates in the indistinct realm between Hörspiel, new music, sound installation, soundscape, performance art and experimental pop, and which creatively and artistically handles the entire spectrum of the world of sound, the same juxtaposition of noise, music and speech (Breitsameter, 2000).

This approach follows on from my assertion that radio is an instrument, rather than a found object. However, there has been little amount of work carried out on the exploration or seeking to structure its compositional potential.

Rotating the radio dial creates a unique method for sound processing. Robust terminologies are required to deconstruct this interaction and to create a compositional framework. As a starting point, my analysis shall follow mesostructure and morphological studies. The mesostructure groups sound objects into a quasi-hierarchy of durational phrase structures, which are measured in seconds. This local, as opposed to a global timescale is extremely important in acousmatic composition, as it is most often used to identify 'unfolding' musical phrases and ideas. Therefore, this analytical method is well suited for identifying radiophonic behaviours. In radio, the complex nature of noise unfolding into a signal requires the examination of multiple streams of sound. These include sound masses, sequences, combinations, and transmutations. In the design of sound art, the mesostructured layer offers timbre melodies, simultaneities, spatial interplay, and all manner of textural evolutions. In 1962, Edgard Varese predicted that the sounds introduced by new electronic instruments would necessitate new organising principles:

> When new instruments allow me to write music as I conceive it, taking the place of the linear counterpoint, the movement of sound masses, or shifting planes, will be perceived.

[19] Video of pivoting radio dial marker based on the radiophonic scale indicator: https://blocki.co.uk/hilmi/6.mp4

> When these sound masses collide the phenomena of penetration or repulsion will seem to occur (Vare'se, 1962, p. 14).

Radiophonic behaviours form complex particles of micro-events. They encourage a process of statistical evolution. Through the interaction with dial, the composer manipulates the rate of evolution. The micro-events, from noise to broadcast, takes place in the domain of amplitude (crescendo/decrescendo), internal tempo (accelerando/rallentando), density (increasing/decreasing), harmonicity (pitch/chord/cluster), and spectrum (high/mid/low). A crossfade between two radiophonic materials results in a fluid mutation of these forces. Disintegration and fragmentation are achievable when static and signal collide. The density of static determines the transparency of the material. An increase in static density lifts the material into the foreground, while a decrease causes evaporation, dissolving the material into a vaporous background texture.

In his book, *Micro Sound*, Curtis Roads is influenced by the taxonomy of cloud shapes in the atmosphere. He uses such analogies to analyse the shape and texture of sonic material:

> Cumulus: well-defined cauliflower-shaped cottony clouds
>
> Stratocumulus: blurred by wind motion
>
> Stratus: a thin fragmented layer, often translucent
>
> Nimbostratus: a widespread grey or white sheet, opaque
>
> Cirrus: isolated sheets that develop in filaments of patches (Roads, 2000, p. 16)

Road's, cloud formations share a similar framework to Dennis Smalley's Spectromorphological analysis. In his paper, *Spectromorphology: Explaining Sound-shapes*, he has developed an analytical practice for describing and analysing the listening experience.

> The two parts of the term refer to the interaction between sound spectra (spectro-) and the ways they change and are shaped through time (-morphology). The Spectro- cannot exist without the -morphology and vice versa: something has to be shaped, and shape must-have sonic content. Although spectral content and temporal shaping are indissolubly linked, we need conceptually to be able to separate them for discursive purposes (Smalley 2005).

A spectromorphological approach sets out the dual spectral and morphological processes, offering a framework to understand structural behaviours and relations, experienced in the temporal flux of sound. As radiophonic behaviours require a sonic analysis that is more concerned with spectral qualities rather than musical notes, a spectromorphological analytics seems adequate as workable approach. Radiophonic material could then be analysed by focusing on the varieties of motion with flexible fluctuations of time. Using Smalley's linked temporal stages, "onset, continuant and termination", I will explore the shape of radiophonic behaviours. (Smalley, 2005). The ideas of onset (how something starts), continuant (how it continues) and termination (how it ends), can be used to interpret and analyses the function-significance of a behaviour. As such, traditional concepts of rhythm are inadequate to describe the often-dramatic contours of tuning behaviours and internal tensions.

It is essential to state that a radio set offers other direct means of sound manipulation that are not triggered by the tuning dial. As these manipulations are controlled using a dial, which, as previously stated, has an internal potentiometer that rotates or 'unfolds' linear resistance, the result remains morphological. These include tone, balance, and volume control. The tone regulates the amount of high or low frequencies within the output signal feed. The balance controls radio's stereo specialisation. Although it seems obvious to state that an electrical item with a speaker feature that controls the volume, it is essential to clarify that silence is not often heard on the radio. However, when casting as an instrument, the volume control contributes towards a performance practice that can generate silent moments. From a performance perspective, these controls create a layered practice, where the sound is manipulated locally (via the tuning dial), or globally, (via the volume, tone, and balance dials).

3.2.1 Broadcast Signal

Between 2009 and 2013, I operated an 'indie' record label called, *Pop! Goes the Weasel*. It was a rewarding experience, particularly when preparing singles for a radio play. One of my bands, *Let's Get Science*, was a four-piece ensemble of teenagers (reminiscent of the UK punk bands from the mid-1970s, but with more of a pop sensibility in their writing). The plan was to sneak as many band members into a monthly club night where *XFM* presenter, John Kennedy, held a monthly DJ spot. With their teeth brushed and hair mopped back, Kennedy was more so impressed that the 'baby faced' group made it into the club to pass him a CD of their music. A few weeks later, I received an email from his office requesting a radio edit of the song, *Little Annie*. Being new to the industry, I asked if they could explain what a radio edit required. The email I received went something like this: the song needs to be three minutes or shorter, all curse words must be muted, and the first line of vocals must enter within thirty seconds from the start of the song. *Little Annie* became his 'song for the summer' and aired throughout the holidays on his late-night new music show. I eagerly tuned to the broadcast to find that song we spent so much time producing, sounded vastly different from its definitive master. As the song's producer, I was well versed in its sonic presence. Reflecting on this experience has made me think about the broadcast signal, not as a series of randomised sounds within shows, playlists, or interviews, but as a material with clearly defined shape and aesthetics. Just like radio edits, many rules and expectations control how music and voice are presented over the radio. Therefore, radiophonic material, which largely broadcast signals, has a distinctive sound compared to its non-transmitted counterpart.

I use the term signal to describe sounds containing agency which is intentionally broadcast for radio reception. It is a commonly transmitted material from radio stations. It has an immediacy and liveness (the cultural value of the live experience—its 'nowness') that is in perpetual motion. The broadcast signal is not an amorphous sound like radio static, waiting to be moulded into shape by the dial, but rather, it is a dense, dynamic substance, taut with the tensions of its potential. It is essentially one of many active sound sources, positioned at individual points within a radiophonic spectrum, evolving in shape, structure, and dynamics, regardless of its interactions with the dial. For composition, broadcast signal expresses a range of sonic aesthetics and thematic areas. In its entirety, it offers a snapshot into popular culture, politics, trends, news, and a range of musical genres. With such a full pallet of sound, from speech, music and sound effects, my aim in this chapter is to demystify its sonic aesthetics and themes. For example, broadcast material such as voice and music undergo multiple layers of compression; an identifiable characteristic, as it lacks in dynamic variety, yet sounds intimate and intense. It reminds me of the multiple conversations I had in my recording studio with bands and vocalists. They often remarked, "can you make me/us

sound like it is on the radio? Or, "why does it always sound better on the radio?" Although audio transmission often reduces the fidelity of recordings, while also is prone to receiver interference and discounted speaker quality, the additional layers of compression by the broadcast studio contribute towards its new and unique perception.

Composing with broadcast signals expose multiple levels of authorship within the process of transmission and reception. This feature has partly fuelled radio art's philosophical found art influence, as stated earlier. Compared to traditional instruments, the broadcast signal has no coherent sound of its own. It consists of definitive structures composed, arranged, and performed by others. When composing with this material, a similar process to sampling techniques is adopted. Transmissions become deconstructed to the point where, in the compositional chain, definitive structures reset as source material or fragments. It is then developed into a new definitive work, with the possibility of re-transmission. Novelist and installation artist, Tom McCarthy, has developed an exciting model, highlighting the potential for artistic practices when adopting this cyclical approach. He sees the artist's role as not someone who has 'something to say', but rather, someone who immerses themselves in media, language, transmissions, current media (like today's news) and repurposes these into retro forms. At the *Reinventing the Dial Symposium* (2009), McCarthy, describes his creative practice to involve multiple levels of authorship:

> What these people are doing is looking at this other media, clipping lines from it, whether it be from the tv or the radio, or the newspapers, sending it over to a central desk. It is being reset in quite formal poetic structures, using, Iambic pentameters, Sonnet forms, Villanelle forms. Whenever there were numbers, we would throw them in. We were making these messages that sounded incredibly suggestive, and transmitting those out with a fifty-mile signal, but also, streamed online so that other stations around the world could retransmit it. So, you have a global map of who is transmitting the signal and when… The great thing about radio is it's a physical material thing and if there are clouds, and if there are pirates, the air actually changes from hour to hour (McCarthy, 2009).

The New York-based artist and composer, Christian Marclay, shares the idea of resetting the authorship. Marclay's works include splicing together sections of vinyl records. As part of his process for making unique compositions, Marclay physically cuts records to different sizes and playback speeds. Then, he glues the sections together to form one playable and exhibitable vinyl disc. The audience hears the pops and clicks of the joint pieces, which may include snippets of

music, although not enough to identify the performer or original record. As an artist in residence at the *AA School of Architecture*, Marclay presented a lecture that explores his unique use of material and theme:

> A recording is meant to be duplicated and multiplied, and that is the way to have your music distributed and made available. Here I was going back to a more primitive way of making music, creating a one of a kind recording, so it was not documenting anything. I was creating a unique sound object. Even you could listen to it many times, and you could hear different types of compositions with every play, depending on the speed, depending if your needle would skip, and get stuck in a groove. In that case, it could last a long time and be a lot more repetitive (Marclay, 2006).

In a gallery setting, he encourages his audiences to play, mix and sample these records. Marclay's process not only creates a unique work but through its presentation, he enables the audience to introduce additional levels of authorship and creativity. The practice forms a tradition that historically DJs used to create new sounds. By morphing two records together and manipulating their playback speed, the DJ redefines the tracks into something new.

The radio presents us with similar choices. From broadcast to the reception, there are multiple levels of authorship to consider. For instance, radiophonic environments are populated with definitive sound structures such as fixed media playback (pre-recorded music and compositions, sound effects, radio commercials), live performances (musical performances, traffic updates, discussions and debates) and scripts (written material to be read out). Radio programmers arrange this material in orderly playlists and schedules. Radio artists then repurpose the broadcast signals. The arranged signals present an opportunity for re-transmission, and potential for further recycle into new ideas. Both Mcarthy and Marclay treat their mediums' sonic produce as solid materials for composition.

The contents within broadcast signals are roughly predictable in the understanding of the types of sounds and subjects within a radiophonic environment. Most Western radio stations advertise their programming schedules online and commit to specific audience demographics. The geographical location of the radio set also contributes to the type of broadcasts received and the strength/clarity of the signal. As such, broadcast signals occupy physical space and create sonic territories that are traversable using the radio dial. For example, my radio set in North London receives *BBC Radio 2* at frequency 89.1 KHz, *Classical FM* at 100.9 KHz, and *London Greek Radio* at 103.3 KHz. These

frequencies change as I move around the city, and in the case of London Greek Radio, disappear when exiting the environs of North London. Moreover, broadcasts are received in either mono or stereo. It is more common for AM signals to be mono, and FM to be stereo, although this is not always the case.

In Richard Kostelanetz's work, *The Art of Radio*, the author describes differing radiophonic environments between countries. In his assessment, Kostelanetz compares broadcast signals between USA and Europe- panoramic sweep of the entire FM and AM spectrum in New York City compared to its German counterpart exposes variance in not only the spoken language but also the range and variety of stations available at any given time. The American radio culture differs radically from the European due to the multitudes of different local and independent radio stations available. According to Kostelanetz, this is the result of laxer broadcasting regulations and the differing radio culture in the US. For example, in New York City, stations do not broadcast complete radio schedules. This practice contrasts with the minute by minute programming updates available in countries such as the UK and Germany. In his book, Kostelanetz explains American Radios' most defining characteristic:

> In New York City, as elsewhere in America, most radio stations develop a single, highly defined kind of programming, and then stick to that programming (and only that programming) for the entire broadcasting day, which in America customarily runs for twenty-four hours, which is to say all day and all night. Thus, for example, the station W-I-N-S (commonly called, "WINS") broadcasts news, and only news, along with current reports on weather and traffic updates (Kostelanetz, 2017, p. 115).

The reason for such narrow focusing is that nearly all-American radio stations try to develop a distinctive character that captures specific listening preferences at all time. Kostelanetz describes the musical landscape of radio as segmented by musical genre and themes. Stations picks playlists such as Disco, Country and 60s Rock. Programming schedules become further compartmentalised to favour playlists such as love songs, top-40, best-sellers and 'middle-of-the-road' (ibid). In an interview with electroacoustic composer, Eric Leonardson, initially published by *Chicago Soundweb* in 1995, radio artist, Sabine Breitsameter, elaborates on the differences in discourse and culture between US and German radio. In particular, she comments on the more specified programming in America, as proven by Kostelanetz:

> You have the rock 'n' roll radio here [in the US], and you have the radio for the housewife there. It is more defined by distinctions, categorisation, much more than in Germany. The talking that had been going on this radio was small talk. It was nothing new, it was nothing interesting, it was nothing special and I was never interested in what was going on, because there was no content, no information. It was a very, very small and light kind of talk. Now we have the same thing here. It started 8 or 10 years ago and came up slowly at private radio stations. But in Germany there still is very important public radio, which is not in doing the same thing, especially in its cultural programming. We have very meaningful talk and not this small talk that I experienced so much when I was listening to the American radio (Leonardson, 1995).

In the UK, radio producer, Lance Dann, who worked on a series of radio plays and commercials for BBC Radio 2, BBC Radio 4 and as Commissioning Editor of Programming for Resonance 104.4FM, highlights a valuable insight into the strict programming conventions of British broadcasting. At the *Reinventing the Dial Symposium*, Dann remarks:

> To look at the status quo within the radio industry, we have an industry here, audience demographics heavily drive that, and when I have been working with radio four, you are writing for 45+ A B C 1. It is driven by scheduling conventions. You have those slots, the afternoon play, 2.15-3.00. You have people doing light housework and non-essential repair work (apparently), Saturday afternoon, 2.00 to 3.00. You have the Friday play, 9.00 onwards. Those slots are set and the audience within those slots are premeditated and the understanding on what they are doing is fed down to you through commissioning guidelines (Dann, 2009).

The unifying aesthetic of the broadcast signal that shapes the main difference between sound art and broadcast art is the role of transmitting sound. The broadcaster is aware of a community of people, simultaneously receiving the programming. This idea is clarified by Dann, as he states:

> The audience will not listen beyond 45 minutes, because their desperate to get out of the house by 3.00, and there are set within ideas of how the audience will listen to the radio. It is not a calendrical experience. It's not something that you book in to listen to radio drama on radio four. It's something that is heard as a secondary activity (Dann, 2009).

Once the material is disseminated from the radio, the sense of its community and 'at the moment' is lost. Composers, Andy Cartwright, and Peter Cusack further clarify the type of thematic material from BBC Radio. The former points to the little amount of experimental radio or the lack of more challenging and imaginative programming featured on *BBC Radio 4*. At the *Reinventing the Dial Symposium,* he remarked:

> Things are changing, and they are changing, not for the better. I think things now have to be more mediated through somebody else, and you only have to listen to slots that would have more experimental production techniques, like the 10.30 on Saturday morning at radio four, to now find that you cannot celebrate them in that slot unless you have a good named presenter like Stephen Fry… The problem about public service radio in the UK at least, is how they are chasing these audiences. [Target] audiences are very important to them… Why don't we do something different? It might attract a different audience, and it might attract more interesting production techniques. But no, we can't, because we have to retain the audience, and everything has to be mediated through another person. A journalistic for example. So, they can tell the story, so the audience can understand it (Cartwright, 2009).

Like Cartwright, Cusack shared the same experience. When creating field recordings for conventional radio like the BBC, mundane and environmental sounds are taken no notice of, and rarely heard. For the BBC, any suspicion of an outdoor sound is layered with speech. Even though they are in the background, they are seldom the focus, "so we are not used to listening to every day sounds through the medium of radio" (Cusack, 2009). The lack of environmental and every day sounds inspired radio artist such as Anna Friz to broadcast such material. As highlighted in my *State of Research* chapter, her works have used recordings of wind, breaths, and other bodily exclamations, which she describes as often not heard on commercial radio.

Broadcast subjects and radio etiquette in the UK are regulated by a set of rules and legislative provisions (*The Ofcom Broadcasting Code* by the Office of Communications (Ofcom). While the code does not cater for every possible situation, it includes several new regulations that may affect the type of broadcast signal received at different times and dates. The most well-known regulation is aptly named the 'watershed'. This rule protects children from inappropriate content between 9.00 pm and 5.30 pm. Moreover, in September 2016, Ofcom released a research paper titled, *Attitudes to Potentially Offensive Language and Gestures on TV and Radio.* The document outlines a comprehensive 147 barometer of words, that range from non-discriminatory language describing: general swear

words and body parts, to discriminatory language describing: religion, sexual orientation, and race. Each word has an acceptability rating that ranges from mild to most vigorous or classified as 'debatable'. Participants of this study were asked to pinpoint different language expectations around the watershed transition. Most expected little or no swearing before 7 pm, some mild, infrequent language from 7-9 pm, strong language with warnings from 9-10 pm and the firm(est) everyday language after 10 pm. However, according to the participants' views, other contextual factors should be considered. These include the time of broadcast, likely or potential audience, the regularity of potentially offensive language, the expectation of programme or genre, mitigating actions such as warnings, bleeps or apologies and the perceived tone and intent of the programme. Due to these findings, it is fascinating to note that broadcast signals contain speech that has been carefully controlled, and in some ways, shaped based on audience perception. It further clarifies my previous statement that broadcasters are vastly sensitive to the views of their listening constituents, who simultaneously receive and react to their programmes.

3.2.1.1 Music on the Radio

Towards the start of radio's history, a song on the radio became part of the composition's most definitive form. More recently, music for broadcast is shaped in unique ways creating an alternative version of the song. At the start of this chapter, I mentioned that the radio-playable version of the song is called a radio edit. Music on the radio is shorter in length and features censored words. However, there are always exceptions to the rule. One notable example is *Bohemian Rhapsody* by Queen. At 5.55 in length, it was broadcast on *Capital Radio* by DJ Kenny Everett in October 1975. Music on the radio is often shorter than its original recording to make it more commercially viable for radio stations. The radio edit, therefore, attempts to reduce the length of a song into manageable chunks, thus increasing advertising space for the commercial channel, while also catering to the target audiences' perceived attention span. Although it is not as common for classical music, the average length for songs played on the radio is three to four minutes. For instance, La Roux's release of *In for the Kill* included the radio edit as an additional track. I have identified several aesthetics that are unique to music played on the radio compared to other streaming platforms.

1. Fade Out: On radio, occasionally songs will fade out, a common practice on tracks with long instrumental endings. For instance, the radio edited version of *Heroes,* by David Bowie, fades

in shortly before the beginning of the third verse and fades out shortly before the vocals at the end of the song.

5. Cutting out verses, bridges, or interludes: In La Roux's, *In for the Kill*, the middle eight sections is removed for the radio edit version. In Justin Timberlake's, *Mirrors*, the radio edit also removes the interlude segment.

6. Shortening the introduction and outro: In B.o.B's, *Nothin' On You*, the radio edit skips the first five seconds of the song and opens with the first chorus sung by the featured artist, Bruno Mars.

7. New arrangements: Some songs are overtly remixed or feature different arrangements than the original version. Occasionally they bear little resemblance to the original recording. A notable example of this is *Revolution*, by The Beatles, which is an entirely different recording from the version which appears on *The White Album*.

8. The exception: Like *Bohemian Rhapsody*, the songs that fall within this category do not have a radio edit despite being up to eight minutes in length. The reasoning is due to the listener demand or artistic merit. Iconic songs tend to be played at their original intended length. Examples include *Hey Jude*, (1968) by The Beatles at 7:11min., *Stairway to Heaven*, (1971) by Led Zeppelin at 8:03min., *One*, (1989) by Metallica at 7:24min., and *American Pie*, (1971) by Don McLean with a length of 8:32min.

9. Censorship means the conformation with standards imposed by government agencies, such as the US Federal Communications Commission, the Canadian Radio-television and Telecommunications Commission, the Australian Communications and Media Authority, and Ofcom in the United Kingdom. Radio edits often feature censored words or phrases. The offending words may be silenced, reversed, distorted, or replaced by a tone or sound effect. The edits may come from the record label, artist, or broadcasters, far before songs approval for airplay. Occasionally, the song is re-recorded with different lyrics, ranging from the replacement of one line, such as James Blunt's *You're Beautiful*. It replaces "fucking high" with "flying high" in the second verse, or the change of an entire song, such as D12's, *Purple Hills*. In the latter, which includes multiple instances of profanity, drug references, and other inappropriate lyrics.

3.2.1.2 Voice on the Radio

In the book, *Noise: A Human History of Sound and Listening,* David Hendy comments on the forces that will be influential in shaping radios future characteristics. He recalls the life of what he calls the BBCs "founding father", John Reith (Hendy, 2013 p. 287).

> When it came to the pronunciation of English on-air, Reith was clear that people's life's and employment prospects would be improved if an example could be set. Although there were countless regional dialects and accents to be heard on the streets, pubs and family homes of Britain, the standard broadcast voice should be what the BBC called 'Southern, educated English' (ibid p. 289).

Reith's approach gave early twentieth-century British radio characteristic sound: full of voices with 'posh' English, clear pronunciation, yet lacking pretension. In Hendy's book, he also details a fascinating experiment by Harvard University psychologists, Hadley Cantril and Gordon Allport, who conducted several radio experiments which featured voice. They detail the experimentation in their book, *The Phycology of Radio*. In their 1930, the pair state how they divided a group of volunteers into two groups. The first group read a printed text and the other heard the text via a loudspeaker. The participants who read the piece were more critical about its content, while those who heard the messages over the loudspeaker were more willing to believe the broadcast. This experiment demonstrated the effectiveness of voice over the radio. In conclusion to this experiment, Hadley argues:

> This then was radio's greatest triumph: even though the transmitted words are disembodied, addressing an anonymous mass audience, they nevertheless impact the listener at home as if they are being addressed personally, at times feeling like someone is 'there' in the same room. For radio to have this effect, however, it could not act as a megaphone, shouting at people. Broadcasters needed to speak as if they are talking to you 'one-two-one'. They would tend to speak slightly slower than usual using direct phrases addressed to 'you' and sometimes hesitating, in other words, they spoke as if having a conversation (ibid. p. 290)

However, in America, far away from the rigidness of BBC guidelines, the voice on the radio had a far more natural aesthetic. In the book *Sonic Persuasion: Reading Sound in the Recorded Age*, academic, Greg Udell, has given the most favourable review of President F.D. Roosevelt's broadcasted voice, which included: vocal cadences that insured every word "fell upon listeners like a sledgehammer"

(Udell, 2011. p. xi). One broadcasting official from *New York Times Magazine* was probably more forgiving:

> The human voice, when the man is not making conscious of the use of it by way of impersonation, does, despite himself, reflects his mood, temper and personality it expresses the character of the man. Reveals sincerity, kindness, determination, conviction, strength, courage and abounding happiness (Anonymous, 1933).

In the UK, the voice on the radio has had a considerable shift in aesthetic which now matches the US example. Musical genres such as Punk from the mid-1970s to the Indie movement from 2005, has influenced the broad appeal of hearing one's voice reflected in media, a far cry away from the Southern English accent, what we perceive as the exaggerated inflexions that dominated radio throughout the 1930s. Its development parallels the growth of independent and local radio throughout the UK and USA in the 1970s, of which radio programming became more customer-specific and hosted by demographically diverse presenters. Today radio is an excellent source for a range of regional accents. The epitome of this shift was prevalent in the 2019 campaign, *BBC Young Reporter Competition*. In its online promotional campaign video, a teenage boy starts to speak, and we hear an overdubbed deep booming adult voice come out of him. The video goes something like this: "This is weird, isn't it? (clears throat). *The voice changes to another adult voice but higher in pitch:* "Nope, still weird, but if there is a report about where I live or what I do…" *Once again, the voice changes, but this time, the next phrases cycle through male and female voices in a traditional and professionally spoken southern accent:* "or maybe even this, or sometimes this". *He then continues in his voice:* "The BBC young reports competition wants to change that!".

The advertisement is not designed merely to encourage reporting as a career for younger viewers. However, it demonstrates BBC's attempt in reflecting the everyday voices and stories of 11-18-year-olds in their news reports and broadcasts.

The voice on the radio is describable as 'over-compressed'. The term originates from studio phrase 'over-produced'. In modern music production, the over-produced song has too many noticeable production techniques employed, often diminishing, or focusing the listeners' attention away from the song's compositional features. An example is a track with too much reverb or vocals with the dynamic range 'squeezed out of it'. In radio, a live voice could be perceived as over-produced, or over-compressed, as it is processed through multiple stages of compression. The result leads to a vocal aesthetic, that is intimate, clear, and exciting. The first compression stage is the result of using the technique 'sidechaining' technique. When a presenter talks, the effect triggers a

compressor to quieten or 'squash' sound from a specific mixer channel, often background music. The second stage uses a limiter unit to limit the maximum volume level of the broadcast studio's output. Radio's transmission process causes the final stage. The radio signal is decodable into a compressed format which gets transmitted via a carrier signal into the airwaves. Notably, compression also features within a range of pre-recorded music and speech.

While in broadcasted voice low compression thresholds are typical, the type of microphone can also affect its sonic aesthetic.[20] A popular microphone used by radio and podcasting presenters is the Sure SM7B dynamic microphone. For radio hosts such as Robin Quivers on The Howard Stern show and podcasters like Joe Rogan SM7B, is the microphone of choice. Founder of *The Radio.co Trust*, James Mulvany, writes: "This is not your typical cardioid dynamic microphone. It has a smooth, flat, wide, range frequency response perfect for both music and speech, but it is commonly used for spoken word" (Mulvany, 2019). Its cardioid pickup pattern and outer shielding make it ideal in a broadcast environment, protecting the signal against low level humming noises from computers or electronic devices.

In contrast, in an interview with BBC Essex's senior broadcast engineer, Chris Woodward, the BBC often use a quite different sounding microphone, the world-renowned Neumann U87. It is an exceptionally reliable and flexible microphone, providing warmth, and richness that picks-up on the voices nuance frequencies. It is this more natural sonic aesthetic which sets it apart from the intimate and grittier sounding SM57B. However, both have had a significant influence on the sound of a voice on the radio.

[20] On a compression unit, a low threshold often creates a more aggressive effect.

3.2.1.3 Commercials

Commercials and advertisements are a common feature of streaming media. They are a necessary feature to the success or failure of commercial products, campaigns, organisations, and special events. With an average run time between three to sixty seconds, they became a microcosm of culture and sound art. I documented an interview between Richard Kostelanetz and media composer, Tony Schwartz, who had a career spanning over three decades in radio commercial, portfolio exceeding 20,000 compositions. Schwartz's work ranges from politics to anti-smoking campaigns, fizzy drinks to furniture, and is part of art he refers as, "micro radio". In an interview with Kostelanetz in 2008, featured in his book, *The Art of Radio*, Schwartz expands on his micro radio philosophy. I have inserted examples of self-selected radio commercial pieces to contextualise his points. By analysing this interview, I aim to further demystify the compositional components of a broadcast signal, in this case, radio commercials.

As a composer, Schwartz is influenced by the theories of Canadian philosopher, Marshall McLuhan. In McLuhan's 1964 book, *Understanding Media: The Extension of Man*, he famously coined the phrase "The medium is the message" (McLuhan, 1964. p 7). While scholars have debated the meaning of this paradoxical phrase, McLuhan was concerned that media theorists often focus on the obvious. In doing so, we are habitually blinded by the content of a medium, oblivious to our own subtly introduced structural changes. He elaborates:

> It is only too typical that the "content" of any medium blinds us to the character of the medium… And it is the character of the medium that its potency or effect – its message. This is merely to say that the personal and social consequences of any medium – that is, of any extension of ourselves – result from the new scale that is introduced into our affairs by each extension of ourselves, or by new technology (McLuhan, 1964, p. 9).

His arguments positions radio more as a found object, a context that I have diligently steered away. Nevertheless, commercial composer Schwartz is drawn to Mcluhan's media theories, such as how instant information creates involvement and depth. In Kostelanetz's 2008 interview, Schwartz states: "I take music many times from real life, where your hearing evokes a previous experience and adds to your understanding" (Kostelanetz, 2008, p. 119). To better understand the relationship between music, text, and speech, he suggests that music alone does not 'set the scene' of a commercial. It is a combination of hearing music and the actions of people that contribute to its reception. It is clear from Schwartz's compositional philosophy that the sounds he uses are a

documentation of the life around him. When referencing the commercial, Smith Brothers' *Cough Drops*, which features a recording of a person coughing over the music, Schwartz paraphrases Picasso's definition of documentation: "to look and to show, to look at life and show people what you see" (ibid). Schwartz's use of recording technology encompasses Picasso's idea and sheds light on the role of a composer of a radio commercial. He defines his recording practice in two ways: environmental re-creation, "taking the environment and copying it" and environmental recreation, "playing with the auditory environment in the place we are in" (ibid. p. 120).

Interestingly Schwartz defines commercial composition as influenced by a 'print base', or 'auditory base'. The print approach includes the use of sound effects to add colour to the piece. It derives from written formats such as sound effect indications in scripts for film or radio. Schwartz champions the latter for his creative practice. He remarks, "my whole area of study has been how sound affects people, or the effect of sound, not sound effects" (ibid. p. 121).

In a twenty-second-long commercial composed by Schwartz about a motorcycle racing movie, he comments that people hears an average of four times as fast as they can talk. As such, he designed this piece to include the fast delivery of words. Schwartz remarks, "there's great compression of acoustic information, yet the listener doesn't lose anything" (ibid. p. 120) The fast delivery also conveys the emotional feeling of the movie (motorcycles racing fast). In sound design for visual media, using sound to controls the perception of time (temporalisation) is a useful tool. A series of 12-second adverts by FedEx titled, *The Fast-Paced World* (1981), is a hilarious example of this technique. It features fast-talking John Moschitta (also known as Motormouth), speaking tremendously fast in different business situations. The fast-paced delivery proceeds FedEx's slogan, "One company can keep up with it all"- a commitment to a quick postal delivery service. Schwartz further examines the use of spoken text in radio commercials. He states:

> "for people who speak English, you only have to hear this commercial once in your life, and you will always remember it when you need it. Moreover, this is an example of how you can design words, and not necessarily use words in the same way people would speak. You can create a new form that is original to radio" (ibid. p. 121).

Schwartz further comments upon an 'inner trip' that people take within broadcast environments. He contends that a radio commercial must be rooted in the same way we hear and understand our

world: "If I told you that you had a cold, you could know what he had; if I told you he had an attack of 'dragamougus', you would not know what he had" (ibid).

As adverts are such a short form piece of media, one could question their effectiveness at communicating ideas. Schwartz tackles this question head-on. He argues that instant information creates enhanced involvement and depth for the listener, and draws parallels between sound and the evolution of storytelling in cinema:

> Years ago, in the old movies, if Charlie Chan was going to travel from Hong Kong to New York, it would take him a minute or so, a minuet and a half. You would see him going down to the ship, walking up to the gangplank. You'd see the ship crossing the ocean with smoke coming out of its smokestacks. You'd see it coming up to the Statue of Liberty… Today in film, the same audience can understand that man can travel from New York to London by doorknob or ashtray, in that you zoom in on the ashtray in New York and pull out in London; and people will know you've travelled. The same thing happens with sound (ibid).

Schwartz further comments on the standard length of commercials. He states the commercials started at sixty-second, then reduced to thirty seconds, and now can be fifteen seconds, or "spots" (micro commercials that range from three to five-second). In a snappy remark to Kostelanetz's remit, that messages are communicable in three seconds, Schwartz responds, "got a headache? Come to Bufferin" (ibid. p. 124). An example of this tongue-in-cheek micro commercial style is insurance company Geico's advert campaign, *Unskippable* (2015). The advert features a family sitting at a dinner table, with a voice-over saying: "You can't skip this Geico ad… because its already over".

Finally, Schwartz speculates the future of radio commercials: what they will sound like and how they will be composed?

> …the areas that I think are important and will become increasingly more important in the course of time are word-de-sign…and the use of a much greater dynamic range. The ability to hear sounds as they -are-, to have a little mosquito heard and an electric train or a boat whistle heard, each at its natural volume. With the dynamic range of the compact disc, we can play it that way. It's phenomenal (ibid. p. 125).

While I sympathise with Schwartz's vision in which future radio adverts shall utilise sound design techniques more prevalent to the cinema audience, and the recording industry shall continuously

strive for dynamic perfection, for the reasons argued within this chapter, over a decade after this interview, we are still to realise his vision. In CommunicorpUk's radio advert archive, they sampled a range of commercials and commented on their form. According to the company's findings, adverts broadcasted throughout January 2019 have the overriding characteristic of 'urgency'. The advertisements featured in this archive are voice-centric with an often driving or powerful delivery and over-compressed sound.[21] To complement the adverts product or message, sometimes environmental sounds can be heard in the background. Therefore, as a radio composer, it would be useful to expect broadcast signals to feature such aesthetics regularly.

3.2.2 Broadcast Noise

In contrast to the broadcast signal, broadcast noise describes radio space consisting of static or white noise. White noise is a sound containing many frequencies with equal intensity. It derives its name from white light (a light source consisting of multiple colours). It is the continuous and 'crunchy' sound one hears when one tunes to an empty radio frequency or a television channel. It is a by-product of signal interference and sparseness in transmission. In Ofcom's 2010 article, *License-Exempt Devices,* they termed white noise as the name given to parts of the spectrum that are unused in particular location and at a particular time. Dial gestures morph broadcast noise to shape its sonic characteristics. It includes shaping it into a gestural shape, applying an attack, sustain and release to the previously consistent sound. Without dial's interaction, it is a structureless layer of sound, unchangeable in time, forming its main distinctive characteristic. It becomes structured and shaped through tuning, as opposed to continuously evolving broadcast signal. There are many sonic variations found within radiophonic noise where static forms a background layer of sound, overlaid by interferences. Using a Roberts R9954 analogue radio, I recorded the following broadcast signals. The radio featured a detailed FPR of 5:150. The discovery led to four leading states within FM and AM frequency bands.

[21] I have analysed several advertisements aired in 2019, including Mars', Confessions, O2's, 02 Family, Northumbria Universities, Clearing, Gov.uk's, Smart Meter Campaign, Costa Coffee's, That Spare Pound, Vodafone's, Moo Call, McDonald's', Cheesy Bacon Flatbread, The Post Office's, Bank, Easy Jet's, Last Call, The Royal British Legion's, Fade Away and Branston's, Smooth Branston.

1. White noise:

Most of the empty radio space consists of white noise.[22] It occurs when the radio receives atmospheric electricity. It is a crackling sound which incorporates granulated noise. Through dial gestures, the texture of the granulation changes resolution.[23] A sweeping filter effect is producible by rotating the dial slowly.[24]

2. Electromagnetic noise:

Electromagnetic noise is a result of the radio antenna receiving nearby electrical impulses[25] It has an underlying of white noise, with electronic blemishes interwoven within its sonic makeup. These blemishes can take the shape of various tones and timbres. The electrical tones are controlled by dialling gestures, changing its pitch, rhythm and volume.[26] An exciting range of results is producible while tuning the radio and placing electrical devices at points near the antenna.

3. Stutter noise:

It is a radiophonic sonic phenomenon where white noise has a rhythmical shape.[27] It is comparable to a stuttering or gating processing effect. The turn of the dial manipulates the variations of the stutter.[28] I experienced this sound when I positioned the radio near an external device that produces a rhythmical electrical pulse. For example, when tuned into static, a device with a blinking light can be received by the radio tuner as *stutter noise.*

4. Radiophonic whistle

When scanning AM frequencies, a radiophonic whistle occurs.[29] It is a consistent pitch, sharing similar sonic aesthetics to a sign tone or guitar feedback. In response to the rotations of the dial, the pitch rises and falls.[30] There are numerous causes for radiophonic whistling. Unlike electromagnetic noise, which is caused by external interference, this sound is a sonic anomaly

[22] White Noise Recording: https://blocki.co.uk/hilmi/7.mp3

[23] Audio recording of white noise changing granulation resolution: https://blocki.co.uk/hilmi/8.mp3

[24] Audio recording of a sweeping filter effect by rotating the dial slowly: https://blocki.co.uk/hilmi/9.mp3

[25] Audio recording of electromagnetic noise: https://blocki.co.uk/hilmi/10.mp3

[26] Audio recording of a manipulating electromagnetic pattern by rotating the dial: https://blocki.co.uk/hilmi/11.mp3

[27] Audio recording of stuttered noise: https://blocki.co.uk/hilmi/12.mp3

[28] Audio recording of stutter noise pattern being manipulated by rotating the dial: https://blocki.co.uk/hilmi/13.mp3

[29] Audio recording of a radiophonic whistle: https://blocki.co.uk/hilmi/14.mp3

[30] Manipulating the pitch of the radiophonic whistle by rotating the dial recording: https://blocki.co.uk/hilmi/15.mp3

produced by the radio's receiver circuitry. When radio frequencies overlap with one another, the tuner receives both signals. The carrier frequencies shared between the transmissions is amplified, creating an audible pitch. It resembles multiple sine waves overlapped in-phase to increase their amplitude.

Moreover, a radiophonic whistle occurs from a *superheterodyne* receiver, a feature of most modern radios. The heterodyne process mixes the incoming radio frequency with a sine wave generated by an internal oscillator. The modulation of the mixed signal is converted into a preset frequency. A radiophonic whistle is a by-product of the mixing process which inadvertently produces additional frequencies as audible sine waves. The clockwise rotation of the dial increases the frequency of the oscillator. In doing so, the pitch of the whistle sound also increases.

There are also several 'extended techniques' for radio's re-appropriation of sound outside the dial and tuning practices. These techniques function like the previously mentioned global processes (rotating a radio's tone, balance, and volume dials). The band shifting is a term that describes the sound produced by changing the received frequency band.[31] Voltage dimming describes the use of manipulating the on and off buttons.[32] Finally, touching the antenna produces various interference with the radio's reception.[33]

3.2.3: Radiophonic Behaviours

Living in London, the effect of landscapes on broadcast material significantly fashioned my approach to radio art. Along the way, I found myself guided by Tetsuo Kogawa's liberation of the airways, and the works of Anna Fritz and Magz Hall, who experimented with micro transmitters that shift between real and imaginary space. However, for my research, to replicate citywide electromagnetic radiation and interference between close distances of micro transmitters and their receivers became challenging. To address this problem, I decided to understand and deconstruct the complex interaction of tuning behaviours. In doing so, I considered notions of proximity and distance, interference and feedback, where the radio is not limited to the more palpable circuits of

[31] Manually pressing the AM and FM band switches video: https://blocki.co.uk/hilmi/16.mp4

[32] Applying a small amount of pressure to the radio's on/off button: https://blocki.co.uk/hilmi/17.mp4

[33] The granulation of white noise decreases by applying pressure to the top of the antenna: https://blocki.co.uk/hilmi/18.mp4

low-watt transmitters, but is instead, an instrument shapes by its surroundings, landscape and environment. In this chapter, I shall describe the realisation of my framework to miniaturise the expansive web of radio transmission into a performance space.

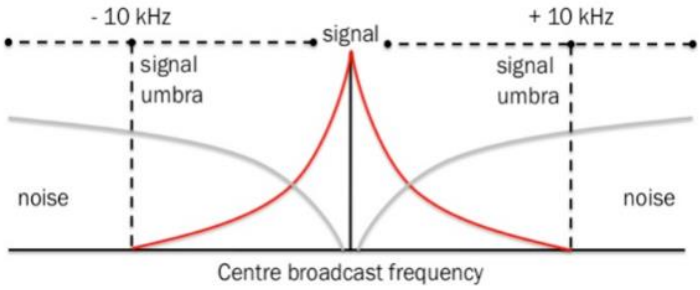
Figure 12: I created a visualised interpretation of radiophonic behavioural territories within my local area.

If we could see the streaks of radio signals around us, what would they look or feel like? Trenches cutting through the skies, signals 'splatting' against the buildings and dissipating into a web of electromagnetic interference. Particles gained, fragments lost: a symbiotic relationship of sound, funnelled through a speaker to our ears.

In a radiophonic environment, multiple auditory relationships between signal and noise are present. The sound starts with noise then develops and evolves into a signal (and vice versa). I define this correlation as *radiophonic behaviour*. It is a symbiotic relationship that contributes to the processing and morphing of radiophonic material. The understanding of these behaviours assists in the framework to sculpt radiophonic environments.

Radio broadcasts are most energetic at a specific frequency, increasingly dissipating when turned away from the carrier signal—the envelope from noise to signal forms the shape of a radiophonic

behaviour. A radiophonic environment consists of multiple radiophonic behaviours, overlapping or positioned away from one another. In a presentation on her research, *Adapting John Cage's Radio Music for a Digital Score (2012),* Lindsey Vickery, has analysed radiophonic behaviours as generally unfolding from noise to signal. On slide 15, she has created a diagram to pinpoint AM radio band tuning behaviours:



(Vickery, 2012)

Using a Roberts R9954 3-band radio, I documented contrasting radiophonic behaviours, covering AM and FM bands. This radio has an FPR of 4:180, ideal for receiving detailed inter-frequency signals. I recorded behaviours by rotating the radio dial clockwise. The process was repeated in anticlockwise rotations to reverse the shape of the behaviour. For clarity the observation, a behaviour starts with radiophonic noise, unfolding into broadcast material, then dissipating back to static. In complex radiophonic behaviours, many broadcast materials of varying velocities overlap each other. To achieve consistent dial rotations, I initially attached a servo to rotate the radio dial, marking the sound of each degree of rotation onto a chart. The servo was programmed to rotate in single tick, operated by a separate dial. I drew the result of each tick as a line on a graph. At each small movement, I analysed the sound and marked a graphical representation to its corresponding line.

However, this experiment became problematic. The servo interfered with the broadcast noise, overlapping electromagnetic tones onto the radiophonic behaviour. Furthermore, the flickering 'live feed' light on the recording device (Zoom H4n field recorder) emitted stutter noise. Although electromagnetic and stutter noise was adequately documented, I did not want the recording process to impede on any naturally occurring radiophonic material. To solve this issue, I routed the radio's headphone output directly into an audio interface. I modelled, and 3D printed a dial attachment to rotate the dial in consistent intervals accurately.

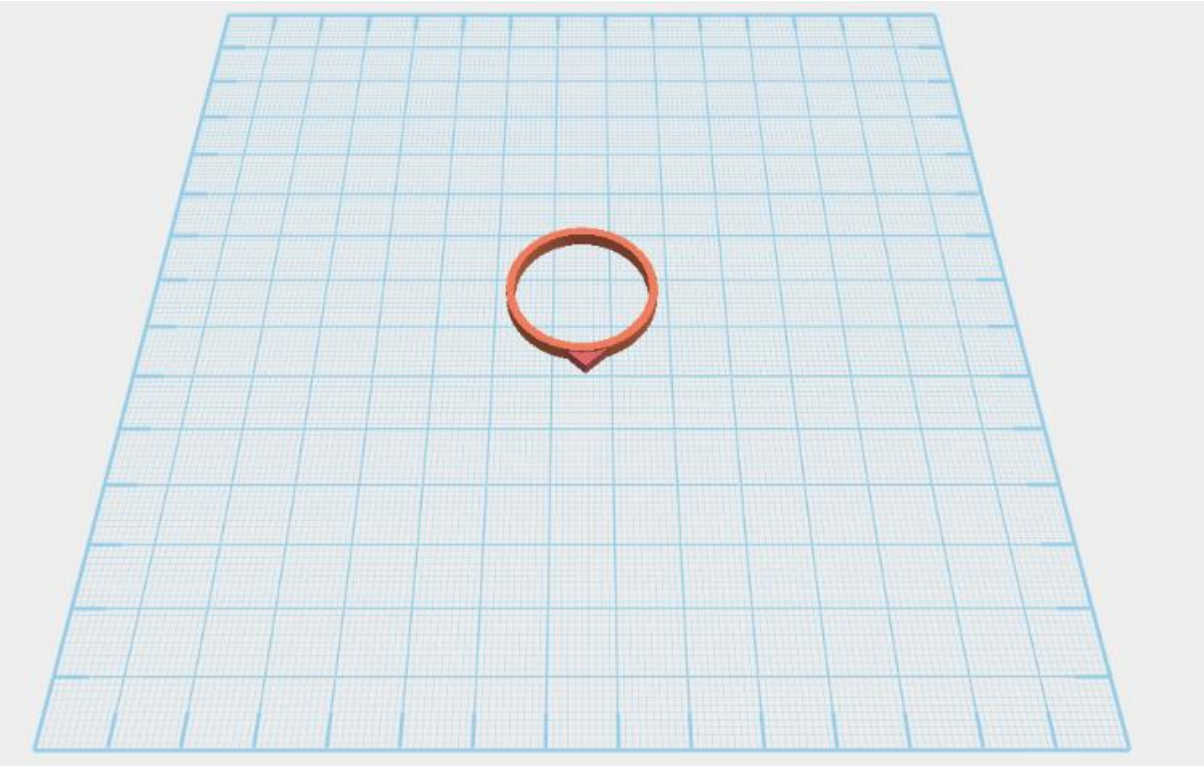


Figure 13: The design of the 3D component.

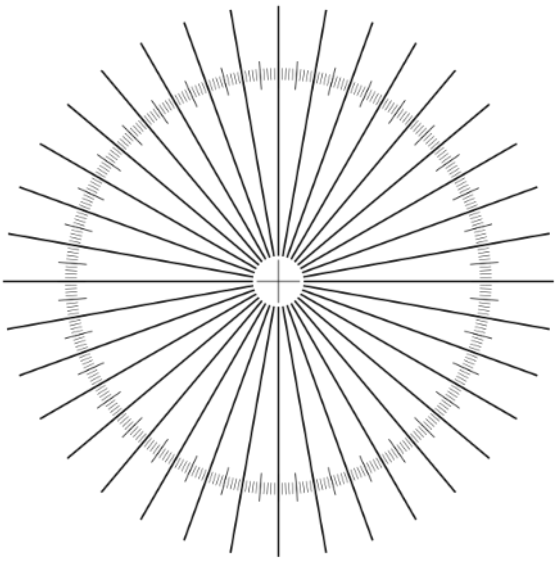


Figure 14: The design of the tuning segment disc.

Once I identified a behaviour, I rotated the dial to follow each interval within the circular face. At each tick, I interpreted the sound as a graphical score.[34] The recordings took place from 09:00 to 09:30, 12:00 to 12:30, and 21:00 to 21:30. I repeated this experiment for seven consecutive days, twice a month for three months. Each radiophonic behaviour displayed complex multiple scales of fluctuation. Before I detailed the audio-visual results to these tests, I created a graphic representation of each envelope, based on a minimum and maximum intensity. The individual pieces were overlaid to create a graphic score using this unified language or graphical toolset.

Throughout the tuning process, the primary radiophonic material, static, changes in various ways. The most common is its granulation stage. Increased static granulation often occurs while tuning towards a broadcast signal. In my graphic scores, the thickness of the static block represents its volume, compared to other radiophonic materials:

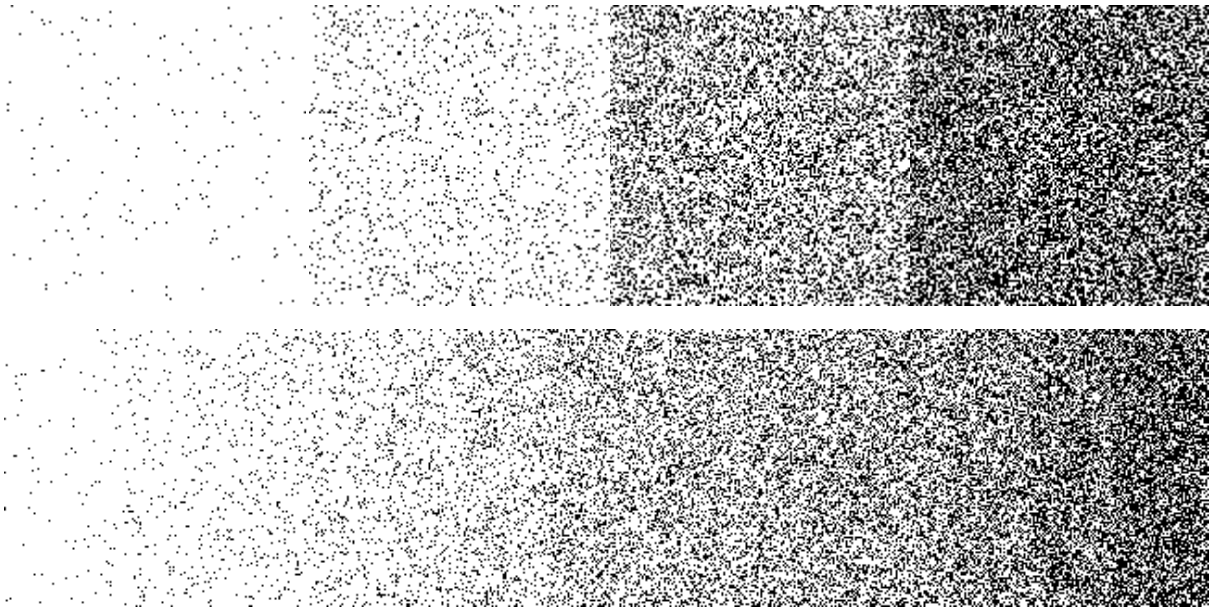


Figure 15: Static from minimum to maximum granulation.

[34] Demonstrating the process of documenting radiophonic behaviours video: https://blocki.co.uk/hilmi/19.mp4

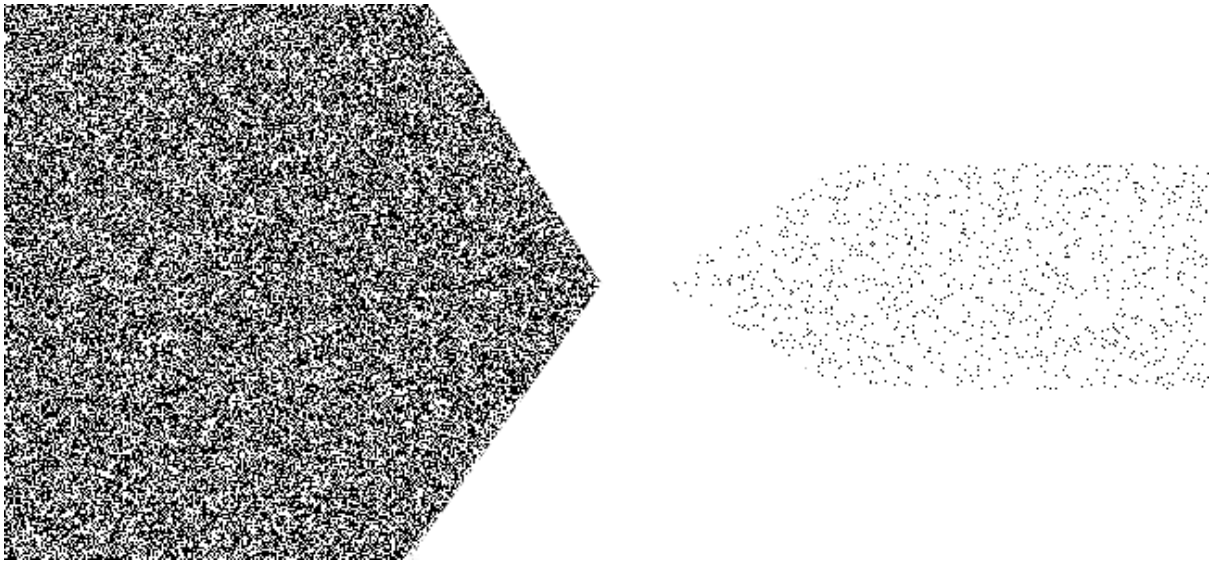


Figure16: Static material with a low granulation level and high volume, fading out into silence, then returning with a fade-in from silence to a moderate volume and a granulation level.

The broadcast signal is represented as a black square or rectangle. Its thickness indicates the volume of the broadcast, relative to other radiophonic materials within the behaviour.

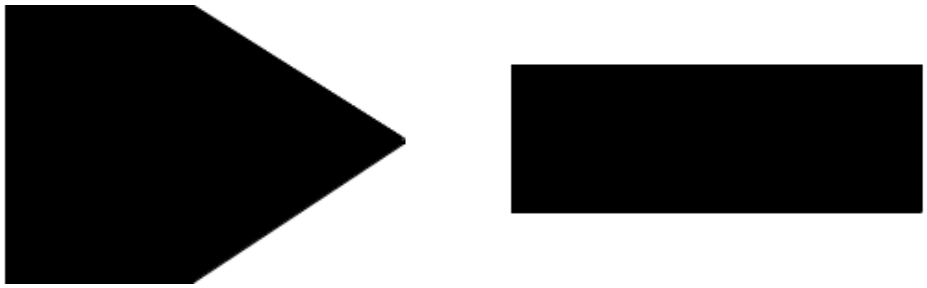


Figure 17: Broadcast material fadeout from loud to silent, then returning at moderate volume.

It is common for a broadcast signal to become weaker as one tunes away from its intended frequency. The result includes a range of sonic aesthetics, such as the signal becoming more distorted, quiet, modulated (cutting in and out), or granulated.

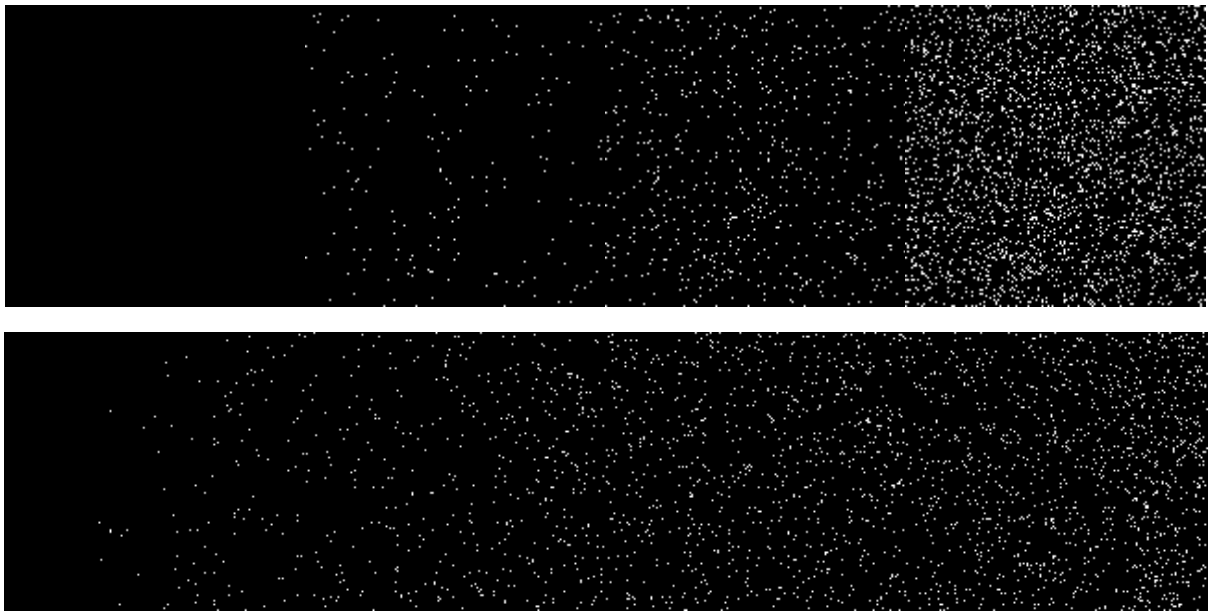


Figure 18: Broadcast material from minimum to maximum granulation.

In my graphical toolset, I positioned the broadcast material towards the centre of the canvas, surrounded by static. Visually, the colour scheme creates a clear indication between foreground and background layers. Furthermore, as broadcast material becomes increasingly granulated against a graphical backdrop of static, a translucent effect becomes apparent.

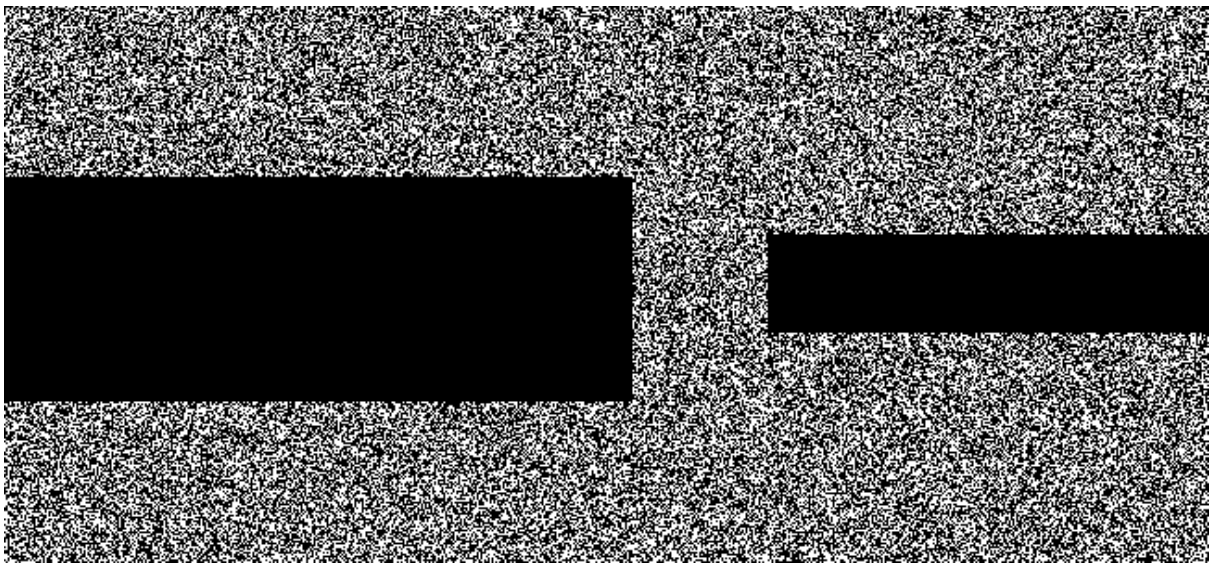


Figure 19: Background (static) and foreground material (signal).

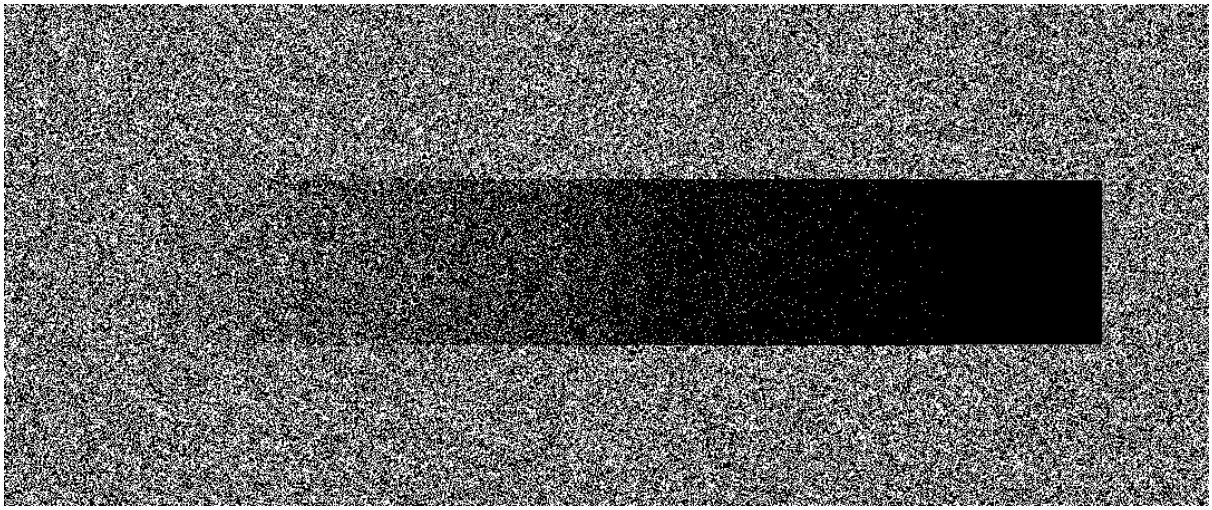


Figure 20: Translucent broadcast material.

As stated, both signal and noise have multiple sonic variations when experiencing interference. The following figures are graphical representations of these behaviours:

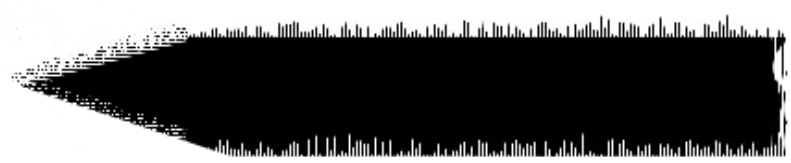


Figure 21: Broadcast signal experiencing distortion (variation 1, horizontal lines)

Figure 22: Broadcast material experiencing distortion (variation 2, vertical lines)

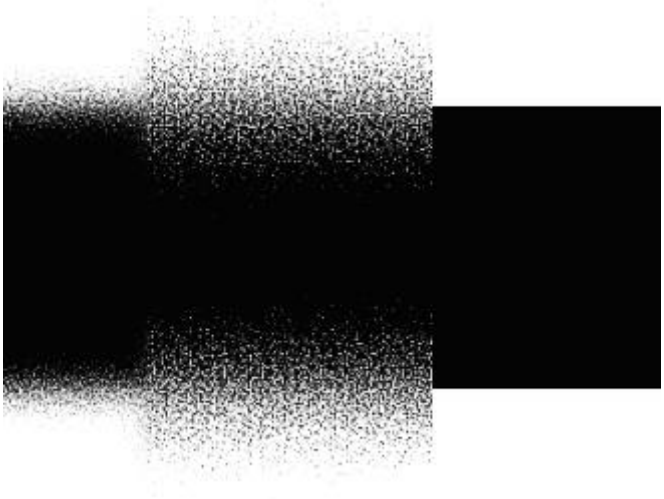


Figure 23: Broadcasting material experiencing distortion (variation 3, granulated sides)

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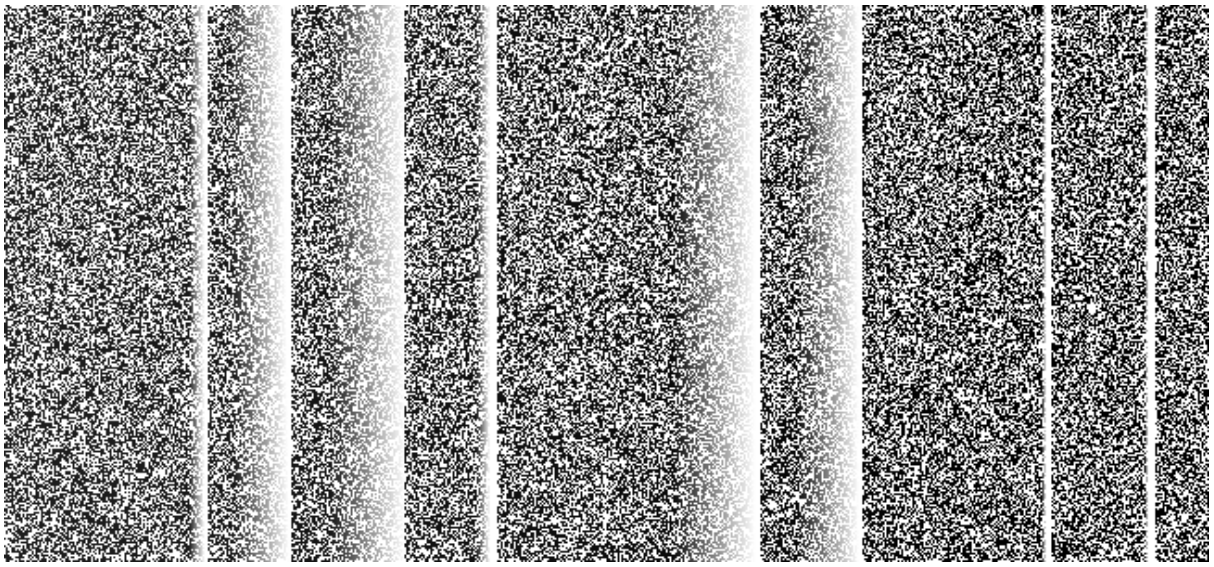


Figure 24: Stuttering effect on static material. The thickness of the line indicates its fadeout strength for each stutter.

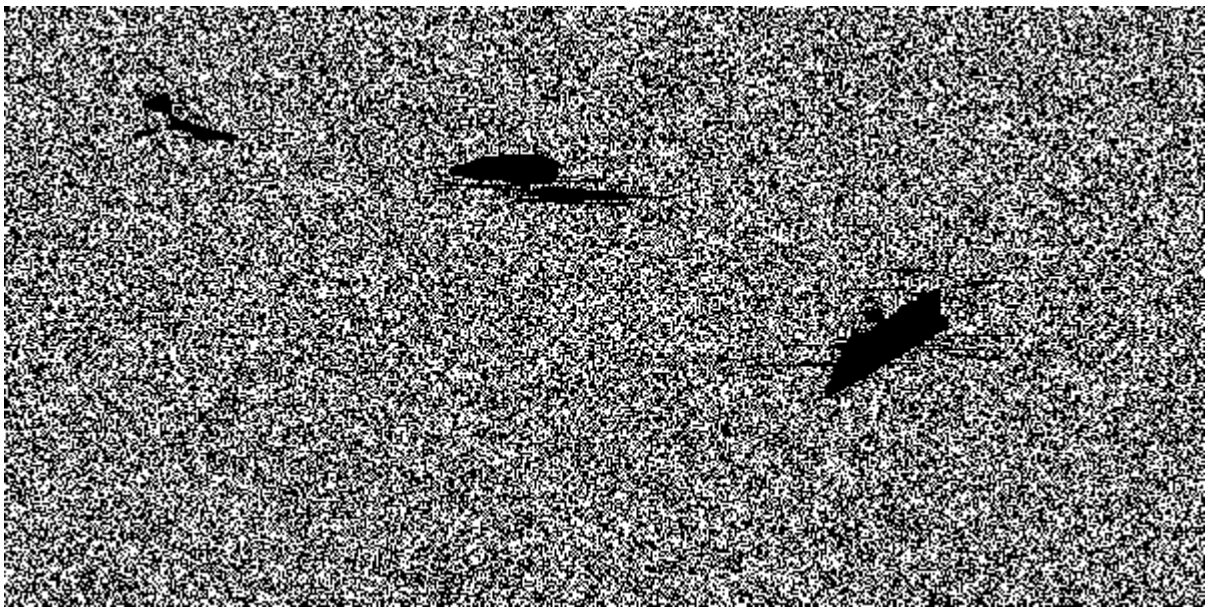


Figure 25: Electromagnetic 'blips'. The graphic's thickness represents volume. Height relative to canvas represents pitch and like broadcast material. It has a scale of granulation reflecting its clear transparency.

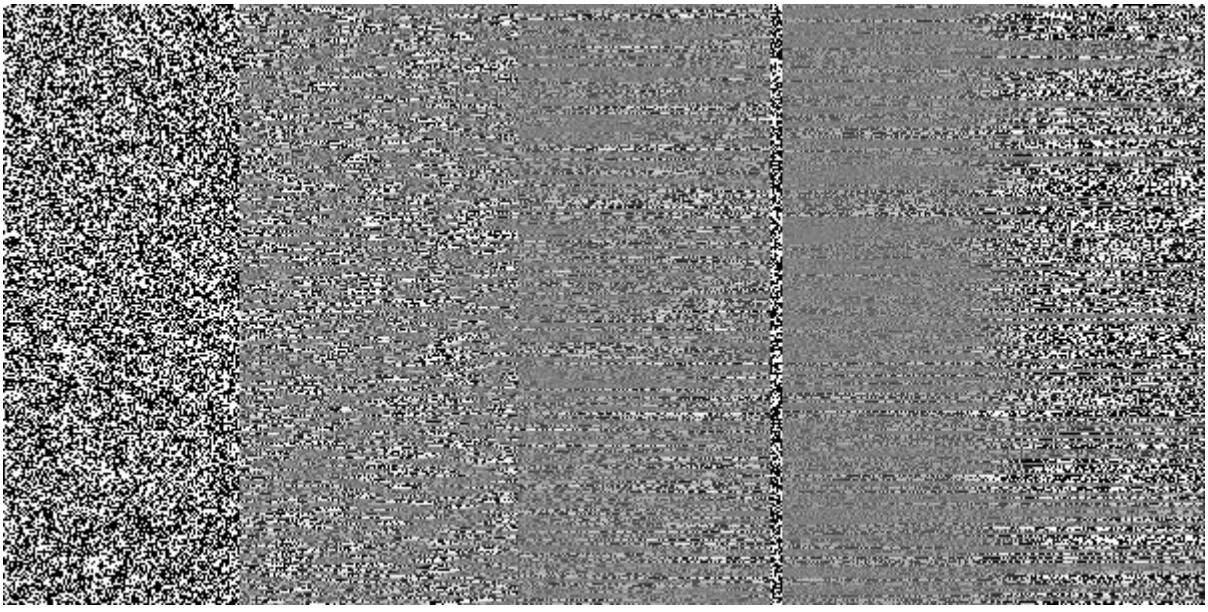


Figure 26: Electromagnetic static overlay increasing in intensity (variation 1, horizontal lines)

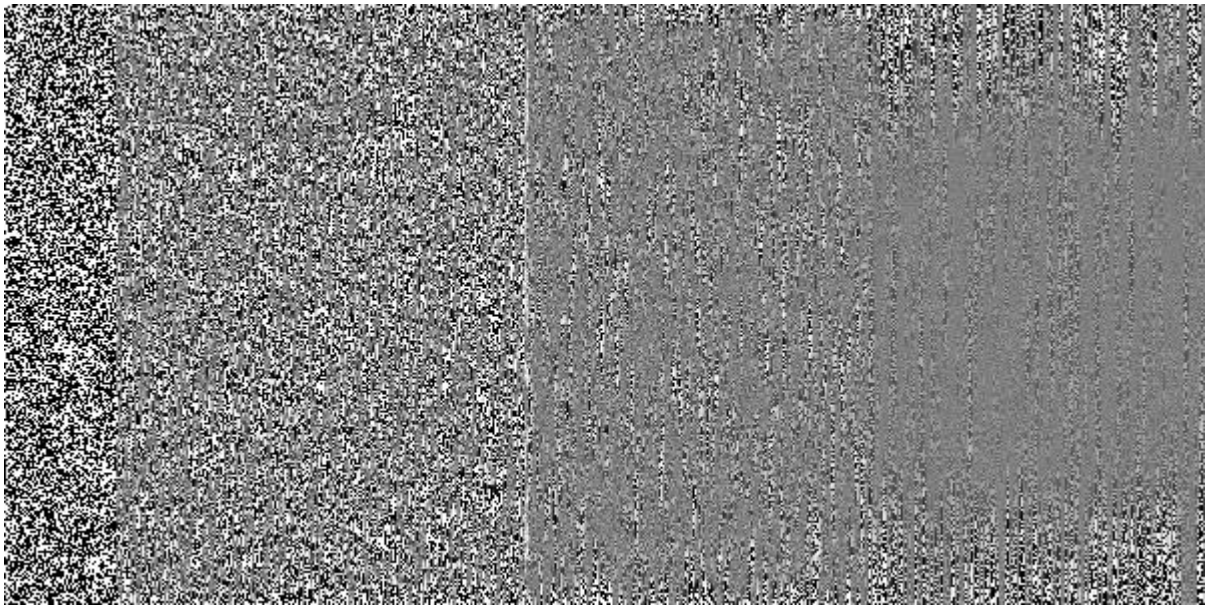


Figure 27: Electromagnetic static overlay increasing in intensity (variation 2, vertical lines)

Finally, I have visualised the material, radiophonic whistle. Its height reflects whistle's pitch, its thickness represents volume, and its length the duration.

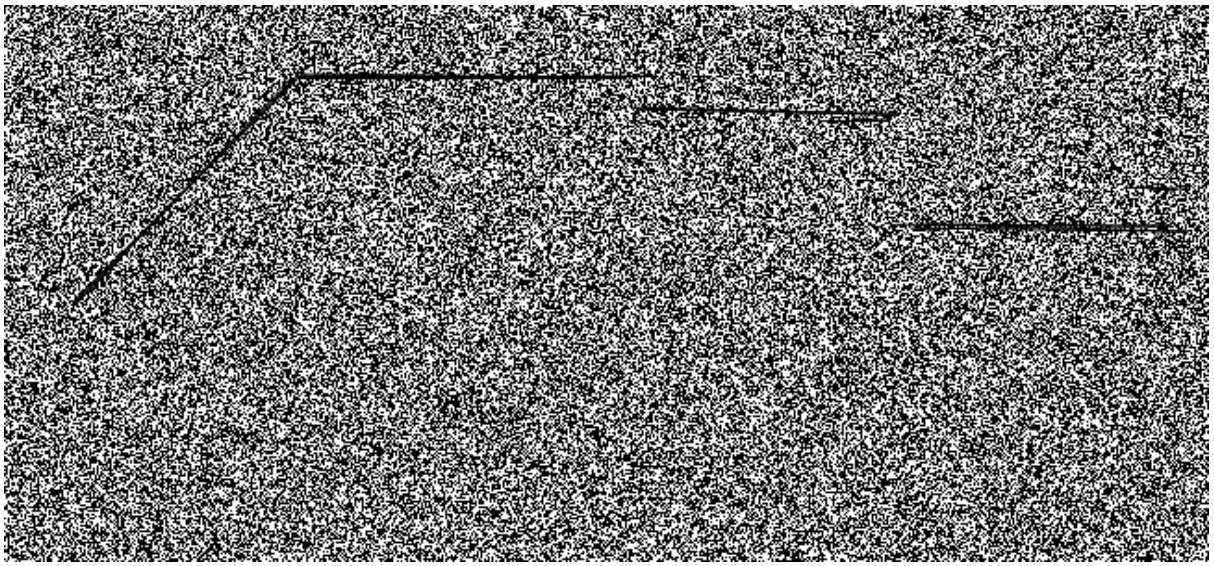


Figure 28: Radiophonic whistle at a low volume, starting with a glissando, then descending into three pitches.

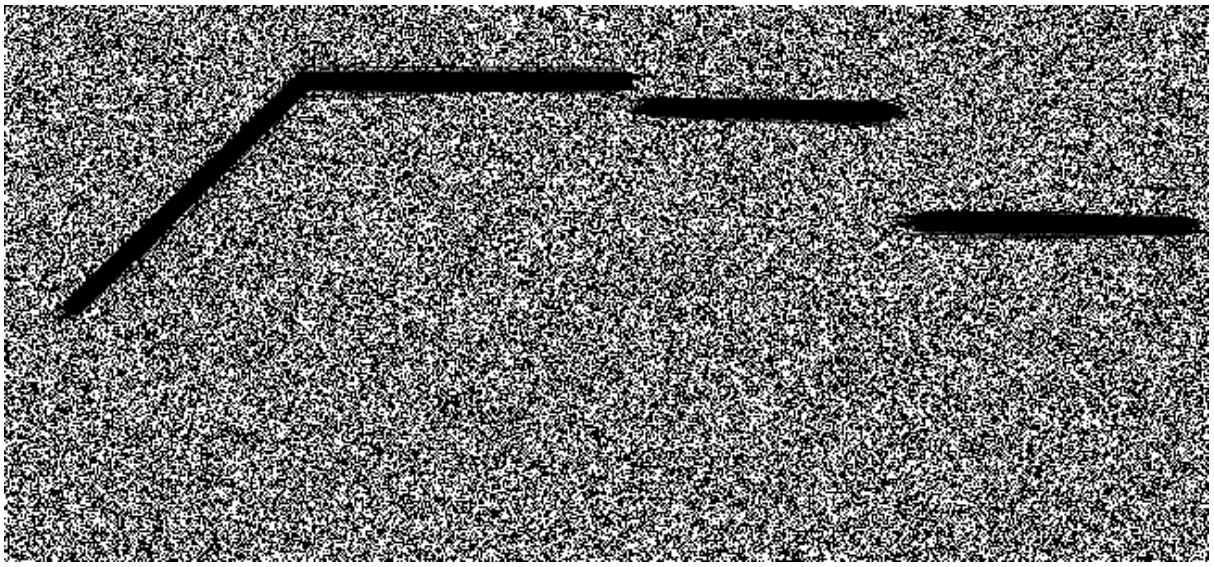


Figure 28: Radiophonic whistle pattern at loud volume.

The following results are from my earlier experiment. They identify a selection of different radiophonic behaviours, and sonic processes identified in both FM and AM spectrums.

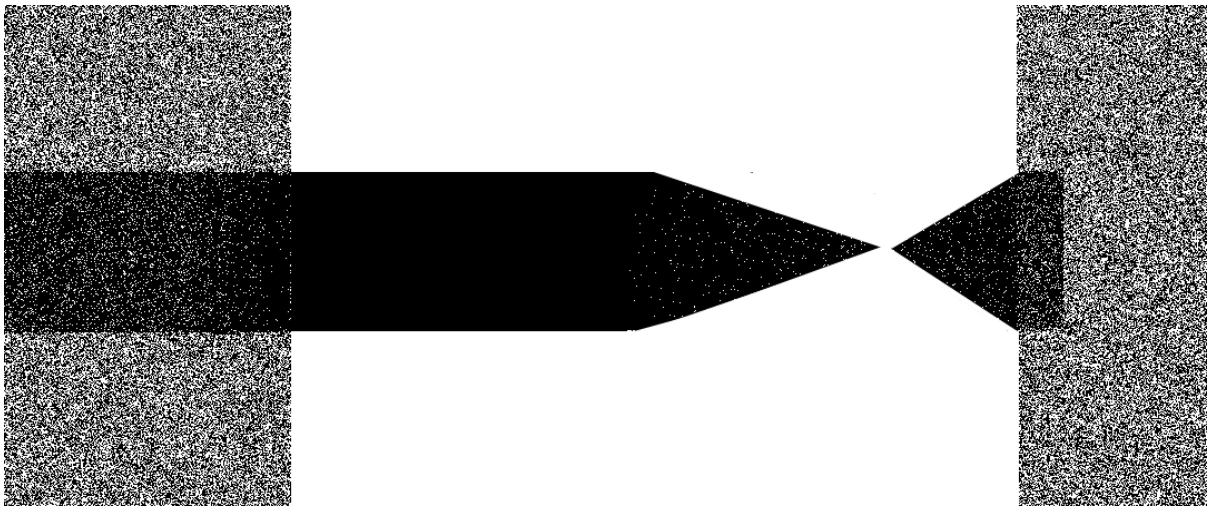


Figure 28: Fragmented broadcast material.[35]

[35] Behaviour recording: https://blocki.co.uk/hilmi/20.mp3

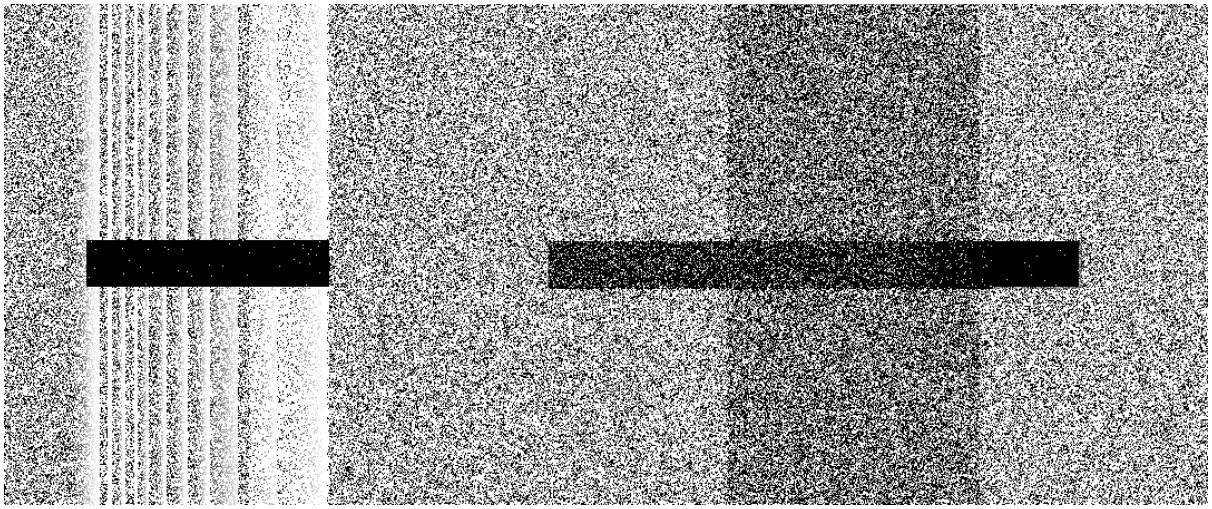


Figure 29: Stutter noise gradually decreasing in the modulation rate.[36]

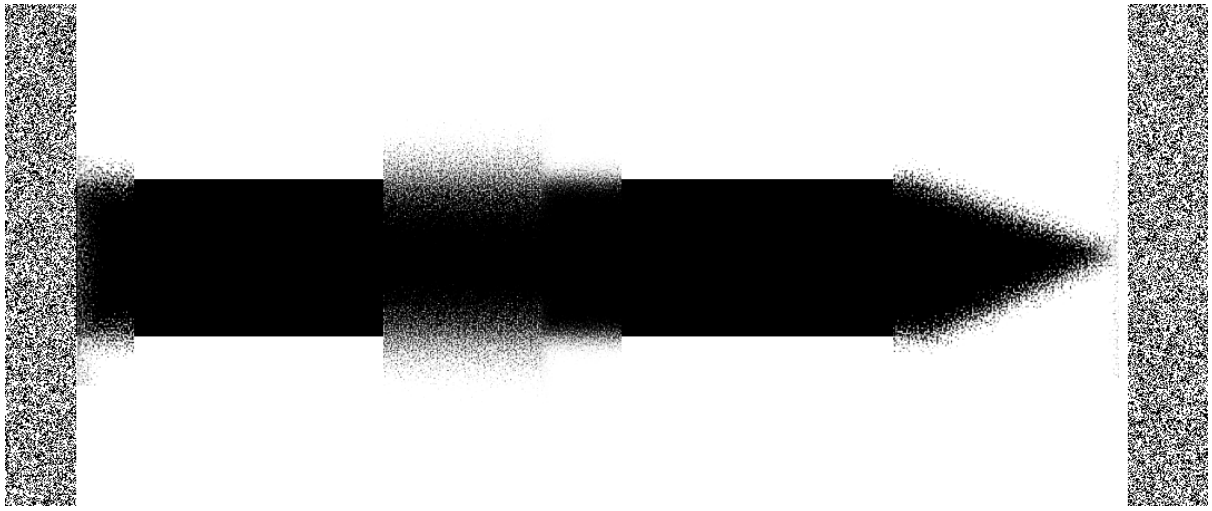


Figure 30: Distorted broadcast material.[37]

[36] Behaviour recording: https://blocki.co.uk/hilmi/21.mp3

[37] Behaviour recording: https://blocki.co.uk/hilmi/22.mp3

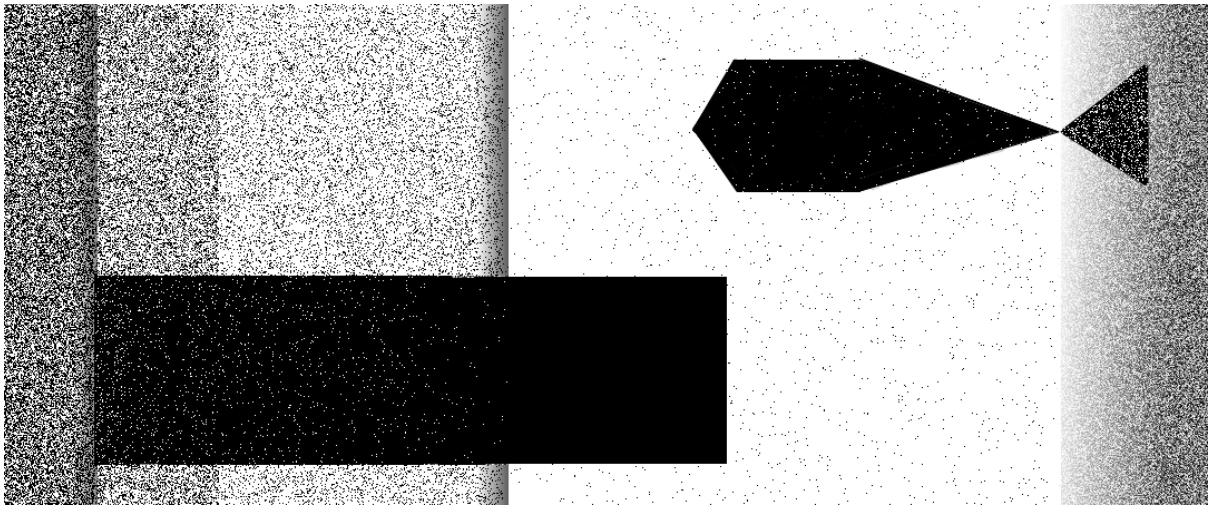


Figure 31: Crescendo into two separated broadcast signals and diminishing resolution of white noise granulation.[38]

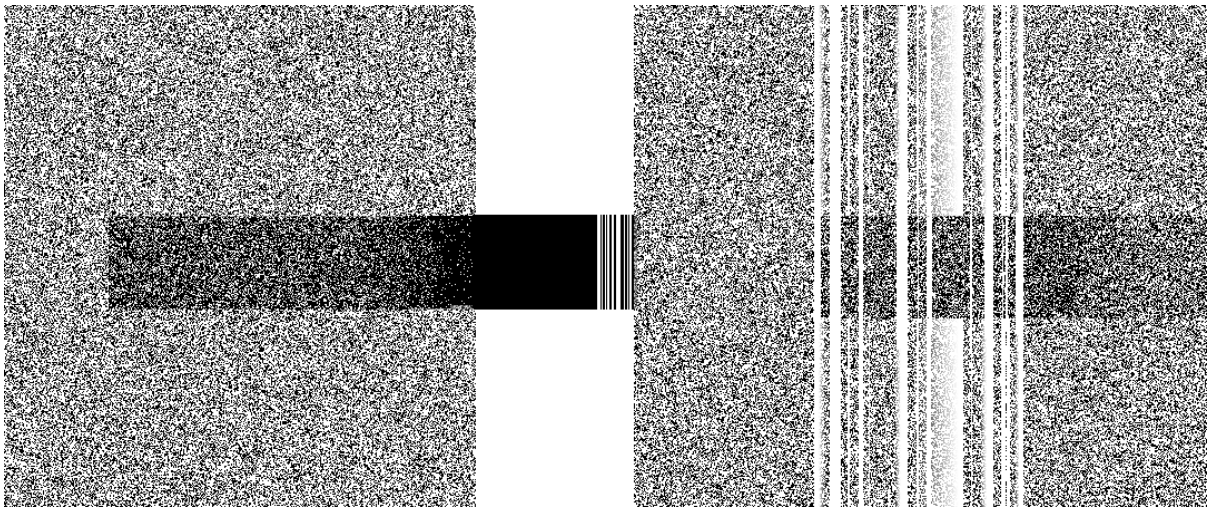


Figure 32: Broadcast stuttering and stutter noise.[39]

[38] Behaviour recording: https://blocki.co.uk/hilmi/23.mp3

[39] Behaviour recording: https://blocki.co.uk/hilmi/24.mp3

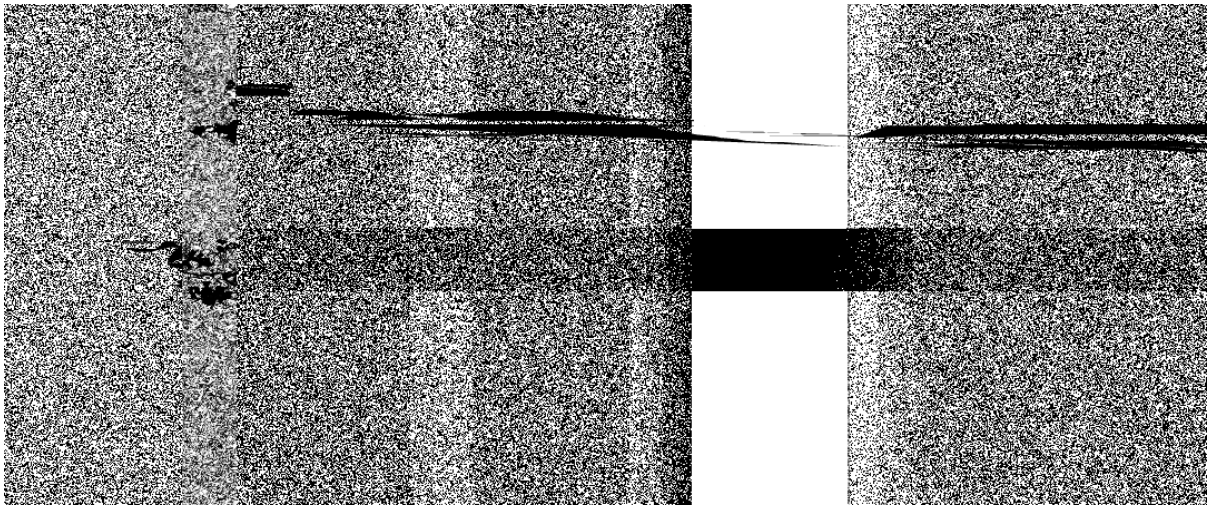


Figure 33: Electromagnetic tones, muffled broadcast material, white noise fragmenting.[40]

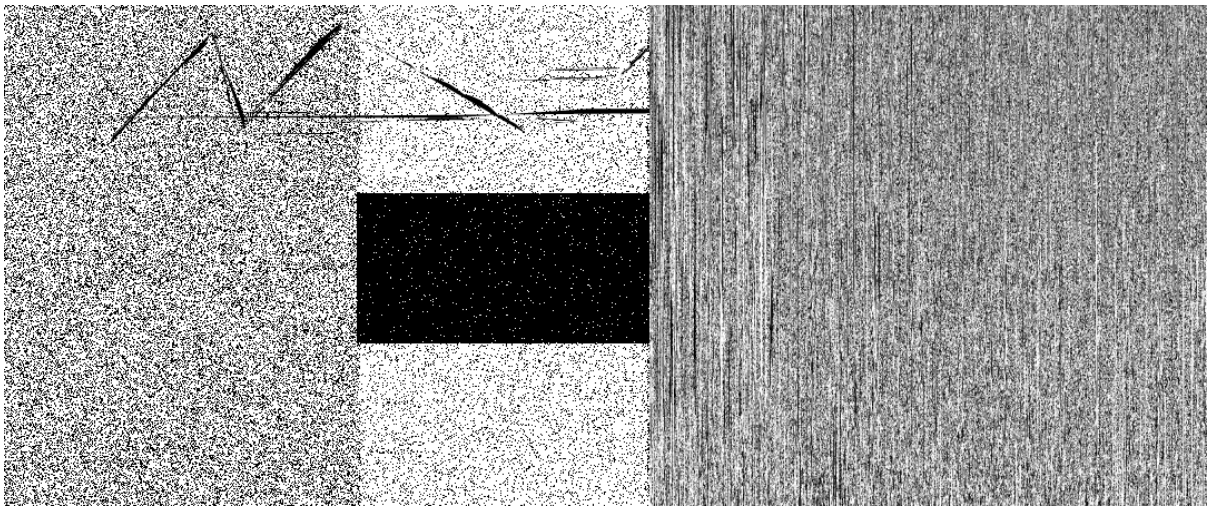


Figure 34: Radiophonic whistle pitch acceding in a gradually ascending and descending wave pattern. Electromagnetic noise increasing in stuttering intensity.[41]

To sketch an example of a theoretically composed radiophonic environment, I placed together multiple behaviours. The graphic scores demonstrate the potential of radiophonic environments as compositional spaces. They are composed by positioning radiophonic material and crafting behaviours between them. In going forward, creating a system based on this framework is my primary motivation. In *Chapter Four: Hardware and Software Development*, I will document the development of a digital composition space influenced by these findings.

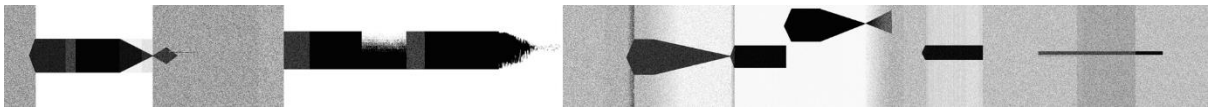


Figure 36: Arranging behaviours to create a radiophonic environmental composition.

[40] Behaviour recording: https://blocki.co.uk/hilmi/25.mp3

[41] Behaviour recording: https://blocki.co.uk/hilmi/26.mp3

3.3: Radiophonic Performance

As I turn the radio dial, the tuner scans through dozens of broadcasts. The dial and its internal components offer little resistance, but I feel a tug at my fingertips at each broadcast. One broadcast after another, it feels like over speed bumps in a car. It is part of a feedback loop between my perception of sound, the movement of my hand, and the way the dial shapes that sound. The tension embodied within radiophonic behaviours (the move between static and broadcast) creates a receptive response where tension is 'felt' and reacted against it.

Radio is unlike a traditional instrument. It is yet to develop a robust performance convention. However, it offers unique opportunities that aim to solve conceptual ambiguities. There have been several studies on how the cognitive perception of sound influences other sensors, such as sight and touch. In their 2001 research paper, *When Sound Affects Vision: Effects of Auditory Grouping on Visual Motion Perception*, Katsumi Watanabe and Shinsuke Shimojo, designed a set of experiments that presented identical visual stimuli with varying sounds, and evaluated how the sound changed the perceived qualities of the visual objects.

In one study, two visual dots travelled on a colliding course and the exact timing of the sound sample (just before or just after the collision) determined whether the participants perceived the dots bouncing off or passing through each other. Pawel Michal Orzechowski from Heriot-Watt University developed a multi-gestural touchscreen application to simulate fabric textures via sound stimuli. The application showed graphics of a range of different fabric textures. By applying gestures to phone's screen, such as pinching and rubbing, participants of Orzechowski's research team were able to use acoustic information to decide on the physical qualities of the fabric, just because of the type of sound they were hearing. Even though the phone screen is designed for smoothness, the participants felt the fabric textures as dictated by the sounds produced by the application was granular—a sensation which I experienced with radio; despite the radio dial providing no resistance, as one rotates the dial and passes through broadcast signals, one perceives a slight tug of resistance that helps to pivot back and forth in a clearly defined gestural motion. This is due to the dialling structure of the radio as well as the produced sound. A quick rotation does not speed up the received signals, but rather, it cycles through individual movements of the radiophonic behaviour at a faster speed. As such, rotating the dial produces the gestural shapes and sounds, whose attack, sustain and release are shaped by the dial gesture. The performance gesture and the resulting sound therefore are implicitly linked.

By analysing the waveform of recorded tuning fragments, I propose a shape that best describes the materials' abstract collage. The tuning process unfolds with a forward momentum, which quickly dissipates as the broadcast signal is discovered. Due to its gestural shape, when the dial passes through the broadcast signal, there is a sense of physical resistance.

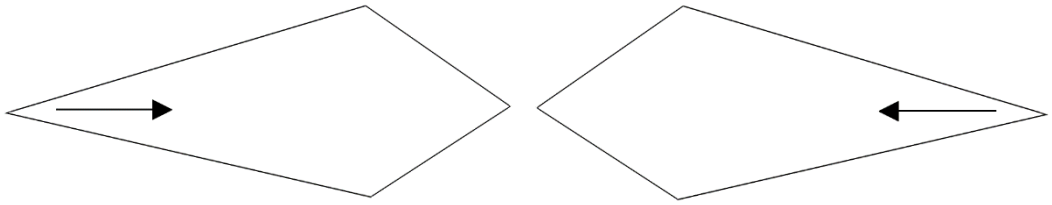


Figure 37: Example of tuning gesture velocity for clockwise and anti-clockwise rotation. When the tuner passes through the strongest point of the broadcast signal's strength, its velocity decelerates.

The following graphics demonstrate how dial gestures and tuning velocity, shape broadcast signals:

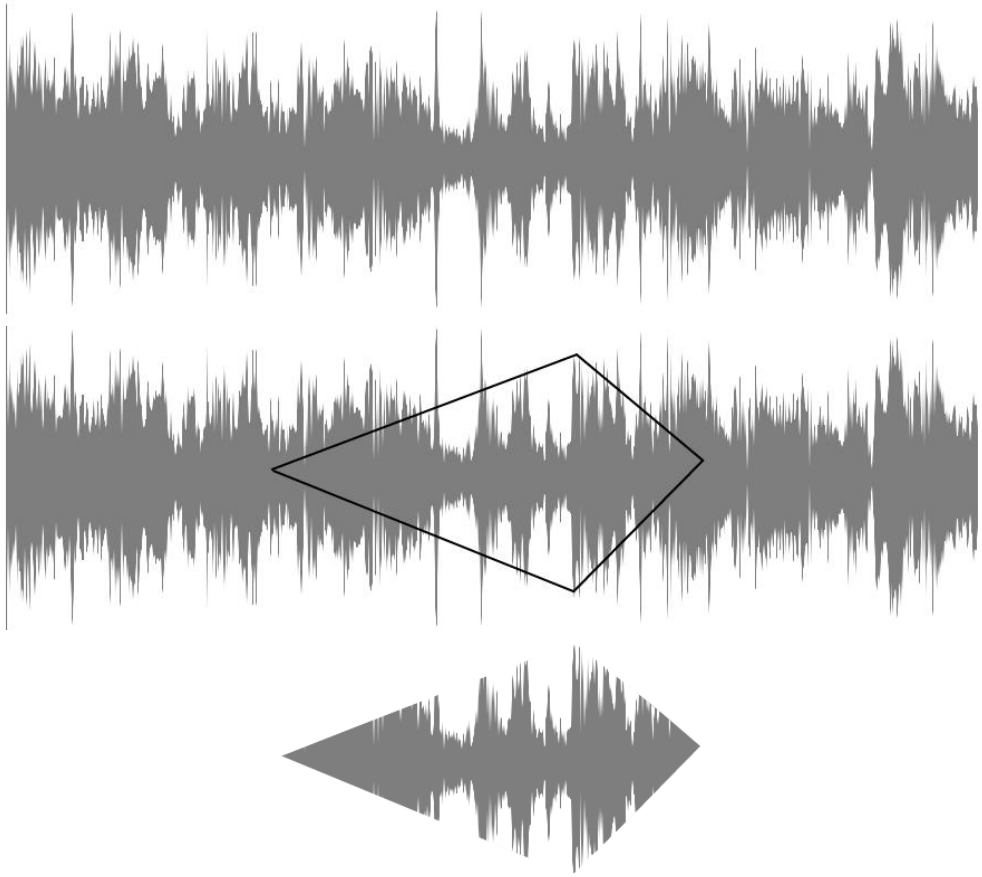
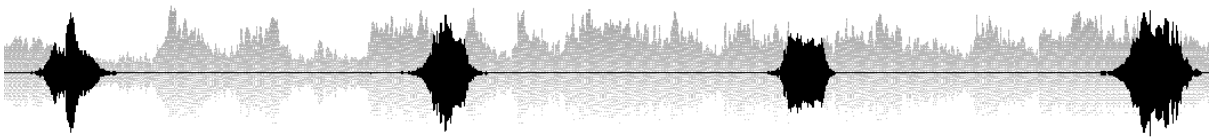


Figure 38: Visualisation of tuning velocity, shaping broadcast material

Over larger scale radio performances, tuning has the uncanny ability to fragment audio, into this uniquely shaped material. The following audio examples show how the broadcast material is fragmented and shaped by the act of tuning:



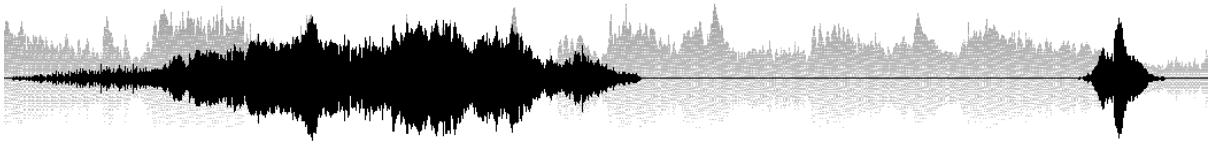
Fragment 1.[42] **Fragment 2.**[43] **Fragment 3.**[44] **Fragment 4.**[45]

[42] Tuning fragment 1 audio recording: https://blocki.co.uk/hilmi/27.mp3

[43] Tuning fragment 2 audio recording: https://blocki.co.uk/hilmi/28.mp3

[44] Tuning fragment 3 audio recording: https://blocki.co.uk/hilmi/29.mp3

[45] Tuning fragment 4 audio recording: https://blocki.co.uk/hilmi/30.mp3



Fragment 5.[46] **Fragment 6.**[47]

When tuning through broadcast material featuring voice and speech, fragmentation of words and vocal sounds occurs. In the research paper, *Text-Sound Composition – The Second Generation*, by William Brunson, he provides a list of seven ascending language levels found within text-sound works, from utterance to complex texts. Through performance gestures, it is possible to create vocal fragments that imitate some of these levels. These include:

Level 1: Beneath the phonetic level: Screams, grunts, smacking, onomatopoetic calls, inhaling sounds, exhalation sounds, animal sound imitations, "poetry in the mouth", different emotional vocal gestures, which imitate linguistic behaviour.[48]

Level 2: The phonetic level: Phonemes, morphemes, fragments of "real" words, fragmentation of words in small parts, Lettrism in various forms, and substitute phonemes.[49]

Level 3: Artificial language: Imaginary words/imaginary language without semantic content, words, and sentences, which appear to take from original yet unknown languages, i.e. artificial Swedish, an extensive mixture of words from known languages.[50]

Level 4: Limited linguistic material: All sorts of linguistic minimalism, compositions with minimal word material, "real" words which are combined for their sounding/sonorous expressive potential.[51]

[46] Tuning fragment 5 audio recording: https://blocki.co.uk/hilmi/31.mp3

[47] Tuning fragment 6 audio recording: https://blocki.co.uk/hilmi/32.mp3

[48] Voice tuning fragment recording: beneath the phonic level: https://blocki.co.uk/hilmi/33.mp3

[49] Voice tuning fragment recording: the phonetic level: https://blocki.co.uk/hilmi/34.mp3

[50] Voice tuning fragment recording: artificial language: https://blocki.co.uk/hilmi/35.mp3

[51] Voice tuning fragment recording: limited linguistic material: https://blocki.co.uk/hilmi/36.mp3

Interestingly, when moulding my visualisations of tuning fragments into a circle, it highlighted a unique insight into the dial's rotational movements. In the *Portfolio of Works* chapter, I aim to demonstrate rotation in the animated charts, to represent the correlation between dial gestures and radiophonic behaviours in my compositions.

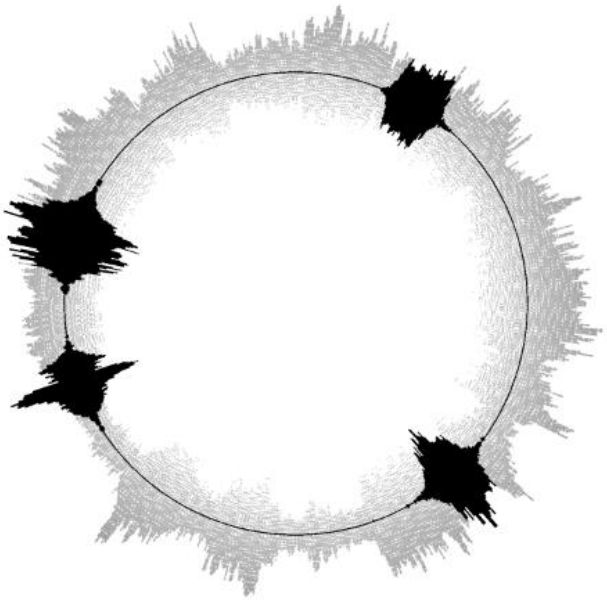


Figure 39: Circular design of tuning fragment example.

I further apply this graphical affect to some of the radiophonic behaviours explored previously in the current chapter. In this form, as the dial is rotated, the resultant behaviours demonstrate the texture and sonic characteristics of the radiophonic environment.

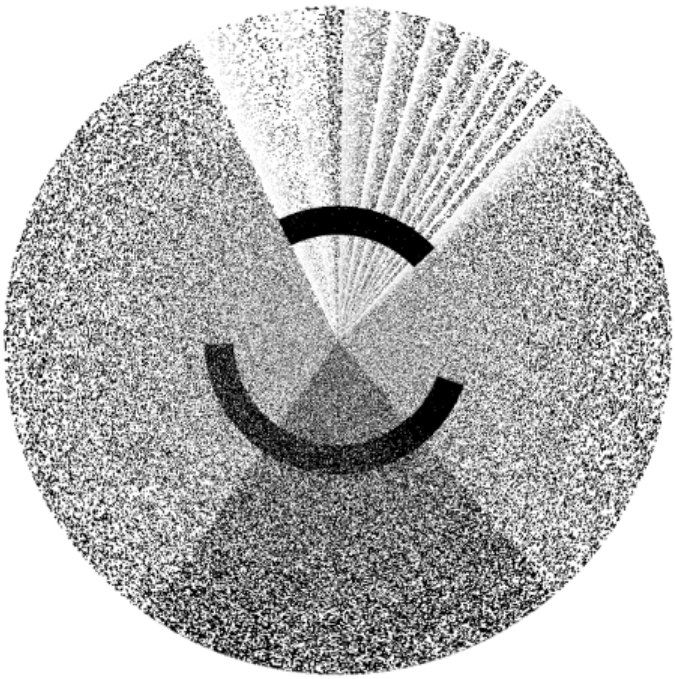


Figure 40: Radiophonic behaviour 3.

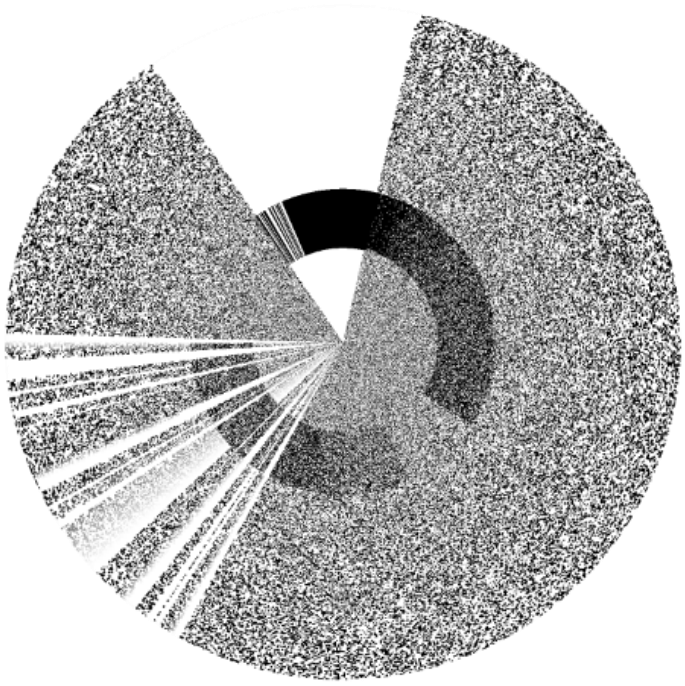


Figure 41: Radiophonic behaviour 4

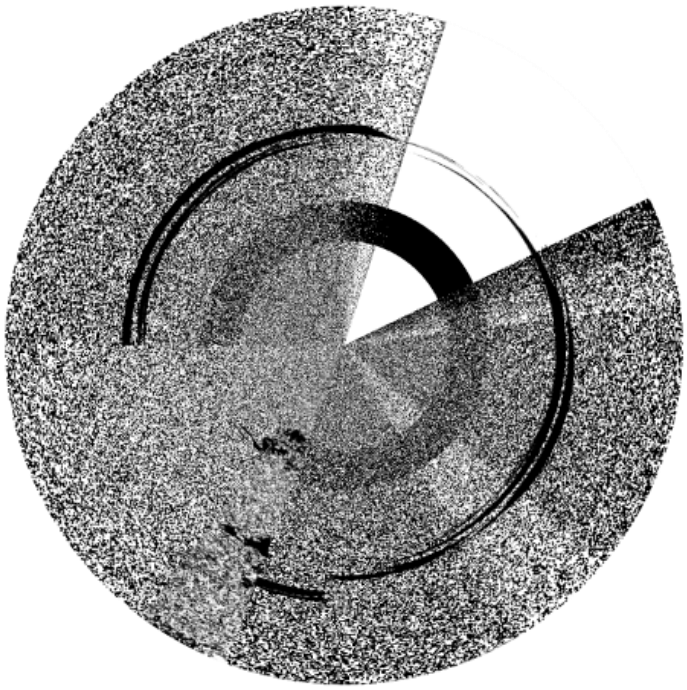


Figure 42: Radiophonic behaviour 7.

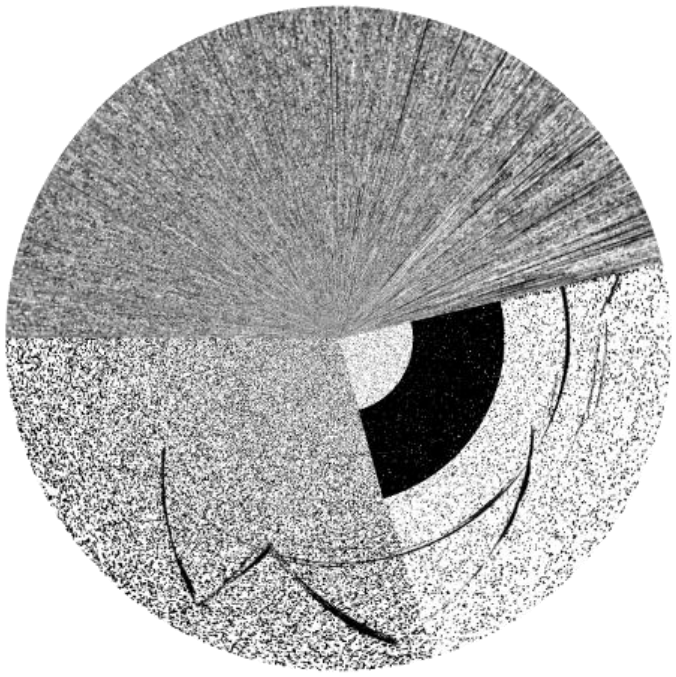


Figure 43: Radiophonic behaviour 8.

If one imagines an interface on which one glides a finger, the smooth circles trigger fragmented radio sound. Would it help therefore to better understand and visualise the deep sensory links between a slight touch and hearing? In a similar way to Pawel Michal Orzechowski's fabric simulation application, this crossover of sensations is an idea I will fully explore in my portfolio chapter.

3.4 Summary

Composing and performing with analogue radio is a unique experience. It also has a rich sound pallet of contrasting sound. Broadcast material provides a snapshot of the current trends, cultures, and politics of its reception. Radiophonic noise offers an exciting sonic aesthetic, one that is becoming lost in our digital age. The materials act as parallel forces to one another, however, merge through tuning gestures. Analogue radio, therefore, is an expressive instrument that processes, shapes, bends, and crushes sound in exciting ways. In Serge Cardinal's book, *Radiophonic Performance and Abstract Machines: Recasting Arnheim's Art of Sound*, he describes the elementary forces of composing with radio:

> Familiar to all such sounds is the chromatic rise in intensity and pitch, the swelling and increase of strength, and just this is the unique expression that such sounds transmit to us…It should be realised that elementary forces [intensity, pitch, interval, rhythm and tempo] lie in the sound, which affects everyone more

> directly than the meaning of the word, and all radio art must make this fact its starting point (Cardinal, 2007, pp. 12-13).

In this chapter, I attempted to demystify processes that often overlooked in found material. By perceiving radio as an instrument, it opens multiple opportunities for composition. Through my framework, I have identified a performance practice that could grow into a performance convention. Although these experiments use non-collective data, it is a starting point for further research. Throughout this process, I have also created a graphical toolset that allows me to create graphic scores and analyse complex radiophonic environments. By arranging these graphics in different formations, it offers insight into radiophonic material as a malleable substance for composition.

In the next chapter, I will use my framework to develop a digital workstation to compose radiophonic environments. Analogue radio is a relatively spontaneous and inconsistent medium for producing sound. Without external devices such as micro FM transmitters, a composer is bound by the broadcasting schedules of radio stations for source material. It is not easy to transmit custom material via narrowcasting, without destroying the radiophonic behaviour's exciting morphology. Therefore, the positioning of broadcast material and radiophonic noise on a broadcast frequency scale is uncontrollable which results in inconsistent reproductions of performances. It is also not possible to control or change the FPR of a radio set.

Moreover, recording radiophonic behaviours are prone to change over time. Many devices within a standard recording setup interfere with the sound and shape of the behaviour. The imposition of recording equipment creates a significant barrier for recording radiophonic material. In a digital environment, these inconsistencies are controllable. Therefore, I pose a similar question as stated in my previous chapter: What are the potentials for radio and radio art, when the medium becomes simulated or digitised? This path treads a thin line within the scope of radio art composition and research. Although there are artists that implement digital technology to control the radio, cutting the radio out altogether is a bold step. It has been one of the art form's most shared definitions. Through this process, I will argue that a radiophonic environment can be sculpted without using material produced by a radio. The material can still be classified as radiophonic if it embodies the aesthetics documented by my framework. In doing so, a composable realistic environment is possible, while adopting digital practices such as pre-sets, precision, and flexibility.

Chapter 4: Software and Hardware Development

When I was managing the day to day grind of a recording studio, I had a regular client who booked two or three sessions each month to work on his album. He was a man in his early 40s gript with dragon imagery and the mysteries of the universe tattoos. His song, appropriately named, *Fire Dragon*, was a 1970s Beatles inspired ballad, featuring Motown drum and bass rhythms, double-tracked vocals, and 'pointy' lead guitar melodies. At the outset of recording the tracks, he instructed me to record using reel-to-reel tape. My studio had a growing collection of ex-BBC recording hardware, including a vintage eight-track reel-to-reel, Studer. As a confessed analogue purist, my client adorned this type of equipment. However, recording onto a tape requires specialised working knowledge. It is also time-consuming and expensive. While I was doing my utmost to accommodate his small budget, using such specialist equipment did not seem practical, nor economical. As I did not want to disappoint him, I downloaded the *Studer A800* digital plug-in onto Logic Pro, and began fiddling with reels of tape, tightening them to my original machine. Over the intercom, I shouted, "We are all set…", and I clicked the dimly lit record button. The reels began to spin. "Fire dragon, fire, fire dragon! Beyond space and time, I am glad I called you mine…" After several hours of vocal takes, guitar, and some crude drumming, he walked into the control room to hear the result.

He was particularly pleased with the recording, especially its vintage aesthetic. Towards the end of the session, I felt compelled to tell him that his song, *Fire Dragon*, was processed using a digital plug-in. In a typical fashion, he responded that he could not tell the difference, and I was some sort of "space wizard time-traveller", amongst other things. This experience started my fascination with digital programs that emulate analogue hardware. It has made me reflect on the unique attributes of each paradigm.

In an interview with a senior product manager at *Universal Audio,* Lev Perry, by *Secretsofthepros.com* founder Ken Walden, Perry explains why someone would want to model analogue hardware. He states that equipment like the *Studer A800* was used in, "so many of the classic albums that we like the sound of, that we would like to try and emulate" (Walden, 2017). Perry also stresses two essential points that are unique to digital emulation. Firstly, the original *Studer A800* machine would be calibrated to match the type of audio being recorded at the time. By adjusting screws behind the tape heads, slightly changes the input frequency and impedance. In *Universal Audio's* digital version, he states, "we get all the benefits of the sound, but none of the hassles of having to calibrate it, set it up, and tweak it" (ibid). Lev commented that calibration settings are accessible via a hidden menu. The default preset is set to a "golden standard", that "just works" for any sound

input (ibid). This aspect of digital emulation has its pros and cons. It is an example of the possible implication software has on the sound of your work as most users would never change this 'golden' preset. In this chapter, I will not enter the age-old debate regarding the merits of analogue over digital and vice versa. Instead, I shall explore the potential of such a relationship.

There are limited products on the market which are inspired by analogue radio. The few allow composers and performers to harness radiophonic material in a controlled environment. For example, Schalappi Engineering has created an audio processing module called *Interstellar Radio.* It is a solid piece of hardware that replicates the destructive transmission aesthetic of analogue radio.

Figure 12: The Interstellar Radio processing module.

The *Interstellar Radio* module simulates the radiophonic process of modulating and demodulating a signal. It has a range of customisable dials, allowing the user to input sound into the unit for destructive processing. It achieves radio's unique sonic aesthetic through oscillation, aliasing, distortion, and frequency modulation techniques. The result transforms the audio signal into a granulated sound. It affects sounds like broadcast material that is distorted due to weak transmission power. I compared its destruction capabilities to the part of a radiophonic behaviour where the broadcast starts to break apart as you tune away from its frequency signal.

Secondly, there is a sampler made by Teenage Engineering, that features a built-in radio receiver. The *OP-1* sampler allows the user to directly record sounds from its radio and trigger playback through its keyboard. In this case, the sampler's many radiophonic materials assigned a key for the creation of a crude radiophonic environment that is controllable.

Figure 12: OP-1 by Teenage Engineering.

The design goals of these products are not to produce a radiophonic workstation. However, they are heavily influenced by radio's instrumental qualities, producing solid radiophonic material for composition.

In the previous chapter, I deconstructed radio's sonic characteristics into a compositional framework. This research led to the development of my proprietary, *Radiophonic Environmental Designer* (RED), software and its associated performance interface, *Performance Interface Network Kit* (PINK). I built the former to address the unpredictability when working with analogue radio as a composition tool. It was conceived by attempting to merge the sounds and gestures of radio with the precision and reliability of digital audio workstations. In my design objective, I wanted to retain the immediacy and liveness of radio reception. In particular, the way sound overlaps and become fragmented when using the dial. I sought to realise a method to compose radiophonic environments with prodigious control and accuracy over the received material. Along the way, the project has had many bumps and pitfalls. Like many radio artists seeking to control and personalise a small part of radio space (think Anna Friz and Magz Hall), I started by experimenting with micro FM transmitters. Next, I developed a workstation utilising the MAX MSP software suite. Unlike other programs, like Logic Pro and Pro Tools, MAX can manipulate live incoming data to create performance patches that are adjustable in real-time. Limited only by imagination and CPU power, they offer composers and programmers a blank canvas to create algorithms by 'patching' together

and editing predefined objects.[52] My final development stage involved building a gestural interface through the use of scripting software, Fusion 2.5, and programming a microcontroller via C+.

The development of RED has been a long and arduous process. Since its inception, I exceeded 200 iterations. Development lasted twenty-four months, split into three, eight-month cycles. Along the way, I kept a video diary of my progress and experimentation. Its development included multiple prototypes, productivity tests, and material comparisons. As such, the aim of this chapter is not to focus on RED's step by step optimisation process, but rather, how each milestone has challenged my core understanding of compositional practice; building radiophonic environments, constructing radiophonic behaviours, and simulating tuning gestures. Furthermore, digitising analogue processes is a topic I am exceedingly interests in. In this chapter, I shall explore several design theories related to this practice, such as the relationship between coding and control, User Interface (UI) design principles, the cyclical impact of software on composition, and composition on the software.

4.1: Micro Transmission: Working with Custom Radiophonic Material

On December 8th, 2006, the UK communications regulator, Ofcom, updated their broadcasting regulations to regulate the use of micro transmitters. In their statement, *Wireless Telegraphy (Exemption)*, they define a micro transmitter, (sometimes referred to as a 'car baby' device),

> designed to facilitate a secure connection between audio sources (such as digital audio devices and MP3 players) and standard FM broadcast receivers by way of a radio link.

The commercial use of such devices connects phone or music device wirelessly to car stereo or audio equipment. The specifications of legal and unlicensed micro transmitters include a radius covering under 50 Nanowatts on 0.2 MHz channel spacing in the FM frequency range, between 87.5–108MHz. The transmission distance is limited up to 8 meters.

In an interview I conducted with Magz Hall at Canterbury Christ Church University, she shared her thoughts on asserting control to counter the transitory nature of radiophonic material. Hall stated that micro transmission technology allows her to create consistent environments that are "repeatable between multiple installations and performances" (Hall, 2018). These devices form the

[52] A-Max object is a prewritten piece of programming code that can be linked together with other objects or edited.

backbone of her fictive stations by inserting custom recordings and compositions into the radio spectrum. Among others, Anna Friz, Tetsuo Kogawa and Ed Bear use the micro transmission to craft unique radiophonic environments for their radio art pieces. My initial goal, as with above artists' was to create carefully controlled radiophonic behaviour through the transmission of precomposed sounds into the FM spectrum. Using a micro transmitter, I could broadcast to empty radio space or overwrite existing commercial broadcasts. As legally sold micro transmitters comply with Ofcom's transmission (distance) regulations, both options were viable. In theory, I could have multiple transmitters, each broadcasting at equally ascending intervals. A radiophonic behaviour could then be constructed by tuning through naturally occurring static material and arriving at the custom transmitted frequency. I aimed to package the final device as a piece of hardware, like a mixing or summing desk, with multiple inputs to insert custom audio. For each input, the user would select induvial radio frequencies to transmit to, with the possibility of being able to switch between FM and AM bands. Because, a radiophonic environment is craftable through multiple points of frequency intervention.

I sketched preliminary designs visualising a device with five audio inputs, individually transmitting to FM frequencies set by the composer. Utilising a built-in analogue receiver, I used the hardware as a musical instrument, manipulating a dial to tune into each sound source. I planned to incorporate preamps into the signal chain to encourage microphone transmission for collaboration with other performers. The positioning of the FM frequency selectors would reinforce the linear aspects of creating a radiophonic environment. Like a radiophonic scale, each number would represent the auditory occupation of radio space, housing a potential audio source.

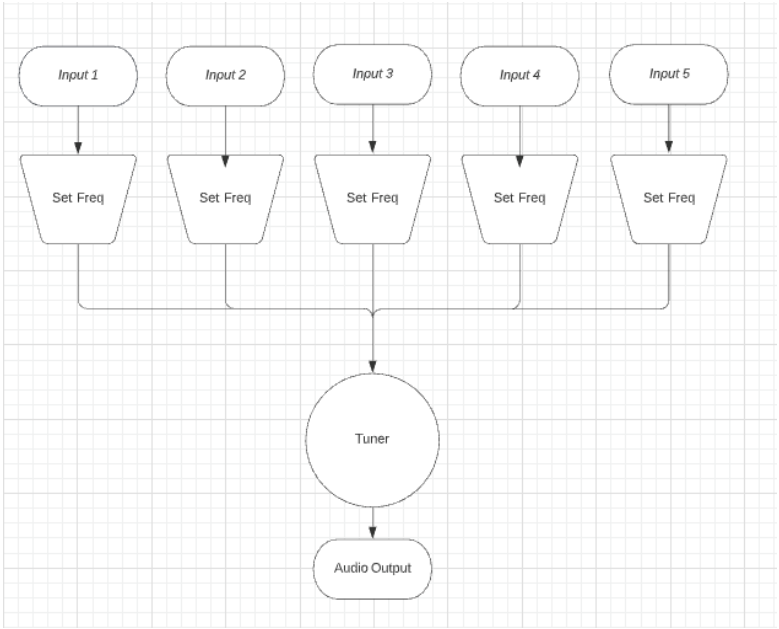


Figure 13: Flow chart for my micro transmission instrument.

Using a commercially available micro transmitter (VT-0418-B), I began to experiment by broadcasting audio to a radio receiver. The transmitter had a range of up to five meters. Initially, I transmitted a recording called *Gong Station Chimes*, from the radiophonic archive, *The Conet Project*. The recordings were transmitted to the FM frequencies, 90, 100, 110, and 120 KHz. I tuned into the audio using a high FPR radio. The radio receiver was positioned at set lengths away from the transmitter, (half a meter, one meter, two meters, three meters, five meters and ten meters). The radiophonic behaviours, which are typically most intriguing, were limited in sonic aesthetic and variation. The materials which are ordinarily definable gestural shape (as identified in my framework chapter), was not present. As I tuned to the micro transmitter's frequencies, the resulting radiophonic behaviour did not incorporate the intricate granulated fragmentation. Instead, it sounded like a 'flick' between static and audio in the same way one might mute and unmute a track on a mixing desk. When applying slower turning rotations with an accurate radio tuner (low FPR), the result was a quick volume fade from noise to signal.[53] While the sound between the transmitter and receiver (up to a three-meter distance) was clear, beyond this mark the custom material would distinctively switch from clarity to distortion. Unlike conventional transmission and reception methods, there was no gradual audio dissipation between these distances. When moving the transmitter away from the radio past a five-meter distance, the reception stopped. Although I found this method of producing radiophonic behaviours limited, there was at least some consistency when reproducing the crossfade.

In my next experiment, I tested a more advanced transmitter (CZE-7C), which enabled me to set a frequency and transmission range. I could transmit sound that covers multiple frequencies to occupy a customisable size of the radiophonic environment. The device's transmission power is also customisable between 1 and 5 watts. As my previous experiment, failed to produce unusual radiophonic behaviours. I followed with new concept based on transmitting multiple overlapping frequencies. In my framework, radiophonic behaviour is built upon multiple layers of sounds. Using two CZE-7C devices, I recorded the melody to broadcast between FM frequencies, 88-90 MHz, and recorded the chord pattern, between, 89-92 MHz. Both audio transmissions share overlapping frequencies, 89 MHz and 90 Mhz. This experiment aimed to test how the sounds blended. When tuning from 89 and 90 MHz, I expected the sounds to overlap. However, despite sharing frequencies, the result was a distinctive flicker from the melody to the chords. The transmitted audio did not overlap or fade between one another.

[53] Demonstrating the process of tuning into a custom signal on the FM frequency, 100Mhz: https://blocki.co.uk/hilmi/37.mp4

These experiments demonstrated that micro transmitters do not replicate the complex shape and sonic characteristics of radiophonic behaviours. While it addresses one aspect of my objective- to position custom audio within radio space- its 'micro' nature has limitations. There were also various levels of unwanted interference by the recording equipment. In Magz Hall's PhD Thesis, 2015, *Radio After Radio: Redefining Radio Art in the Light of New Media Technology through Expanded Practice*, she describes such inconsistencies when working with micro transmitters for her exhibitions:

> Working with micro transmitters has proven at times difficult to control... the complete knockout of the transmitters has been most uncomfortable listening, particularly in the early stages of Radio Recall and Babble Station, which were produced on-site without the vigorous testing to avoid sudden playback issues which would knock out the transmitters, causing unwanted white noise and sending visitors fleeing from the gallery (Hall, 2015, p. 139).

Through rigorous testing, it has become clear that my aim was to miniaturise the expansive web of radio communication into a manageable composition and performance space. I found Tetsuo Kogawa Anna Friz and Magz Hall's approach for the liberation of the airways valuable as they utilise micro transmitters to communicate and shape real and imaginary spaces. As mentioned in my previous chapter, living in a city such as London has influenced my appreciation for complex tuning material. However, micro transmitters restrict radio's natural sound pallet. It is challenging to replicate citywide electromagnetic radiation and interference between the close distances of micro transmitters and their receivers. In order to achieve my objection, I investigated several other avenues; to tune into regular transmissions of my work on existing radio stations; acquire a radio license to broadcast freely (although within UK standards); or transmit outside the radio regulations over vast distances. As these choices are unworkable to achieve, I have turned towards digital practices and hardware simulation for inspiration.

4.2: Design Theories Introduction: Navigating through Sonic Spaces

Although my past experiments with micro transmitters were somewhat ineffective, the experience of tuning to custom material was exhilarating. Yet, the tests were far from scientific. However, the process I uncovered formed the backbone of my methodology; positioning sounds on a vertical space which is only audible when a marker overlaps its position. There are various programs and applications with a similar interaction. For example, *Playground*, for Android and IOS phones

converts touchscreen inputs into musical tones. In this application, the user assigns samples to segments of virtual space and swipe their finger over them to trigger and manipulate the sounds. The performer determines composition's evolution by navigating the virtual space. The result generates unique melodies, textures, and sounds, embodied with gesture. Like tuning a radio, as the user's finger passes (or tunes) through different shapes, the momentum affects the sound's attack, sustain and release. These programs explore cyclical relationships between gesture and material. As *Playground* advertises on their website, *www.getplayground.com*: "no musical knowledge is required to play: Rhythm and tones are guaranteed". The scales and formulas they use make it difficult to play out of time, or wrong note, shifting focus towards an exploration of shaping sound.

Sound placement and user navigation are essential features of locative audio works. In the *WI: Journal of Mobile Media*, Frauke Behrendt explores walking through placed sounds and sonic interaction. Artists and designers curate the distribution of sound, triggered by GPS coordinates. According to Behrendt, *Locative Media as Sonic Interaction Design: Walking through Placed Sounds* (Vol. 9, 2015), the participant does not contribute their material or determine the location of sounds. Instead, depending on their trajectory, each member creates their version or remix of the locative audio work. The choices each artist makes such as direction, length of the walk and time spent in specific locations, determines the participant's experience. A crucial part of interaction is how the audience accesses sonic content. Sounds are fixed to locations and require the user's geographical presence. However, some works have an "armchair mode", that allows people to have some of the experience remotely (Behrendt, 2015. p. 8). By clicking on icons on the digital map, sounds associated with these locations are triggered. Pathways may be both linear and nonlinear. Linear ones attempt to curate audience's journey by guiding them along a set path, from one location to the next. Nonlinear examples do not prescribe a set path to users but allow them to explore the placed sounds in any order through their own chosen paths.

The popularity of mobile sound art is evident by the emergence of touristic, educational, fictional, and gaming applications. For example, the London application T*alking Statues* presents the user with a map of historical sites throughout the city. When standing next to a featured statue, a comical voice speaks to you about 'their' role within history, from a first-person perspective. Another 'placed sound' example is works that explore spatialised fiction. These focus on crafting a layer of reality upon our existing audio and visual experiences. Relationship between audience, space, and narrative, rather than historical facts, are explored.

In the development of my workstation, I approached sonic interaction design in a similar way to a linear sound walk. On the surface, it may seem like radio offers straightforward causal

relationships between the dial and produced sound. However, there are multitude of complex sequences that unfold to create a radiophonic behaviour. In a similar way to sound walks, the composition of a radiophonic environment shift between highlighting reality and creating new narratives. Sounds are positioned at any point on a virtual environment and navigated through on a linear path. In a virtual or digital space, this path is multifaceted. There are multiple layers of sounds that unfold at different rates when tuning the dial, and each path follows a design principle for seamless tuning experience. The following concepts are realisations of my sonic interaction and sound placement ideas that have developed organically. They are presented in chronological order, from inception to final concept, and aim to unpick radiophonic behaviours and the tuning process. They are an attempt to build a variable method for the creation of custom radiophonic environments, within the controllable confines of digital space. While each method harbours a different approach to composition and interaction, they have all contributed towards my final design. As stated previously, my goal is not to present a step-by-step developmental document. Rather, it is to highlight the central design milestones that have challenged my understanding of radiophonic materials, behaviours, and environments.

4.2.1: Crossfade

Influenced by my micro transmission experiments, initial methodological approach featured the common practice of crossfading audio. The crossfade is a widely used technique within audio mixing. It allows the user to fade sounds in and out at the same time. Its effect is achieved by routing audio to different faders on a mixing desk—one fader set to its maximum volume, and the other to its minimum. As the user moves both faders to their opposite extremes, the volume of each channel is reversed. The result is a crossfade between the audio tracks. As the first channel fades out, the second fades in. In Logic Pro, I replicated this process by creating two audio tracks, loading static recording into the first, and broadcast material into the second. Volume automation was positioned, creating a smooth fade between static and broadcast material. On the workstation, automation lines visually represent changing volume. By inserting markers, these lines are manipulated to produce attractive volume fades. A range of tuning variations is produced by changing the steepness of these lines.[54]

[54] Video demonstration of automated radiophonic behaviour created in Logic Pro: https://blocki.co.uk/hilmi/38.mp4

Although the sounds are freely positionable in a linear direction (as in positioning radio frequencies to create a radiophonic environment), their interaction is limited. Moreover, there is no process to control playback through a dial rotation. Logic Pro's Ecosystem uses a fixed global timeline, where sounds are positionable, but interaction is limited to start/stop playback functions. It is inappropriate digital environment to construct interactive behaviours. As such, I improved this concept using the programming software, MAX MSP. While Max is a system that specialises in live processing and interaction; such processes needed designing and programming from scratch.

The journey led me to the first iteration of my software, RED, which had a radiophonic environment split into multiple segments. Although the number of segments chosen was arbitrary, with more development time, it was possible to vary this value. I created four channels allowing separate audio files to be loaded and stored. A background audio file containing noise was programmed to be always playing. By manipulating value boxes, I enabled each segment within the radiophonic environment to control the volume of the audio files (or broadcast signals), the trigger process being the rotation of a virtual dial. Like volume automation in Logic Pro, changing of the number boxes to reflect different sequences created variations of crossfade. As the audio file became louder, the background static became quieter.[55]

The result had its pros and cons. At times, slow fading between noise and signal sounded authentic. Having a background layer of static also reinforced a sense of depth. The static seemed to form a layer that existed behind the clearly defined audio signals. The virtual broadcast signals emerge or 'steps through' the static, becoming focused in the foreground. However, this crossfade did not faithfully represent the defined shape of radiophonic behaviours. Constructing a realistic radiophonic environment should rely on a balanced relationship between the materials, although RED contributed to difficulties in attaining a fluid sonic interaction. It was also very delicate to precisely line up intricate and precise fades that required time dedicated to backtracking- tuning into the material using the virtual dial, fixing the fade, then tuning back into the material to hear the result (and so forth). Furthermore, the construction of radiophonic behaviours was limited to volume automation.

In moving forward, my goal was to create a dynamically controlled behaviour. By rotating the dial, I wanted to dynamically control the 'crunch' and dissipation of radiophonic materials.

[55] Video demonstration of RED, version 1.4: https://blocki.co.uk/hilmi/39.mp4

4.2.2: Three-part Behaviours

The next milestone in RED's development was the construction of radiophonic behaviours using three connecting segments. When creating a behaviour, a blank template appears, offering the user three workable segments. The outer segments were reserved for noise, while the middle, earmarked for the broadcast signals. By assigning a simulated radio frequency value to the behaviour, RED operates within virtual environment. In my previous prototype, static was a background layer to the compositions. With this new approach, it became part of a customisable mass that sandwiched the broadcast signal. By using the stated methodology, a virtual radiophonic behaviour incorporated three segments- middle, left and right. At this stage of development, I built a processing module, namely, *The Fragulator*, which became a central module which I will demonstrate in my final design theory. The Fragulator allowed me to change the characteristics of static material, in response to dial rotations. Automation lines were drawn on a chart to control the granulation resolution of noise. The chart ranged from its lowest value (no processing effect) to highest (maximum granulation intensity). A diagonal line from its lowest to highest point created the illusion of static fragmenting into small particles[56]

My three-part behaviour concept was a stride forward in interactivity. In my crossfade example, behaviours contained a limited amount of detail. There was only ten ticks/steps worth of automation data available for each crossfade. In this version, I found that 40 slots either side of broadcast, was sufficient in producing natural and smooth dynamic processing. As the dial rotated, the behaviour embodied a precise shape and momentum that sounded radiophonic. However, overlapping blocks of three-behaviours in digital space was quite fiddly.

Furthermore, when pushed to its limits, creating complex behaviours proved problematic. The three-part design formed a disjointed relationship between behaviours. Each behaviour was disembodied and unconnected to others. The result became poorer when multiple behaviours' noise segments overlapped, creating unexpected volume spikes and gestural inconsistencies. Moreover, noise segments felt like a secondary focus: like taped on wings to a piece of broadcast material. Going forward, I repurposed my approach by deconstructing the three-part behaviours into a unique element for composition. I wanted to create a truly equal relationship between noise and signal, each having a part to play towards the behaviour's reception and evolution.

[56] Video demonstration of RED, version 2.81: https://blocki.co.uk/hilmi/40.mp4

4.2.3: Node Theory

The next phase in RED's development addressed some significant shortcomings provided by the previous three-part behaviour, and the crossfade concepts. Here, I focused on the lack of fluidity between the disembodied segments. In this version, I explored the possibility that radiophonic material has a centre of mass. From this centre point, it can be positioned within a virtual environment, and feature a customisable size. A radiophonic environment, therefore, could consist of multiple sized blocks, positioned throughout the virtual space on a liner horizon. Each block would contain material, either noise or signal, which overlap to create behaviours. This development stage involved filling a virtual composition space with nodes.

In Max, a node is a circular graphic that tracks interpolated data, positioned within a two-dimensional space. It consists of two interacting components. The first is the node itself. You may position up to 64 nodes within a square space and set their size and position. The second is a marker object that is moved around the virtual space using a mouse. When the marker overlaps a node, interpolation data counts the position of the marker concerning the node's centre point. For the development stage, I programmed an interface where I could embed audio into a node object. Each node had a customisable size and position yet limited to sit within a horizontal plane. Complex behaviours are crafted by layering multiple nodes and overlapping them in sequences. As the dial rotates, it moves the marker through the centre point of each node like a radio tuner. Thus, data for interpolation gets generated. This interaction dynamically changes the audio's sonic aesthetic.

Following extensive modifications and finetuning, the outcomes became encouraging. As I dynamically rotated the dial, the result worked well to process audio. With the creation of nodes, RED's complex radiophonic behaviours became apparent. Within a single node, multiple processes unfold. I built upon a limited list of processing modules featured within my previous versions (volume and Fragulation). These included a dynamically controllable radiophonic whistle, distortion, and modulation module. It was easy to create; position and size each node, then design how the embedded audio unfolds during the tuning process. Positioning blocks of behaviours in digital space was also part of an intuitive workflow that was effortless to develop ideas around. Although, at this stage of development, my software somewhat struggled to process large amounts of values. At slow and medium tuning speeds, the complex behaviours performed wonderfully. However, quick, multidirectional rotations, produced inconsistent results.

Nevertheless, this experience led to the development of my final version. This development phase helped me find an adequate balance between functionality, control, and sound quality. In the next chapter, I will aim to deconstruct RED's final features, including processing modules and its sampler.

4.2.4: The Final Design of RED

The final form of RED uses an optimised version of my node approach. I split the remaining overview into sections covering the compositional features of RED. An enclosed demonstration video ties together such features, providing a step by step guide to composing a radiophonic environment. RED's automation modules include volume, fragulation, radiophonic whistle, modulation, distortion, filtering, and multichannel diffusion. Each module has several options to control the tuning behaviour of the sound. As audio processing is part of a dynamic interaction between the dial and the materials, some modules feature methods to preview the sound. For example, in the distortion unit, by rotating a separate set of dials one can preview the live intensity of the distortion. When satisfied with the sound, the position of the dial is replicated. There are also several quality-of-life features, such as buttons and settings, mute and turn processing modules, On and Off feature

1. **Volume module**

This module forms the first stage of the processing chain. My earliest crossfade experiments influenced it by marking automation values onto the chart; the volume of the signal would shift as the dial rotates. To build a radiophonic behaviour, the volume module requires activation.[57]

2. **Multichannel diffusion module**

Below the volume chart is a multichannel designer menu. When this option is selected, a sub-patch opens. Firstly, the module may be set 'on/off' by clicking the 'X' icon. The process changes the node's audio output from stereo to multichannel. RED has up to 16 mono channels that are linked

[57] Video demonstration of noise and signal with the commands: steady volume increase, crescendo and rapid volume dips: https://blocki.co.uk/hilmi/41.mp4

to make eight stereo pairs. Audio is distributed to 12 simultaneous outputs on an audio interface, creating multichannel opportunities for a composer.[58]

3. Radiophonic whistle module

This module creates a pitch that sways and bends as the dial is rotated. In my compositional framework, I defined this noise as a radiophonic whistle. There are three functions to mould the sound: *pitch offset, trim* and *range*. Pitch offset is a dial that sets the transposition of the radiophonic whistle. Alongside this setting is a chart that automates pitch. The trim function controls the overall volume of the radiophonic whistle. There is also a process to automate the volume of the whistle, as the dial rotates. The final function sets the range of the pitch; the dial shifts the lowest and highest pitch value of the whistle. I have also created a multiple routing setting. These options include *off*, which mutes the whistle, *through,* which routes the whistle to other modules, and *pass*, sending the whistle to a single output channel. This module was a result of a development to replicate its iconic analogue counterpart, so, great effort was made to strictly focus on replicating its tone and nuances—for instance, the pitches' glissando between one another. Furthermore, if the whistle is set to its highest note, the resulting tone would collapse with a quick downwards glissando.[59]

4. The Fragulator Module

My fragulator module shapes radiophonic material in a way I associate with analogue radio. The aim was to create a module that reduces a sound into tiny granules or particles. Fragulator has two controllable functions. The first, called, *dropout/intensity*, where the sound's granulation resolution is controlled. The second controls the *wet* and *dry* signal of the processing effect.[60]

5. Modulation module

[58] Video demonstration of the multichannel designer to send audio through multiple interface outputs: https://blocki.co.uk/hilmi/42.mp4

[59] Video demonstration creating a radiophonic whistle with the commands: smooth upwards glissando, pitch folding in on itself and erratic patterns: https://blocki.co.uk/hilmi/43.mp4

[60] Video demonstration of a fragulator module with the commands: slow dissipation, fragmented radiophonic whistle, crossfade dissipation between two materials: https://blocki.co.uk/hilmi/44.mp4

Compared to other processes, the modulation module has the most flexibility and controllable options. It has five functions to control dynamic interaction. These include *modulation depth, excellent panning frequency, rate modulation frequency, course panning frequency* and *wet/dry signal.* By manipulating these options, we can replicate the waves and stuttering motions found in radiophonic behaviours or create a piece that sounds completely different.[61]

6. Distortion module

The distortion module destroys the clarity of the material while retaining some of its rhythmical shapes. A drop-down menu has additional options to change the characteristics of distortion's dispersion.[62]

7. Filter module

In my framework, I documented static material that unfolds using a filter-pinch-like process. I have previously explored broadcast material that features filtering and EQ sweeps. My filter module replicates this tuning interaction. It is a module that controls high-pass and low-pass filtering.[63]

So far, I have covered two main features of RED: positioning audio using nodes and dynamically manipulating audio using the processing modules and virtual radio dial. The final set of features demonstrate my approach to customised input signals. I have developed a sampler and mixer, where any sound, recorded or live, can be assigned to a node. As static is also an essential aspect of broadcast noise, RED features a *static designer*. Before the static is processed through the modules, there are multiple settings to shape its sound.

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[61] Video demonstration of dynamic noise modulation with the commands: accelerating and decelerating wave motions, stutter pattern (variation 1-2): https://blocki.co.uk/hilmi/45.mp4

[62] Video demonstration of the distortion module with the dynamic command: increase and decrease distortion intensity: https://blocki.co.uk/hilmi/46.mp4

[63] Video demonstration of the filter module with the dynamic command: sweeping high pass filter. Sometimes in radio, signal interference filters parts of a broadcast. The effect sounds like sections of the instrumentation is removed. By combining the distortion and filter module, similar sounds are achievable. In the second part of this demonstration, only the rhythmical shape of the instrumentation is heard: https://blocki.co.uk/hilmi/47.mp4

1. Sampler

RED's sampler is a flexible tool that allows composers to load, store and trigger audio files in exciting ways. Sounds are uploaded through a 'drag and drop' playlist which generates a sonogram for each track. Once a piece of audio is loaded, its initial volume can be adjusted using the horizontal gain slider. Sounds loaded into the sample is not heard until the user tunes into its connected node. By highlighting parts of the sonogram, a section of audio is highlighted or looped for playback.[64]

As part of the sampler, I developed a set of trigger functions, to control the audio's playback characteristics. With this feature, I can replicate radiophonic interference, or create interactions that are far beyond what an analogue radio can produce**.** The sampler has several functions: *through, pause, stop, cycle* and *play*. In RED's sampler, the standard playback mode for audio is set to the *through* option. This option reflects how radio reception functions for broadcast material. Even when the dial is not placed to the material's position, the playback method creates a constant stream of muted audio.[65] The *pause* function is a departure from the authentic analogue radio experience. It is a process more at home with digital practices. As you exit the node with the tuner, the audio pauses. Upon 're-tuning', the audio file would continue its playback.[66] The *stop* function works like *a pause*. When the marker exits the node, it stops the audio. As such, once the marker renders, the track restarts its playback from the beginning.[67] The *cycle* function creates a unique playback method. As the tuner enters the node, it triggers the sampler to cycle through its playlist.[68] The *play* function triggers an audio file to playback indefinitely. It is not possible to interrupt this function by untuning from the note. As such, the entire sample is played from start to finish, unaffected by other interactions. This feature is useful when triggering very quick fragmented tuning sounds and radiophonic interference.[69]

[64] Uploading audio to a node using the sampler: https://blocki.co.uk/hilmi/48.mp4

[65] Tuning to a node with its sampler options set to *through*: https://blocki.co.uk/hilmi/49.mp4

[66] Tuning to a broadcast signal using the *pause* function: https://blocki.co.uk/hilmi/50.mp4

[67] Tuning to a broadcast signal using the *stop* function: https://blocki.co.uk/hilmi/51.mp4

[68] Loading a playlist into the sampler and *cycling* through the audio via tuning: https://blocki.co.uk/hilmi/52.mp4

[69] Using the *play* function, quickly scanning a radiophonic environment to trigger a fragmented broadcast recording.: https://blocki.co.uk/hilmi/53.mp4

There is a final menu within the sampler left to discuss. This menu allows composers to trigger audio from one node by tuning into another. It works alongside the *stop, loop,* and *cycle* functions. By tuning to specific nodes, radiophonic material can cycle through branching paths of audio.[70]

2. Static designer

Static is an integral part of analogue radio reception. I included a *static designer* module to produce a steady stream of white noise, previously not pre-recorded, but instead, generated live using an algorithm. If pre-recorded noise is desirable, the use of a sampler is acceptable. There is a drop-down menu with a range of filter manipulations to shape the initial static sound[71]

3. Interface input

The final audio function connects the input channel from an audio interface. As such, live signals such as microphones, electronic instruments, and network performances can be used as material to construct a radiophonic behaviour. Up to 12 simultaneous inputs from an audio interface, each one with individual volume control can be routed to a node that reveals a range of interactive possibilities between performers and RED[72]

Using a mixture of the above modules and functions, vastly customisable yet realistic radiophonic behaviours can be performed.[73] RED offers composers the freedom to craft fully interactive radiophonic environments, mixing the vast and exciting sound-pallet of analogue radio with the customisation offered by digital environments. However, as the Max project continues to grow and grow, it proposes the question, what has RED become? How do we define RED?

4.3: What has RED become?

RED's early design sketches looked like a mishmash between a sampler, a workstation, and an instrument. More Frankenstein, then Steinway. Initially, I had ideas to create some sort of large box, full of inputs, dials, transmitters, and UV meters. However, my experiments with physical hardware such as micro transmitters failed to produce the desired sound. In its digital form, RED

[70] Interconnecting the audio playback, from nodes 1 and 2: https://blocki.co.uk/hilmi/54.mp4

[71] Video demonstration of the static designer: https://blocki.co.uk/hilmi/55.mp4

[72] Tuning to a node that contains a live microphone feed video: https://blocki.co.uk/hilmi/56.mp4

[73] A step-by-step guide on how to compose a radiophonic environment using a range of the discussed functions: https://blocki.co.uk/hilmi/57.mp4

started development as part of the back-end functionality to a composition idea. The process, such as positioning radiophonic material was fixed, rather than part of a flexible workflow. RED quickly grew into something far more functional. In this section, I aim to answer the seemingly simple question, what have I made? The answer, however, is not so straightforward. Audio-based software is modifiable under multiple categories. Is RED the back end of an interactive composition, or, is it a plug-in, audio unit, or software instrument? Could it be a simulation of radio or a digital audio workstation? By answering this question, I will address how digital programs deal with hardware simulation and the relationship between programming, design, and control. I will also explore user interface design principles and digital software's unique influence on compositional practices.

Before the early 1980s, and the wide release of DAWs, recording studios burst with analogue equipment. Artists and producers attributed successes in their career to hardware like the *Neve* mixing desk, a must have hardware for any BBC control room, the *EMT 140* plate reverb or the Eventide Clockworks' *Instant Phaser*. In the 1990s, computer-based DAWs became part of the standard recording studio offering and combined a mixture of analogue and digital audio production technology. In today's market, there is no longer a prerequisite to use analogue hardware. An entire virtual studio, from Neve channel strips to legendary guitar amplifiers, are loadable from a laptop. Developer, Colin McDowell, is a pioneer within the plug-in software industry, specialising in authentic analogue emulation. In an interview with, *Sound on Sound*, on *Plugin-Modelling: Emulating Hardware in Software*, McDowell states:

> Anything created in hardware can be recreated in software. Writing software is a much more fluid engineering method and, by its very nature, more flexible than a fixed hardware design. Furthermore, the notion that 'classic' analogue gear can do something that the average computer cannot do is outdated. Limitations, if any, only exist in the imagination, experience and creativity of the engineer(s) making the audio plug-in (Lambert, 2010).

Developing virtual models of analogue equipment has three commonly used approaches. The first method, called the white-box, digitally recreates physical hardware on a circuit-by-circuit level which is achieved by schematic analysis and in-circuit measurements of the original devices. The results are digitally mapped using virtual simulation software. However, some devices, such as guitar amplifiers prove challenging to simulate using this process accurately. Developer, Chris Townsend states:

> We could have modelled the guitar/amp impedance interaction, but we would have had to know the impedance of the guitar [at all frequencies], which is not even remotely practical. The other obvious limitation is time, and how much of it is required to emulate these devices or processes extensively. Theoretically, you can spend years covering every possible use or behaviour, but often that is not sustainable from a business perspective (ibid).

The second process is called a black-box approach. It centres around the identification of sound. Its name reflects development as a blind process, like putting the original hardware into a 'black box' to focus on sound rather than its schematics or physicalities. McDowell describes this approach:

> We listen to the target and become familiar with it… we send a variety of signals into the device, measure how they are affected at the output, and then begin the work of creating a process in software that does the same thing. Some input signals are remarkably simple, and others are complex, but the idea behind each is to pull out a characteristic of the device we're modelling (ibid).

Sometimes, modelling is not intended to copy every aspect of the hardware's sound. Invariably, designers can have a flexible and creative approach to *black-box* modelling. PSP Audioware's master developer, Mateusz Wozniak remarks:

> In most cases, we do not want to imitate specific hardware, but rather port the best analogue sound features to the digital domain. If we find the right solution and it sounds good, it is good (ibid).

Some plug-ins use a hybrid of both approaches, aptly called, the grey box approach. Using this method, developers estimate the measurements of the model's parameters and approximate its sonic behaviours. In an interview with Dirk Hagedorn in October 2016 for the Avidblogs.com series on *Live Sound: Music Creation*, McDowell talks about how this design philosophy is reflected in his work:

> Hey look, it can sound like this equaliser, this compressor, but then look what else it can do. Not only can it sound like some of these things you already have but look at what additional features it has.
>
> Another whole aspect is live sound, where sometimes it is about making it sound like the studio, and other times it is about solving problems. Maybe the

> guitar is a little bit deader today because it got too much sweat on it, or maybe something in the sound is not quite right, so you have all these little nook and cranny controls like peak, slope, and dip. You can go in there and really wrestle with the sound if you choose to do so in an effort to make it sound more like what the record sounded like or how you think the client wants it to sound like (Hagedorn, 2016).

Simulation is also used to enhance the hardware's digitised functionality. As part of Silvin Willemsen's thesis, *Virtual Analog Simulation and Extensions of Plate Reverberation*, he simulated a vintage plate reverb unit and presented their findings. He modelled the 1950s to 1960s reverberation techniques faithfully, and document how digital processes extend compositional possibilities. Steel plates were popularly used in the 1950s as a technique to add reverberation to sound. It has become quite an iconic sound as many popular records from this era use the unique effect. As plate reverb materials are quite bulky and require regular maintenance, a digital implementation would be desirable. In Willemsen's research, he seeks not only to authentically replicate the unique sound of this reverb but also use digital simulation to go beyond the physical possibilities of the original device. His development used a white-box approach, carefully simulating the physics, frequency dispersion, and boundary condition, of the plate. However, this data, which was set to variable values, changed dynamically. According to Willemsen, the final product produces a range of exciting results. Parameters such as plate dimensions can be changed in real-time creating unique 'flanging' and pitch-bending effects, respectively. By creating a digital model, allowed Willemsen a sonic exploration through the changing of parameters.

In the development of digital simulation, the rapid processing speeds of digital computing has enabled real-time manipulation of virtual hardware. The result creates additional layers of control for composers and performers to experiment. Pre-sets can be easily triggered, and performances stored for analysis. The digital implementation also provides a variety of plug-ins to choose from with a reduced size and weight relative to analogue counterparts. In David Te-Mao Yeh's unpublished PhD thesis, *Digital Implementation of Musical Distortion Circuits by Analysis and Simulation*, he refers to simulated hardware as “virtual analogue” (Yeh, 2009. p 2.) It is a term shared by Willemsen.

When growing up, my family listened to the radio in the car. Occasionally, I would discover a song I liked, and persistently ask if we could repeat it. "The radio doesn't work like that", my father would respond. To my disappointment, repeating the song was not possible. Coincidently, this was a somewhat 'digital' way of thinking. Television soon solved this problem with a 'catch-up'

feature to record, pause, and repeat live programs. Today, interacting with media over the internet such as sharing, commenting, pausing, and rewinding, is standard. Radio is one of the few mediums that fall behind in this regard. Perhaps the advancements of *Future Radio*, as explored in Chapter 2, will introduce such features. Like many virtual analogue software, RED offers control over radiophonic material, unique to the digital medium. The sampler for RED addresses such matters. When composing a radiophonic environment, it promotes digital thinking, allowing the user to control how the sounds are streamed and interacted directly.

Throughout RED's development, I found that the black-box approach was particularly helpful in modelling the sonic characteristics of analogue radio. It enabled a creative solution for hardware that produces inconsistent results. However, this approach leads to issues regarding sonic authenticity and analogue purism. It is part of a heated dispute on which medium is more effective; analogue, or digital. The answer shifts back and forth, like debates on authenticity versus artifice, traditionalist versus modernist approach, and human versus mechanical. In the context of this research, I feel this is the wrong question to ask. Instead, I would shift the conversation to explore how musicians and listeners use one medium, to understand another. How do they locate themselves in, produce, and transform a tradition?

REDs simulation of radio is routed in a composition framework that bridges the gap between tradition and transformation. This relationship is most apparent by the way RED conceptually uses noise. In analogue radio, the medium is perceived through its embodiment of noise. Noise is as an artefact of analogue technology. For the case of radio, this indicator is undoubtedly accurate. In Andy Kelleher Stuhl's unpublished PhD thesis, *Reactions to Analogue Fetishism in Sound Recording Cultures*, he argues that "noise makes audible the mechanisms of capture, mediation and playback" (Stuhl, 2013, p. 11). Upon hearing a sound recording, technologies involved in the recording's creation is identifiable. In the digital age, the noise has been dramatically suppressed or eliminated. Conceptually, RED seeks to shift the status of noise from electrical nuisance or a by-product to a malleable material. Through digital processing, I seek out its development and domestication. Across RED's transparent layers and granulation, noise offers the composer the perspective of depth, because, as a physical phenomenon, it creates auditory illusions of space and distance.

While the white box approach best describes RED's development, defining its functionalities is far more problematic. When compared to audio units or digital plug-ins that authentically simulate hardware, it seems to offer more. RED offers composers a slice of virtual radio space to play around and populate. To define it, I turn to my previous experience as a studio producer. A commercial production studio often features specific DAW. The common ones include *Logic Pro,*

FL Studio, Reason and *Sibelius*. Each software works differently with audio. The programmes provide a virtual composition or production environment, where sound can be arranged, edited, and processed. Like RED, plug-ins (or modules) are loaded into a DAW to compose and shape the sound. More importantly, their interface design and core functionality invariably influenced by hardware. For instance, Reason emulates the characteristics and functionality of analogue synthesisers. It references a time before digital plug-ins, where processing audio was a physical 'point-to-point' procedure. It involves connecting audio using rack-mounted hardware and multiple patch leads. In Reason, the audio units are loaded onto a virtual rack and connected using virtual cables. By patching unit's output with another unit's input, we construct a powerful synthesis and processing chains.

Software such as Logic Pro and Pro Tools was influenced by the multitrack machines and mixing desks of the nineteen seventies and eighties. In a time before DAW, machines such as reel-to-reel decks allowed the user to record separate tracks of audio and mix the signals. The tape is positioned to overdub audio at specific parts of the recording. Tracks are then edited by cutting out and taping together segments of the reel. Unlike these machines that offer limited tracks to record with, their DAW counterparts offer a near unlimited workable track (as much as the GPU can handle). Compared to its hardware predecessor, it functions relatively similar. Finally, FL Studio, formerly called, Fruity Loops, is modelled on early sequencers and drum machines. Unlike the original hardware, samples are loaded effortlessly, while the composition length remains variable.

The parallels between DAW's and REDs functionality are noticeable. Like a DAW software, RED offers instant previewing of ideas for consequence-free experimentation. Artists build compositions within a virtual composition space that is purposely designed to reflect its analogue heritage. Interestingly, when reflecting on REDs development, the smallest design and functionality tweaks had a significant influence on its potential to make compositions. As such, I find that DAW have a considerable influence over composition workflow. As composers are influenced by hardware developed and refined for specific genres, instrumentation and techniques, there is often a close and cyclical relationship between a composition environment and the composition process. In their research titled, *The Programming Language as a Musical Instrument*, Alan Blackwell and Nick Collins, comment on this very issue. They state:

> …the predefined (abstract hating) interface of Ableton, makes specific assumptions about the music it will treat. The default rhythm (120 beats per minute, with a 4/4-time signature) is typical of disco music and enables rapid set up for the target end-users; mainstream dance DJs (Blackwell, Collins, 2005. p. 123).

In some cases, composers have had to adopt additional steps into their composition process to break out of these software implications. More pressingly, software's UI design can have a significant influence over composer's approach to composition.

4.4: User Interface Design Principles

The user interface design for RED has gone through many iterations. It has taken as much development time as the many modules and back-end processes that make the workstation function. Although analogue equipment goes through an interface design process, developing a virtual system has unique considerations. In physical hardware, one is limited to the shape, size and weight of materials, circuit boards and components, such as potentiometers, buttons, and sliders. In a digital domain, these restrictions are no longer apparent.

Nevertheless, some designers follow industry standard patterns. Before I unpack the development of my Graphical User Interface (GUI), I will explore design principles that are unique for digital concerns. In the presentation on his software, JUCE, developer, Ivan Cohen, states that musicians have habits and are more creative when interacting with natural processes such as sliders, buttons, dials, and keyboards. There is also a 'placebo effect', where a software's GUI contributes towards the feeling of authenticity. Software that is influenced by the look and feel of old technology is fun, appealing, and inspiring. It is an unambiguous contrast to the 'cold' and clinical arrangement of variables that hide under the hood of the GUI. This design choice is called *skeuomorphism*.

Skeuomorphism refers to a digital interface that represents or imitates a real-world objects' interaction. It mimics the physical motion of its analogue counterpart. For example, a volume slider on a touchscreen phone, or a dial within the software mimics a variable resistor. There are pros and cons to this method. The main disadvantage of these digital objects is cluttered workspaces. They tend to take up a great deal of space within the program.

Furthermore, to increase control over the process, multiple dials, buttons, or sliders must be designed and inelegantly positioned. Moreover, Skeuomorphic objects are not as accurate as a variable number box. However, they can provide more information to the user. For example, an advantage of a dial (such as the ones used throughout REDs UI) shows a clear minimum/starting point position, set position, and maximum/ending point position. In radio-based compositions, this feature is important, because tuning gestures rely on pivoting the dial through an implied point of resistance. A performance based on reading values that quickly increase and decrease is challenging to interpret.

When a Graphical User Interface (GUI) is unclear or complicated, it diminishes the effectiveness of the software. With RED, I tried to remove abstract interaction between the user interface and its processing architecture. I relate this experience to how Reason and Logic Pro handle the signal flow. In Reason, plug-ins are connected using virtual patch cables. In Logic, this process is slightly more abstract. The visual imprint of its connectivity is somewhat elusive. Thus, it makes it difficult for newer users to grasp the concept. In RED, I based the UI on the tuning indicators found on analogue radios. When I rotate the dial, a visible marker travels across the frequency spectrum, much like a radio. Material is positioned along this spectrum, using nodes to visualise broadcast material.

In a seminar I presented at Canterbury University, I demonstrated an earlier version of RED, where the GUI featured an FM radiophonic scale as part of the node interface. A participant remarked on my use of the FM radiophonic scale rather than other frequency spectrums like AM or Citizen Band radio (CB). In my digital environment, frequency numbers are arbitrary, and the background is just a way to visualise the size of the virtual radio space. However, the FM markers still confused the participant. Due to this experience, I refined my GUI to include an option to set a custom radiophonic scale marker system. It provides the user with a blank canvas with no implication of a radio spectrum.[74] There is also a system to set node colours to help a composer or performer navigate complex environments.

4.5: Hello World! Introduction to Gestural Controller

I used the phrase, Hello World! As the title for this section because it is part of the code one often learns when first starting to program. It is a communication script/message sent by the computer which reinforces my view that the computer acts as a transmitter. Alongside the development of RED, I was interested in creating a piece of hardware that controls the virtual tuning dial of my workstation. I imagined rotating a physical dial, and the result transmitted to a speaker. I, therefore, built a gestural controller to perform radiophonic environments made on RED. It was a process that took eight months and started halfway through REDs development. The project had to simulate the delicate responses and interactions found when interacting with a physical radio dial. My main goal was to use this interface to create an exhibit where the participant has the freedom to rotate the radio dial and explore my carefully constructed radiophonic environment at their own

[74] Demonstration video on REDs radiophonic scale marker system: https://blocki.co.uk/hilmi/58.mp4

pace. Although I fixed the environmental shape, its navigation was improvised or interpreted from a score.

4.5.1: The Development of PINK

> For centuries, the pipe organ was the most sophisticated synthesiser employed in western music. The sounds it produced could be precisely sculpted in a novel and artificial ways and were called upon from a keyboard that allowed for rapid and accurate control (Brent, 2011. p. 429).

Designers are experimenting with such a relationship between a sound's characteristics and gestural control. Digital practices possess the ability to decouple sound from their means of control. The slightest movement can trigger an astonishing multitude of sonic possibilities. On the other, the result can also be difficult for audiences and performers connecting with the piece. The difference between acoustic instruments and digital instruments is the way that performed actions correlate to sound production. If we drop a glass, we anticipate an almost inevitable outcome- a loud smash, shattering the glass into pieces. If the object were to bounce like a ball, it would defy our expectation and defy our understating of reality. At a musical performance, we experience a similar impression. We expect the gesture of a bow, moving across the strings of a violin, to produce a particular sound. Likewise, when a rock band becomes animated on stage with broader strokes hitting the electric guitar strings and drum skins, we understand it as a loud, energetic segment (and an appropriate moment to start a 'mosh pit'). However, digital instrument design and gestural controllers shift between this reality but they are likewise elusive. Kim Cascone, in her article, *Laptop Music- Counterfeiting Aura in the Age of Infinite Reproduction*, remarks:

> the recent adoption of the laptop computer in concerts and festivals by digital musicians and DJ's has caused much controversy amongst concert promoters and audiences… laptop performances being considered counterfeit, fake. The antagonism arises when a performer generates music by a process unknown to the audience, using technology more at home in an office cubicle than a musical performance (Cascone, 2004. p. 5).

Cascone suggests that the laptop is ingrained in public consciousness as a business tool, and to use it as a musical instrument is considered a violation of the codes of musical performance. The audience feels cheated because the laptop musician appears to be merely playing back sound files stored on their hard drive. She has a tongue-in-cheek poke at "laptop stereotypes", wherein mid-

performance the artist stops and "logged his tax return electronically!" (ibid.). Gesture and spectacle disappear into the micro-movements of the laptop performer's wrists and fingers. From the audience's view, the performer sits motionless, staring into the luminous glow of the laptop screen. At the same time, sound flies around them and fills the space by processes unseen and misunderstood.

Performance with RED could have fallen into the laptop stereotype, as described by Cascone. In its most basic form, RED is a piece of software exclusive to a laptop or computer. The development of my physical interface, PINK, however, addresses this problem head-on. The radio may not have performance gestures as large as violin or a guitar, but it produces sound through an interaction that is ingrained in most people. Tuning a dial is easy to understand, and most people have experienced it with radios. As mentioned in Chapter 3, the radiophonic material is also interconnected and shaped by performance gestures.

To create the controller, I used a micro-controller unit (MCU) called an Arduino. It is a small device that has several analogue and digital inputs and outputs. The Arduino can be programmed to run looped start-up tasks. I tested several input methods, including, Musical Instrument Digital Interface (MIDI), a rotary encoder, a potentiometer, and a gyroscope. It is important to note that RED splits a radiophonic environment into a spectrum of 1000 steps or ticks. The challenge was to generate enough numeri to continuously scan RED's tuning marker through the full 1000 step environment. My first experiment was a dial converted into MIDI data. MIDI messages specify instructions for digitalised music including a note's notation, pitch, velocity, vibrato intensity, panning position, and tempo (clock signals). Many virtual instruments use MIDI as a communication protocol between software and performance controllers. As part of the technical standard for MIDI, controllers generate messages up to 127 values, with the note, middle C correlated to the value 60. Therefore, in the tests, a full rotation of the dial produced values between 0 and 127, far below the 1000 steps I required. In REDs case, the current MIDI controller would not be able to cover the entire composition environment in one rotation.

I attempted to address this problem by creating a counter in Max, that would increase up to 1000 steps, as MIDI data changes. I also had to modify the dial, so it produced a continuous rotation. Such dials are commercially available. By dissembling its case, I removed a small plastic mould that gets caught on an outer rim when it hits the values 0 and 127. The fix rotates the dial continuously and produces these values in a loop. However, there was a flaw with this setup, rendering its use problematic. If the dial rotates at high speeds, it skips some values which made the tuning process unpredictable.

The next method using a potentiometer solved the problem. A potentiometer is a dial that provides variable resistance, the value of which is read by the Arduino board. Depending on the model, an Arduino is conventionally powered by a nine-volt battery. It allows two output terminals of 5.5 volts and 3.3 volts. When connecting the potentiometer to 3.3 volts, it produces resistant values between 0 and 530. 5.5 volts, on the other hand, produces values between 0 and 1023. I created a script that transmitted these resistance values via Bluetooth to my max patch. As the potentiometer dial rotated, the tuner marker moved throughout the entire radiophonic environment.

Finally, I wanted to improve the look and portability of my interface. Visually, I aimed to hide these components within a radio set. I chose a radio that has a vintage/retro design to explore the perceptive response to an aesthetically authentic or unassuming looking radio and its digitally composed output. As such, I opted for a retro radio carcass that juxtaposed the digital technology hidden inside. Using a 3D printer, I designed a value mechanism, that would join the interface's potentiometer with the radio's original dial. I fastened the Arduino circuit inside the radio shell and a Bluetooth speaker positioned towards the radio speaker grille which is quite an invasive procedure.

However, the results were not uniform for each radio. In other attempts, the carcass was sometimes too small or the tuning mechanism inaccessible. To imitate radio's visual impression, I wanted to avoid cabling between the computer and the controller. Therefore, I used a Bluetooth device to create a wireless link with the computer up to ten meters away. Using a custom Max patch, I instantly established the connection. The resultant sound quality has clarity with little interference. I finally sealed the radio shut[75]

To finish, I developed a sub-patch that can change the FPR of REDs virtual dial.[76] As explained in Chapter Three, radio sets have different tuning detail. My FPR ratio can test this level of detail. It gives performers and composers, extra freedom to adjust the gestural controllers' interaction with RED.

[75] Testing the gestural controller video: https://blocki.co.uk/hilmi/59.mp4

[76] Setting the FPR to 1:1, 2:1 and 5:1, and tuning through the environment: https://blocki.co.uk/hilmi/60.mp4

4.5.2: Don’t forget about BLUE

The search for radio art on a website such as YouTube results in little exhibited work. There is a small number of works that exist in accessible formats online, or on devices such as mobile phones. Radio artists insist on using radio as their primary diffusion method which has links to the radio being viewed as a found object, as discussed in chapters two and three. This approach narrows the consumption of radio works with exhibition and gallery settings the definitive setting for its distribution. I find this characteristic a limiting factor in the art’s social reach and accessibility. As such, I developed new distribution links for the interaction and consumption of radio art, which led to a development process that tackles this shortcoming. The creation of *Broadcast Link-up Environment* (BLUE) uses JavaScript and HTML5 and is currently in its beta phase. My goal was to create a website that lets the user interact with their phone to tune into radiophonic material. The current version includes a website that features a radio dial that can be interacted by swiping one’s finger across the screen, or by rotating the phone.

For the creation of BLUE, I first designed an image of a radio dial. Like RED, space was carved into segments. I programmed markers around the radio dial that triggers messages via a touch screen interaction. This interaction rotates the dial picture, giving the illusion of user control. Each marker triggers a range of commands. These include: play audio, stop audio, mute audio, pause audio and set audio volume. By setting the volume value for consecutive markers, a volume envelope is created. I wrote a short formula that linked a phone's gyroscopic inputs (between 0 and 360 degrees) into these commands. As the phone rotates, the audio's volume likewise is manipulated.

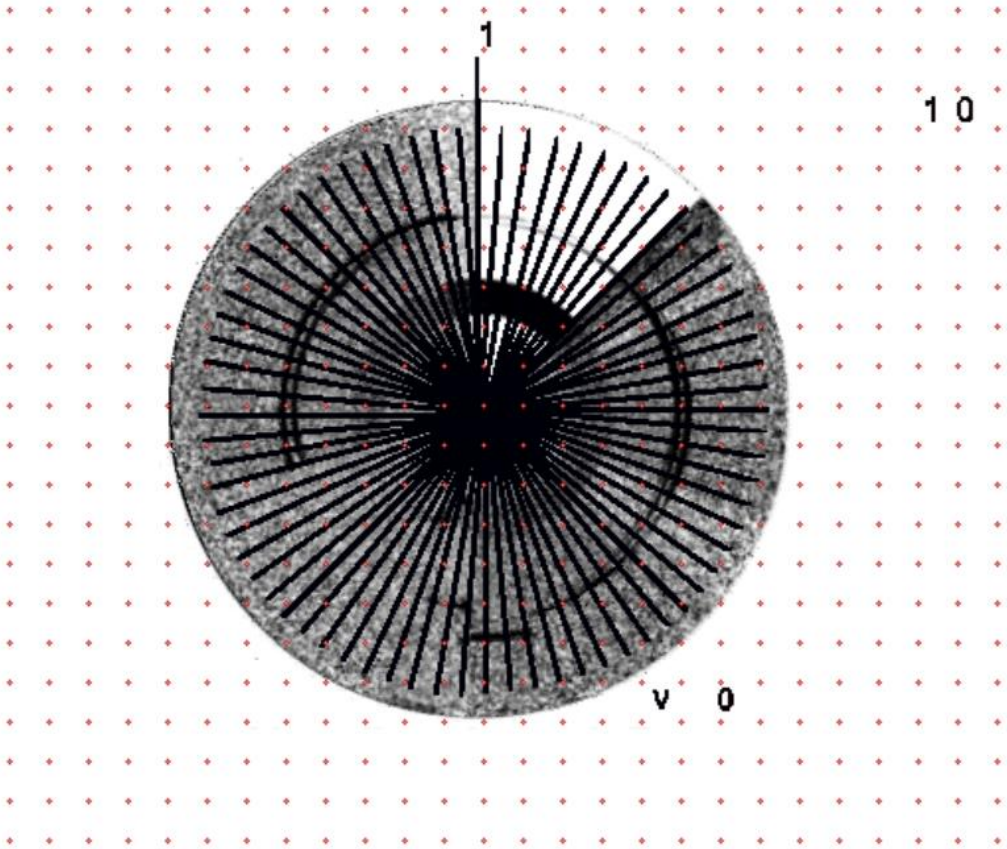

Figure 14: BLUE test environment.

My initial tests proved encouraging. To realistically convoy a radiophonic environment, I bounced at least five tracks from RED within a full-sized node. The user experiences the environment by uploading the application to a website using HTML5, (which supports gyroscope data) and opening the webpage on the phone. Touching the dial with a finger rotates it and triggers the radiophonic material that crossfade between each another. As the phone is positioned horizontally and tilted from side to side, the sounds unfold. BLUE requires no downloading, just a URL link to access.[77] The development of BLUE is ongoing. More is needed to add new features, which is out of the scope of this research. However, I have used this technology to host a realisation of John Cage's, *Imaginary Landscapes No. 4*, and multiple interactive archives, featured in the next chapter.

[77] Video demonstration of BLUE: https://blocki.co.uk/hilmi/61.mp4

Chapter 5. Portfolio

> Time passes most perceptibly; nothing of what has just been left to the next moment; only the course of the single line of melody exists; all the action is pure movement. [...] If the piece is adagio, then the whole world is adagio (Arnhime, 1986, p. 15).

I am journey bound. Like all journeys, there are twists and turns, starting points and destinations, arcs of different velocities. Like the Whirling Dervishes, I rotate, seeking a transition from one state to another. The Dervishes meditate through dance, spinning their bodies to symbolise their journey towards clarity. In their posture, one hand points at the sky, and the other at the floor, like a radio antenna, extended outwards, channelling the airwaves to the radio below. By spinning in circles or 'whirling', gradually they 'tune' into a divine state. Gradually they shed their outer black robes, revealing a pure white garment beneath. Both hands then crossed, as if heaven and earth are in unison, their destination reached. My attempt at navigation around radio art and subsequent discovery of boundless compositional opportunities of radiophonic behaviours resonate with the Sufi Dervishes' journey for higher spiritual achievement- the movement between states, rotations of the dial in search of clarity, the bridging between the cosmos and our earthly transmissions.

Throughout this research, my portfolio has taken the form of fixed stereo works, performances incorporating live electronics, multichannel diffusions and interactive installations. In my compositional output, I aimed to build on a commonality shared practices by radio artists- the re-imagining and re-definition of analogue radio, to widen the scope of creative practice. My probing into analogue radio's compositional potential has revealed both an intriguing framework to compose with, and technological limitations within its presentation. Using my custom software and hardware, I aimed to go beyond the medium to the compositional potentials provided by digital environments. My objective was to create an open relationship between the reality of authentic broadcast and the illusion of hyperrealistic space. Each following composition realises my framework, influenced by the characteristics of radiophonic material and behaviours. Therefore, while my works share an underlining compositional language with other, yet it is realised in different ways. As such, the following pieces present vastly different approaches to crafting radiophonic environments. My portfolio is presented in chronological order of enhancement, fitting alongside the development of the structure and software.

There has been a symbiotic relationship between the workstation's design and the creation of my portfolio.[78] As such, the opening compositions are part of an exploration of radiophonic material and progress by the introduction of digital interventions. They conclude with interactive works that fully simulate radiophonic environments.

5.1: 96-104

96-104 is a composition that explores how analogue radio's tuning gestures produce pitched and rhythmical phrases.[79] The work is named after frequency range used to generate its source material. All sounds were recorded from a 1970s *Grundig Boy 1100* radio, scanning frequencies between 94 MHz - 106 MHz in FM, and 750 kHz - 1300 kHz in AM. This radio has a high level of tuning detail, with an FPR of 4:180. The composition process was in two stages. Small fragments of radiophonic materials and behaviours are spliced together to construct larger phrases. Firstly, I scanned through sections of the AM and FM spectrum, seeking points of interest. I was drawn to classical and popular music programmes. As the tuner shifted back and forth through these broadcasts, an identifiable pitch and staccato timbre was formed. It was an was an exhilarating experience to produce different sonic patterns, based on my hand gestures. In Chapter 3, I explored this sensation as part of a feedback loop that included subconscious resistance, as the radio tuner passes through a broadcast signal. Using the radio dial, variations of tuning patterns were improvised and recorded, in two-minute to ten-minute performances.[80]

The second stage of the work's development, was editing and arrangement process in the software Logic Pro. I organised the recordings to create the perception of a virtuosic pseudo performance. In a similar method to vocal production techniques, undesirable pitches and sounds from one performance was traded with another. Fragments of radiophonic material were cross-faded with one another, to create the desired rhythms, melodies and motifs.

[78] Testing an earlier version of RED by composing a radiophonic environment based on 'glitch' sounds (video diary: 21/06/2019): https://blocki.co.uk/hilmi/62.mp4

[79] Adem Hilmi, *96-104* (2018): https://blocki.co.uk/hilmi/63.mp3

[80] Recording session for *96-104* (video diary: 09/10/2018): https://blocki.co.uk/hilmi/64.mp4

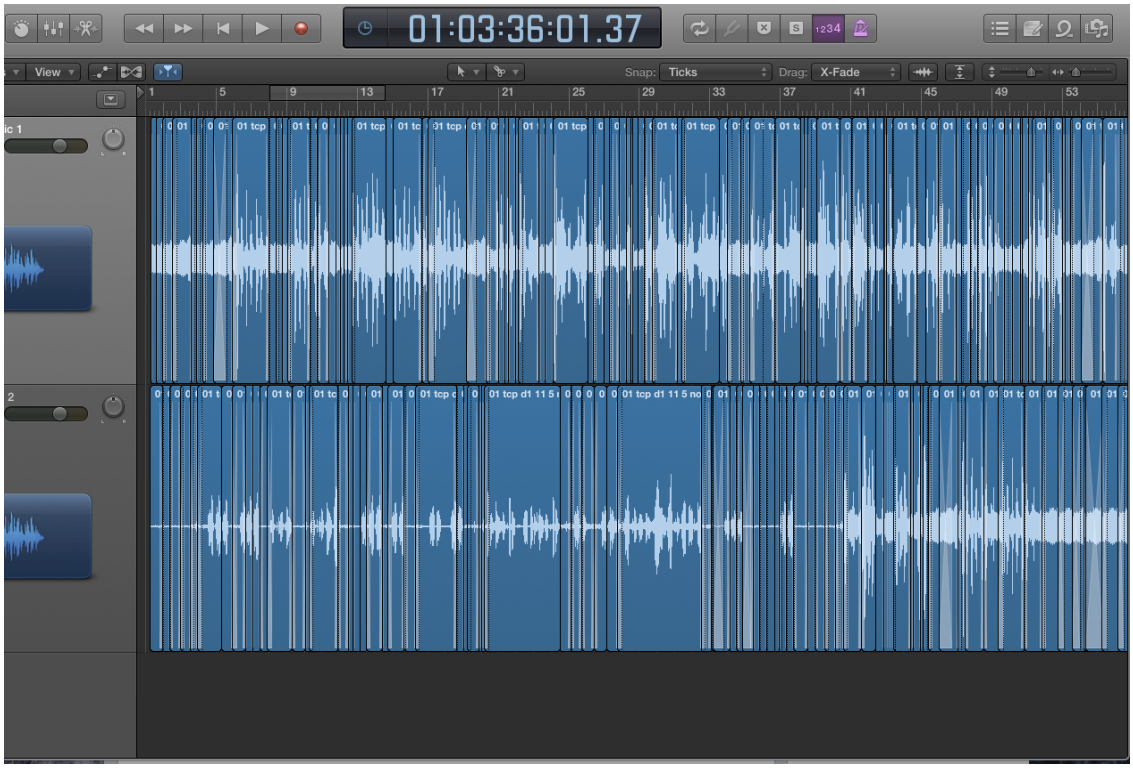

Figure 15: Threading radio fragments to create new and interesting phrases.

My research into analogue radio has exposed a composition medium that at times has little expression. The very nature of radiophonic material almost implies a sense of skittishness (randomly cutting in and out of signals). Like in a classical concert, where one can hear the intensities and resolutions of the performer's interpretation, I wanted the listener to be stimulated and feel an emotional response to the piece. Through the mixing process I shaped expression using reverb, dynamics, panning and silence.

The composition was arranged into four sections: A, B, C, D. Each section incorporates a contrasting aesthetic using noise and signal materials. Section A, (0.00 – 0.57), focuses on the distinctive quality of the tuning gesture, a process that threads sequentially positioned transitions, through quick tuning motions. As the radio featured a mono speaker, I carefully automated the fragment's specialisation. The erratic flicker of material between speakers, was shaped to enhance the gestural morphology and rhythmical momentum embodied within its radiophonic behaviour. The limited depth perception of radiophonic material was also challenged to create and resolve compositional tension. To establish moments of expectation, I automated a reverb to highlight precise pitches and sounds towards the end of phrases. However, at specific points, this expectation was challenged. Finally, silence was used as a device to draw the listeners attention. This is a common technique used by acousmatic composers however, does not commonly feature

in radio art. Section B continues the above methodology, with more focus on voice and electromagnetic interference sounds. Their phrase construction evokes a virtuosic percussive performance. For example: between 0.22 – 1:31, the rhythmical phrases resemble a drummer improvising stochastic fills. After the hectic shift between vocal and static fragments, this tension was relieved by highlighting a musical broadcast for 3 seconds from 0:57 – 1:10. However, once again, tension commences following an interruption of silence for 6 seconds.

Unlike section A and B, which imitate radio's liner textures, Section C and D have a layered approach to composition. Section C (1:39 – 3:23), explores signals found in AM or SW radio bands. Two predominate sounds related to these bands (although not exclusive), unfold throughout this section. First, is a radiophonic whistle, likeable to guitar or microphone feedback. When I was recording with this material, rotating the dial controlled the pitch of this whistle. Tuning towards the higher numbered radio frequencies made the pitch ascend, and vice versa. The pitch had a legato-like quality, like those produced by a theremin or fretless instrument. The second material features a range of electromagnetic interferences. Compared to the previous sections, I performed and arranged these materials with slower tuning patterns. I applied a reverb with long dissipation settings, to create a dream-like transition and enhance the spatial depth. In section D, (3:23 – 5:00), my aim was to create an outro that mirrors the feeling of discovery. Rather than arranging broadcast fragments into patterns, this section featured several longform musical and conversational broadcasts. As such, the outro was shaped to evoke the casual scanning of radio: a slower process where one takes more time listen to the broadcast, in order to find something interesting to listen to.

5.1.1: 96-104 for Tape and Vibraphone

After the piece was finished, I used a WAV to MIDI converter to create the basis of an instrumental score. The converter went some way to transcribing the pitches and melodies of my carefully constructed radiophonic phrases. With some tidying up, I created a manuscript for vibraphone and tape. Vibraphone was chosen as the accompanying instrument, due its similar aesthetic to the resonant sounds in section C. The vibraphone parts have to be precisely synchronised with the virtuosic rhythms and melodies of the recording.[81] As such, I created a score featuring conventional notation and a sonogram. It highlights the rhythms included in the recording, parallel to the vibraphone notes.

[81] Adem Hilmi, *96-104 for Tape and Vibraphone* (2018): https://blocki.co.uk/hilmi/65.mp3

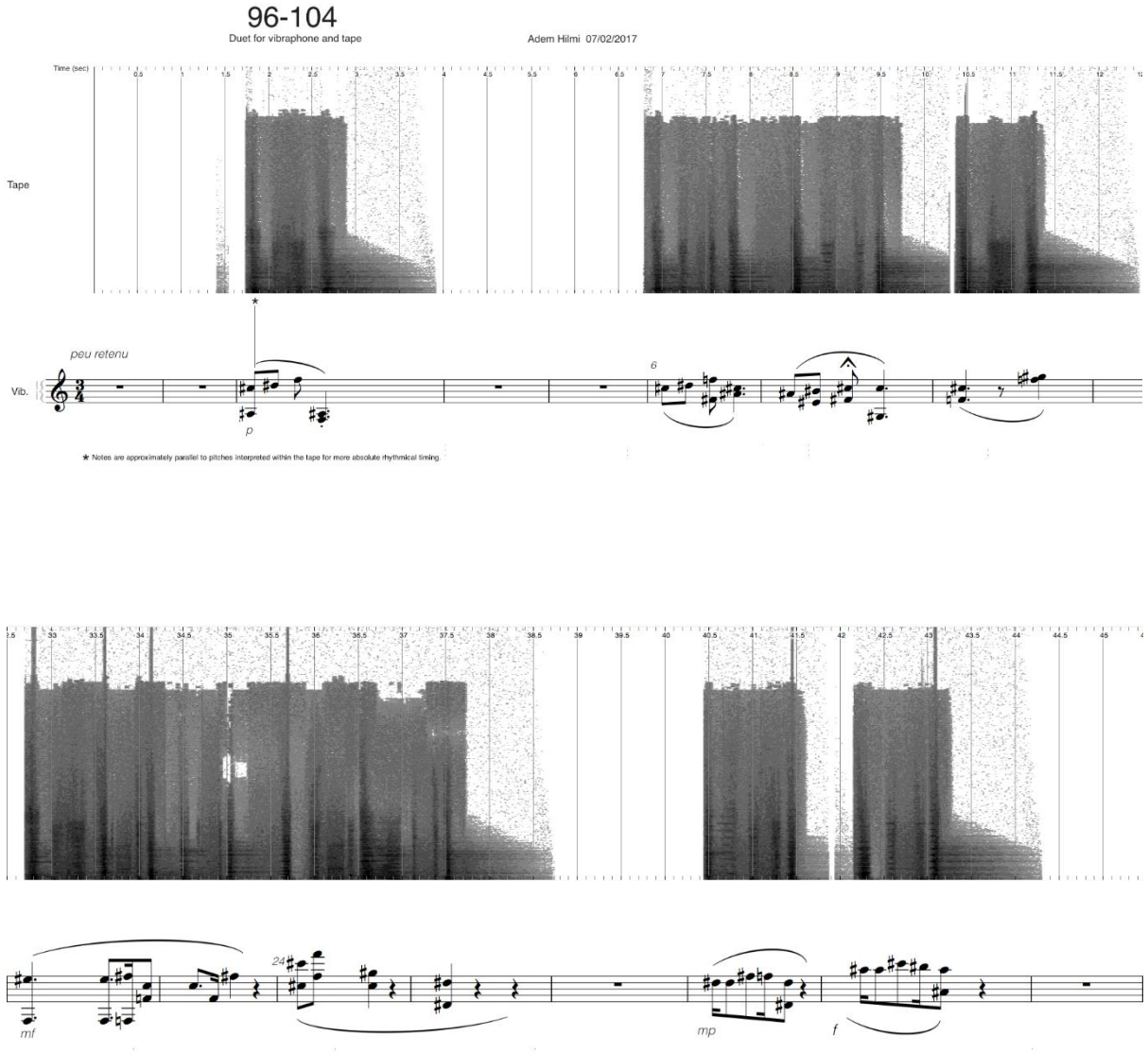

Figure 16: Extract from the score, *96-104: for Tape and Vibraphone.*

5.2.2: 94-104 for Solo Vibraphone

Finally, I have adapted this piece into a solo instrumental work.[82] This arrangement demonstrates the final stage in a long process of reinventing radio, based on its instrumental potential. This early compositional period was the first step in my journey to create a relationship between analogue radio and digital technology. Along the way, I explored this relationship by using a digital audio workstation, to gain a composition control and expression over radiophonic material. It is a process echoed by many contemporary record producers, sound designers and acousmatic composers. As Richard Woznieaks describes in his book, *The Art of Radio*:

> The final project is not a recreation of a previous creative performance but rather a unique creation onto itself, an original performance… Because we can now manipulate time and space during editing, the artist is no longer confined within time and space boundaries (Kostelanetz, 2017. p. 113)

However, it would be foolish to think that the recording medium could ever replace the interactive experience of traversing a radiophonic environment. Furthermore, it does little to address to limitations of analogue radio. Towards the end of writing, *96-108*, I had a desire to extend Section A, with additional melodic motifs. However, when booting up the radio, I was wasn't able to replicate its sounds. The haunting tone of the pitches I threaded together, was lost forever: the brief moment, with its conspicuous morphological shape, had dissipated into the ether. When compositional inspiration becomes squashed, it is awfully frustrating, yet this experience fuelled my ambition to push forward and find a solution.

5.2: Tune-in, Zone-out

Tune-in, Zone-out, is an exhibition piece using five analogue radios. I wanted to build upon my goal of harnessing radiophonic material through digital control. However, rather than repurposing radio sounds, I was more interested in automating the action of tuning a radio. Therefore, my aim was to design a system that would allow me to accurately control a radio's tuning patterns and gestures. I imagined an exhibition of autonomously controlled analogue radios, with their dials rotating back and forth to create a ghostly live collage. When designing this piece, the visual presentation was very important to me. I used five identical non-branded radios that evoke a retro or vintage aesthetic. By concealing the electronics inside the radio, a juxtaposition of old and new was created. The radio's have a distinctive vintage look, yet they are being controlled

[82] Adem Hilmi, *96-104 for Solo Vibraphone* (2018): https://blocki.co.uk/hilmi/66.mp3

autonomously- a feature often reserved for digital mediums. For maximum visual impression, the radio's chosen have a large tuning dial, surrounded by a circular frequency display.[83]

To realise this project, I experimented with an *Arduino* micro-controller. I attached a small servo component to the micro-controller, and created a crude circuit to turn the device on and off. A servo is an electrical component that rotates a motor back and forth in a swinging motion. The servo in this project has a maximum rotation of 180 degrees. This range matched the FPR of the analogue radio. When attached to the dial, a full 180-degree rotation of servo will scan the entire FM spectrum. Next, I needed to create an access point, so a servo could rotate the dial mechanism autonomously. I cautiously detached the radio's circuit board from its frame. This allowed me access to a plastic shaft that slots over the radio's potentiometer. Using a 3d printer, I designed and manufactured a pair of cogs to attach to this shaft.[84]

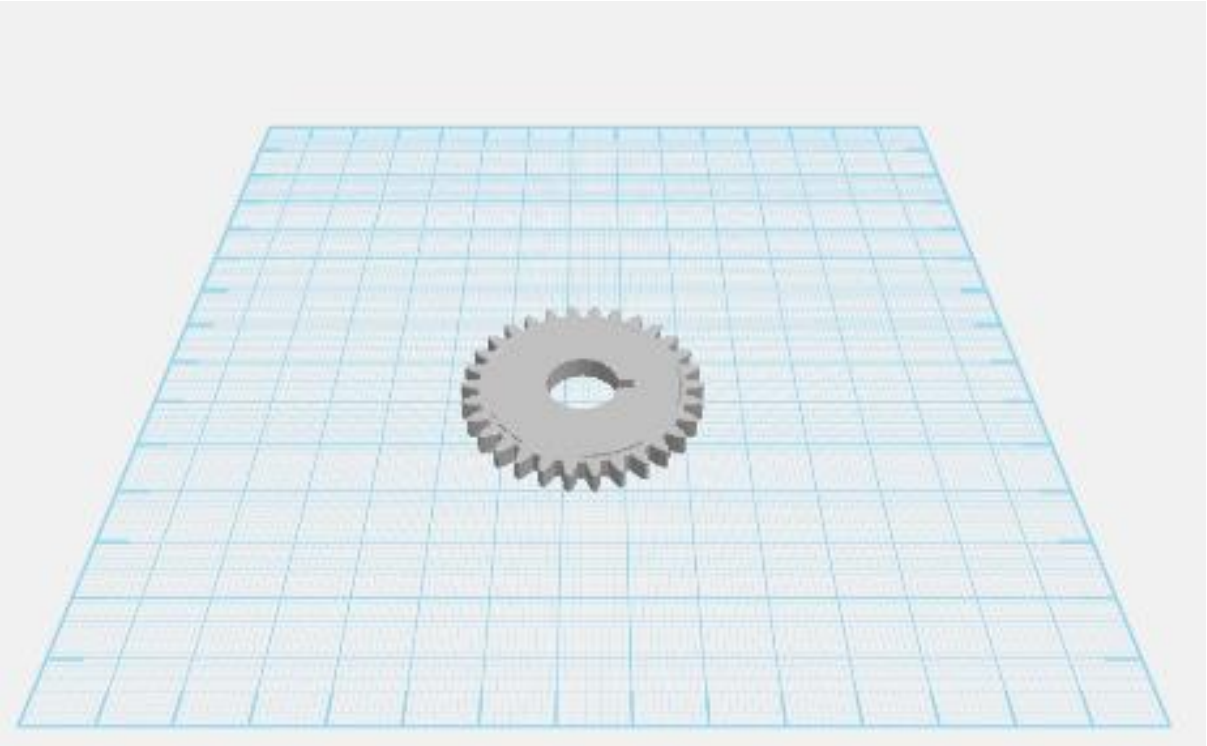

Figure 17.1: Cog 1 (connected to the radio's tuning potentiometer).

[83] Inside the radio (video diary: 15/12/2017): https://blocki.co.uk/hilmi/67.mp4

[84] Testing the 3D printed gear system (video diary: 8/1/2018): https://blocki.co.uk/hilmi/68.mp4

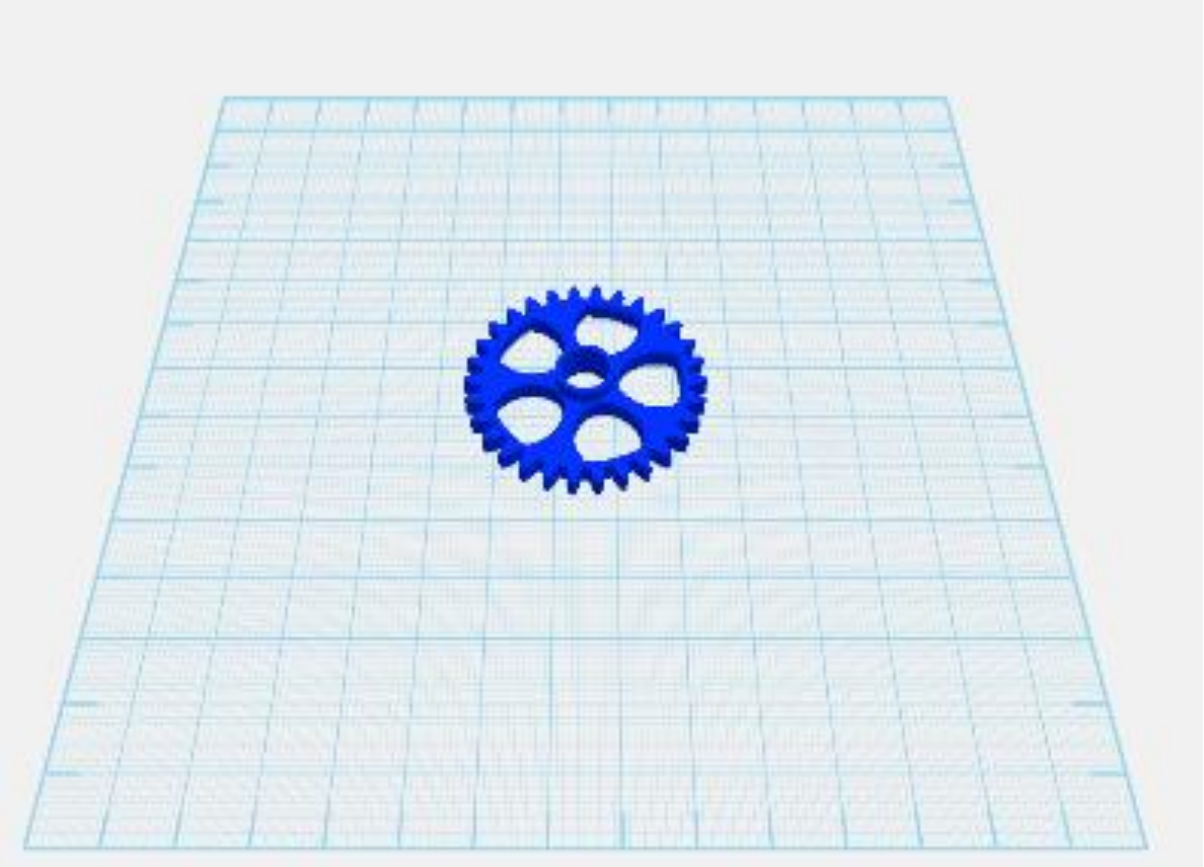

Figure 17.2: Cog 2 (connected to the serve component).

Luckily, there was enough space to secure the servo component onto the exposed cog. I designed a mount for the servo, and screwed the pieces into position.

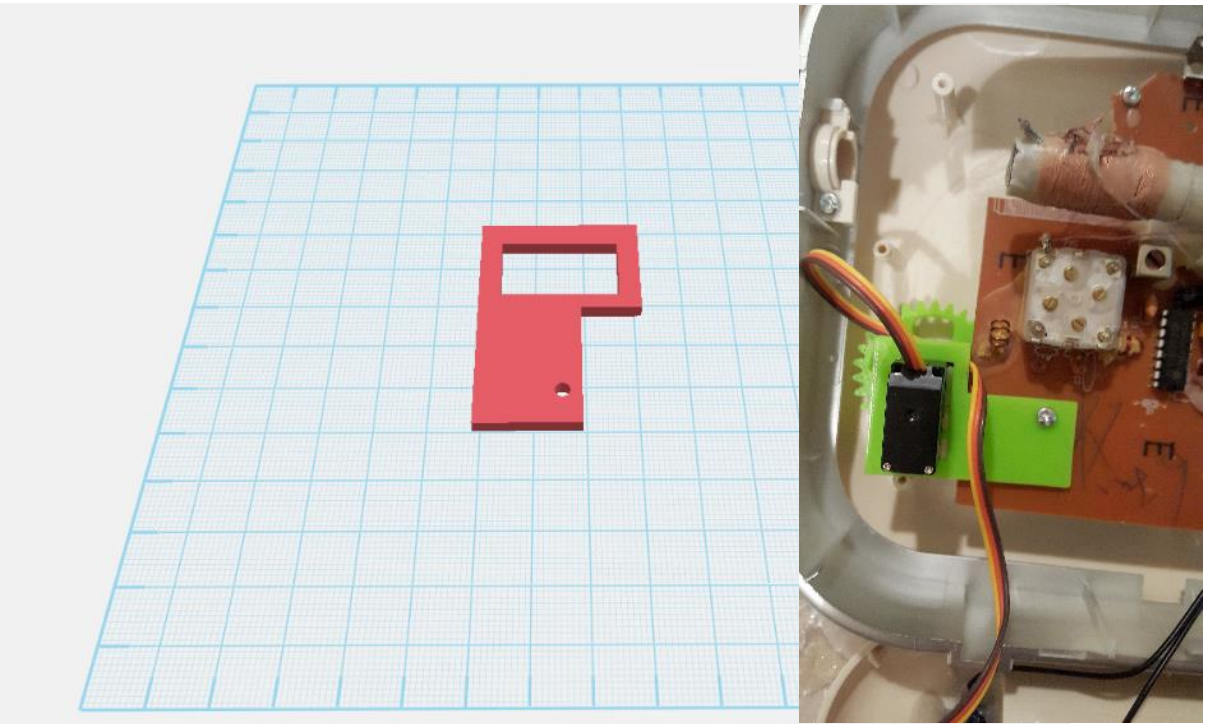

Figure 18.1: Mounting the servo to the outer cog.

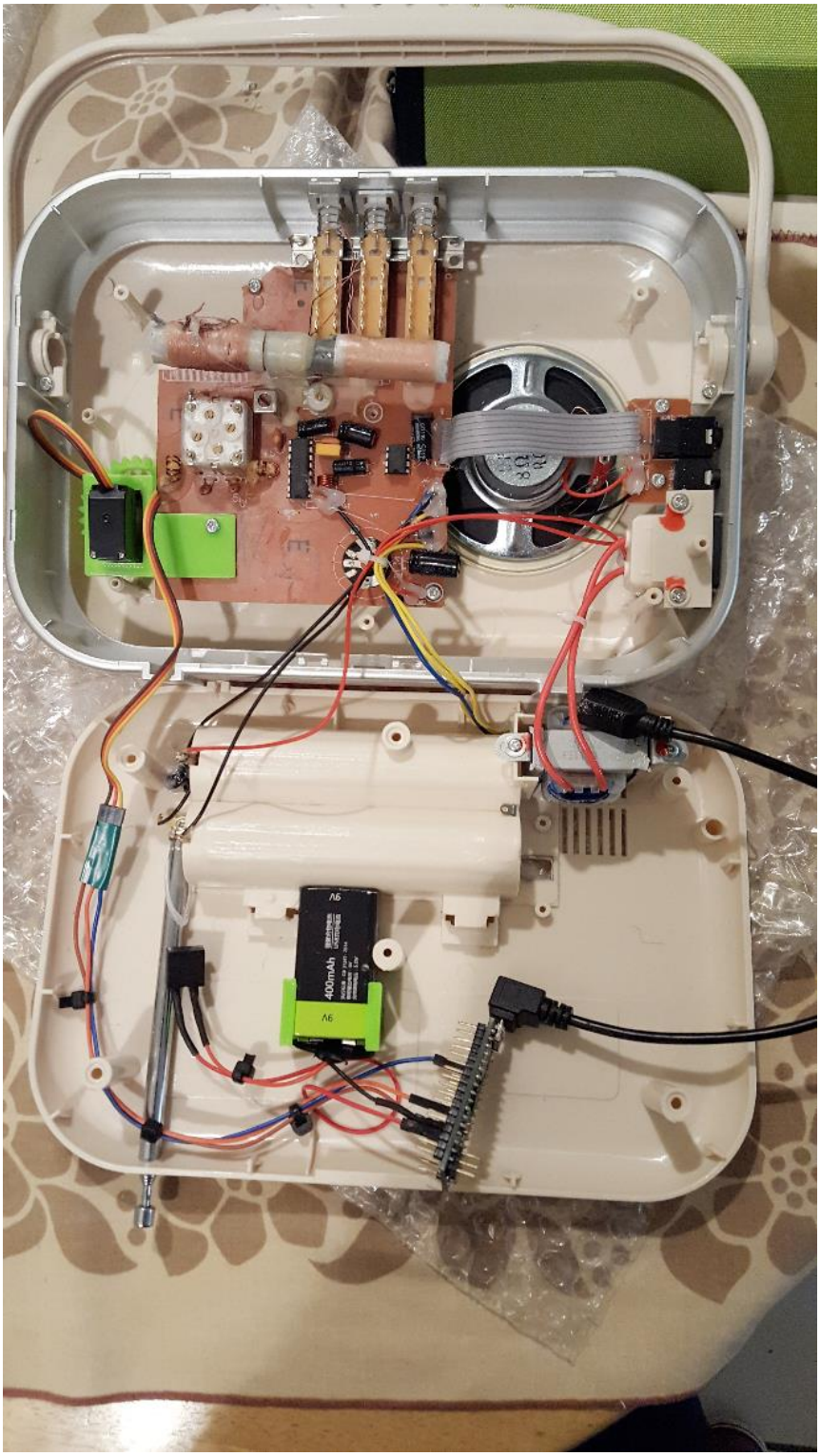

Figure 18.1: Attaching the servo to the micro-controller.

Once the servo was connected to the micro-controller, I programmed each controller, so the servo rotates the radio's tuning dial, in different ways. Through the micro-controllers, I can program the servo's clockwise and anticlockwise tuning positions, and their rotational speeds.[85]

```
1  #include <Servo.h>
2  Servo myservo;
Create a servo object and set how many servos are being controlled (up to 12)

3  int pos = 0;
Set the starting position of the servo by angle (0-180)

4  void setup() {
5  myservo.attach(9);
Set which pin on the controller the servo messages will be sent from (9-12)

6 }
7 void loop() {
The following code will be repeated in a loop

8   for (pos = 100; pos <= 130; pos += 1) {
Rotate the servo clockwise from a set position to an ending position (0-180 degrees),  in steps (1-180 degree steps)

9    myservo.write(pos);
10  delay(250);
Set how long it will take to get through the clockwise rotation (seconds)

11  }
12  for (pos = 130; pos >= 50; pos -= 1)
Rotate the servo anticlockwise from a set position to an ending position (0-180 degrees), in steps (1-180 degree steps)

13  myservo.write(pos);
14  delay(100);
Set how long it will take to get through the anticlockwise rotation (seconds)

15  }
16 }
End of program
```

Figure 19: Programming code for the micro-controller with the variable parameters outlined in italics.

[85] Programming test to evaluate rotational speeds (video diary: 9/1/2018): https://blocki.co.uk/hilmi/69.mp4

Finally, I started shaping the collage. It was a process of trial and error, setting the rotational velocity of each radio, to find interesting radiophonic behaviours and tuning sequences.[86]

On the 13th January, 2018, *Tune-in, Zone-out* was exhibited at *The Sydney Cooper Gallery* in Canterbury. Before positioning the radios on stands around the venue, I had to undergo a tuning process to build the collage. Firstly, I tuned an untampered radio to recognisable music and conversation on the AM and FM bands. I made a note of the frequency and programmed my autonomous radios to scan through it. I also programmed a radio to produce contrasting noise material.

Figure 20: *Tune-in, Zone-out*, exhibited at *The Sydney Cooper Gallery* in Canterbury (13th January, 2018).

[86] Building the collage using the five-radio setup (video diary: 12/1/2018): https://blocki.co.uk/hilmi/70.mp4

The contrast between the untampered, retro looking radio, with the futuristic autonomously moving dial, created a powerful audio-visual aesthetic within the gallery. Furthermore, the self-contained electronics (which included a secret connector to program the micro-controller unit, charge the battery and turn the device on and off), allowed me greater flexibility when positioning the radios around the space. As people walked around the venue, there was an eerie feeling in the gallery. Fragments of stuttering conversations and mismatched beats echoed through the corridors of the gallery. In rare moments, overlapped frequency accentuated one another at different speeds and velocities, creating a fleeting moment of clarity, within the chaos of the collage.

5.3: Goodwin Sans Radiogram

It's the 1950s, the golden-age of radio, and we are broadcasting from a wrecked ship in an undisclosed corner off the English Channel. Whilst the waves outside are fierce, its smooth sailing across the radio waves, and to the comfort of your home. On the show tonight we have stories from the south east, but first, let's go straight a commercial break.

This is the conceptual set of the *Goodwin Sands Radiogram*: an imagined broadcast from a wrecked lightvessel, in the style of old 1950s BBC or Pathe newsreel type programmes. It is named after a sandbank in the English Channel off the south east cost of Kent. It is an award-winning of podcast series by Ben Horner, documenting the hidden lives of people from the south east corner of England. The interviews are pre-recorded, and triggered live using a sequencer by Horner. The show takes residence in the south east (conceptually within 'broadcast range' of the imagined ship) and weaves their stories together using the crackles of radiophonic noise. The artistic impetus behind the programme is twofold: To explore the creative capabilities of the form (referencing old radio sounds but employing a contemporary medium), and to survey the ethnography of the south east (an area prejudicially typified by its bland retirement-home reputation and xenophobic politics). To aid but also blind this artistic concept, is the introduction of a handful of performers. First, the Announcer, acted by 1950s Soho scene relic, Peter Kelly, offers themed insights into (but rarely addresses directly) the interviews' stories). The performers improvise and interpret the spoken word material for the audience in real time. They haven't heard the interviews beforehand, and have no idea on the subject matters touched upon.

In 2018, I was invited to perform as part of Horner's, *Magical Mystery Tour*, the eight episode in his *Goodwin Sands Radiogram* series. My role was penned on the line-up as Radio Operator. I was tasked to generate a range of radiophonic noise, to sandwich the interviews together. Nervously, it was also the debut of my RED and PINK system, used in a live setting. Like past renditions, I was to

privy to any material before the show. Instead, I was given a script that noted my entry and exit points.

01. 'Things were dearer in Australia.'
SAM & OLIVER CRASH on 'fifty-fucking-p'
ADEM radio after whistle. Keep going until after clip stops
ADEM stop

02. 1950s advert
No music
'Still a bit emotional now when you think about it, leaving your family when you're 17'

RADIO BLIP / ANNOUNCEMENT 1 / R DIO BLIP

03. Sam trip – **SAM & OLIVER improv at will**
'Everything I looked at made me think "wow, this is really nice, really good"
SAM & OLIVER STOP

SHORT RADIO BLIP

04. Sam intro
'Very unlikely sort of happy moments just happen to happen'

MEDIUM RADIO BLIP

05. Colin / Dave / Colin
SAM & OLIVER improv AT WILL
OLIVER BYRDS RIFF Colin: 'The Beatles, everyone had a guitar'
'Cos I was out there my parents wanted to come out, and actually it altered everything'
SAM & OLIVER STOP

RADIO BLIP / ANNOUNCEMENT 2 / RADIO BLIP

06. LSD clip / Sam trip – **SAM & OLIVER improv at will**
NEWSPAPER and BALLOONS when mentioned
LEAVE SPACE FOR IMPROV approx. 2 mins?
OLIVER STOP, SAM to continue QUIETLY

07. Madeleine piano
SAM RESPOND

Figure 21: Page 1 of the performance script, with my parts marked out in aluminous green.

I got straight to work, building a custom radiophonic environment within RED for the show. The environment was composed as more of a showcase of what radiophonic noise RED can produce. I split the environment into five segments, with enough space in between each node cluster so I could rest the tuner mark within a silence space. It was important to insert these silence parts into this environment, as there are sections within my performance where I am meant to be noiseless. Uses nine nodes, I designed a range of radiophonic noises, ranging from stuttering, to granulated. Node nine was reserved for a live signal input.[87]

On the 8th February, 2018, the show was performed at Free Range in Canterbury. Performing alongside me, was Peter Kelly (the announcer), Sam Bailey (amplified piano and found objects) and Oliver Perrott-Webb (electric guitar via laptop). Horner stood at the front, conducting us with flash cards, hand gestures and anxious looks! At the start of the show, the audience was warned that this is a live radio recording, so if we have a catastrophic technical failure, we may need to go back and do it again. This gave me a little bit more confidence, as RED had never been used live before. Cheekily, Horner joked, that he will keep everyone until midnight if it needs be, although not after that as the venue closes. The show unfolded with little dismay. [88] My setup included a laptop with RED (hosting the radiophonic environments I built earlier), PINK (which coincidently, fitted awfully well with the 1950s theme) and an interface, radio combo. I used the interface to channel a live signal to the ninth node within my radiophonic environment. It allowed me to introduce an authentic live radio signals into the composition chain. Using this radio, I was able to search for interesting materials to contribute towards the performance. RED gave me the freedom and control to search the airwaves for such material, without the audience hearing. Once found, the signal was locked within node nine within my radiophonic environment, triggered only when tuned, using my gestural controller, PINK.

As per my design goals, my software has given me the opportunity to reproduce this environment consistently. In the case of this event, future showings, the wide range of interesting radiophonic material would be guaranteed. The show ended with no electromagnetic interferences or unwanted radiophonic side-effects, within my signals. As stated in previous chapters, this has always been a problem for radio-based art.

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[87] A video exploring the *Goodwin Sands Radiogram* finished radiophonic environment I composed within RED: https://blocki.co.uk/hilmi/71.mp4

[88] *Goodwin Sands Radiogram*, episode 8, by Ben Horner, Recorded live at *Free Range*, Canterbury, February 8th 2018. Featuring: Peter Kelly (announcer), Sam Bailey (amplified piano and found objects), Oliver Perrott-Webb (electric guitar via laptop) and Adem Hilmi (radio operator): https://blocki.co.uk/hilmi/72.mp3

5.4: Radiophonic Archives

The purpose of sound archives serving radio broadcasting, is to build, maintain and make accessible, a permanent collection of transient material. Radiophonic archives are valuable materials for research within a range of interdisciplinary subjects such as history, politics, music and sociology. They offer a plethora of important categories that document the life around us: events (political, economic, social, sporting), social history and folklore (home conditions, work, leisure, education, customs, traditions), linguistic material (language, dialect and accent), drama and entertainment programmes, music (popular music charts, works unlikely to be issued on commercial records, national music, outstanding performances, live event coverage, sound design, radio dramas, and miscellaneous material for documentary, (reminiscent and general interest programmes), to name a few. The British Library (home to 2000,000 hours of radio recordings dating back to the first decade of broadcasting), has produced a report outlining the developments in radio and audio consumption, in order to consider how it might impact the future of national radio archives. In the 2016 report, *The Changing Landscape of Radio*, Nicky Bird and Dominic Tinley state that radio is becoming more modular, enabling stations to offer personalised content to listeners, based on their needs and interests. The BBC's chief technology and product officer, Matthew Postgate, builds upon this sentiment:

> It's about moving the whole industry away from thinking of video and audio as hermetically sealed, and towards a place where we are no longer broadcasters but data casters (Pennington, 2016).

Bird and Tinley claim that it is based on this redefinition of radiophonic material (data), that radio archives need to evolve. As it stands, radio archives have little interest in featuring the future developments happening within radio. In some way, they follow the strict manifestoes of radio art: to paraphrase, radio art is composed of sound objects experienced in radio space. However, if stuck on this path, radio archives will soon fail one of its most defining features- the documentation of how ordinary people interact and consume radio. Ongoing developments that fall beyond the archive's restrictions may include:

1. Personalised audio: The taxi company UBER is currently developing a computer-oriented audio and podcast curation app:

   > The next time you request a ride using Uber app, a playlist of news stories and podcasts, perfectly timed for your trip's destination, will be waiting for you in Otto Radio. Once your driver has arrived, you can sit back and enjoy your "personally

curated listening experience and arrive at your destination up-to-date about the things you care about most" (Moscaritolo, 2016).

2. Interactive radio like the *Future Radio* project.
3. Immersive audio productions: The BBC have conducted successful trails of a 3D stereo sound for broadcasting.
4. Accessibility developments: Broadcast Bionics and the BBC have been developing automated transcription, to share text versions of broadcasted speech.

In my works, I will be designing interactive radio achieves using recordings from *The Conet Project*. In the creation of this project, I hope to address another problem associated with current crop of radiophonic archives: accessibility. Like most archives, they consist of hundreds to thousands (if not tens of thousands), of materials to search through. These could be recordings, photographs, manuscripts, etc, in a digital or physical medium. They are often hidden in huge databases, accessible on location (for example, The British Library's iconic BBC radio archive, available within their reading rooms), with very little online. Other archives such as, *The Conet Project*, are hosted on obscure websites, often found by stalking dedicated forums. In the following pieces, I have curated interactive archives, allowing the participant to tune into iconic radio sounds. The participant navigates their way through the environments, passing through noise and interference, seeking these long-lost artifacts of the past. This interaction mimics the original experience of tuning to the original broadcasts, providing a compelling presentation of radiophonic archival material.

5.4.1: The Conet Project

We are in the era of hyper-tech encrypted data. Yet I find myself in a cramped room, tables lined with old-fashioned radios with emerald green aluminium caucuses. The room was dimly lit by flickering yellow bulbs, illuminating the frequency markers on the radios. It did little to light the room, yet the atmosphere was lively, the people around me growing in anticipation. The scene was straight out of a black and white 1960s espionage film about the Cold War, although missing the plumes of smoke due to the smoking ban. The clock struck 3pm, and the radio's echoed in synchronisation. 8, 7, 3, 8, 3, repeated again and again: a female voice with an unrecognisable accent. After about 10 minutes, the sequence changed: 6, 9, 4, 1, 0, 7, 5, 8, 9, 8… it felts like they would never end. How did I find myself here? It felt like I fell down one of those YouTube rabbit holes, a string of cute cat videos leading me astray to something more ominous. Yet, there was nothing sinister about the gathering. It was a small event by a small community of espionage

aficionados. They believe sequences like these, are remnants of broadcasts by the world's intelligence agencies, transmitting secret messages to deployed spies in foreign countries. They call these types of stations, Number Stations.

At the apex of the Cold War, radio lovers across the globe started to notice bizarre broadcasts. Sometimes, they would start with short musical extracts, simple melodies or repetitive bleeping. Following this, was the unnerving sound of crudely synthesised/sampled voice or a creepy child. They would recite a string of numbers and letters (often using the phonetic alphabet) in German, English, Russian or Czech. They were broadcast using long and medium frequencies, thus able travel vast distances. Whilst none of the world's intelligence agencies have admitted to using such messages, it has been assumed by the Number Station community that these sequences are codes that can be deciphered using a one-time pad. With great effort, the Number Station community has not been able to crack these 'one-way' messages.

My radiophonic archive, has been made using a collection of number station recordings. It features samples from, *The Conet Project*. This project has documented 150 radio broadcast recordings, from the 1950s until present. A large portion of the recordings are from numbers station. The extracts include: spoken number codes (in a variety of languages), Morse code, short repetitive monophonic melodies, musical extracts, radiophonic noise and unnaturally occurring radio phenomena. I categorised the recordings, based on their musical contents and characteristics.

file name	Sonic character	Instrument	Language	Description	Length
gong station chimes irdial	Distortion, High Compression, Pitch shifter.	Gong Voice	German	7 note melody, 2 short phrases, 3 sections.	3:29
the lincolnshire poacher mi5 irdial	Distortion, Medium Compression, Bit-crusher.	Monophonic square wave synthesiser, Voice	English	13 note repeating pattern followed by English text, 3, 9, 7, 1, 5.	4:37
three note odditiy irdial	Distortion/ Interference High Compression, Flanger.	Monophonic square wave synthesiser, Voice	German	3 note rising scale repeating followed by German numbers.	2:18
dfd 21 irdial	Strong Ring Modulator, Medium Compression.	Voice	German	4 letter repeating phonetic alphabet.	2:37
4 drums and trumpets irdial	Low pass filter, Light compression, Short tape delay.	Trumpet, snare drum	no text	Trumpet melody with marching band snare drum rolls.	2:51
the russian man d-va northern russian voice irdial	Ring-shifter, Bit-crusher.	Voice	Russian	Russian text repeating 5 words in multiple combinations. High pitch ringing in background.	1:35
phonetic alphabet nato irdial	Vocoder / vocal transformer, Low pass filter. Light compression	Voice	English	Phonetic Alphabet consisting of 5 words repeated out of sequence.	0.49
high pitch polytone irdial	High pass filter.	Monophonic square wave synthesiser	No text	2 Sections: 4 slow repeating notes, pointillistic fast patterns.	2.02
the backwards music station irdial	Reverse	Instrumental	No Text	3 layers: High pitch drone with forward momentum, static, low windy sound.	2.30
30 workshop irdial	Enveloper, Low pass filter, Ring-shift modulator	Vocal, Ringing, Static.	Unidentifiable text.	3 layers, High pitch ringing, low muffled voice, Metallic crashes.	2:52

Figure 22: An extract of my classification method.

In the creation of this radiophonic environment, I used the recordings: *The Lincolnshire Poacher, The Swedish Rhapsody, Gong Station Chines* and *Cherry Ripe*. Number Station archivists have given the more recognisable transmissions, colourful names. A famous example is, *The Lincolnshire Poacher,* who's number sequence featured in the above introduction. It was named after the two-bar musical segment featured in its broadcast- the English folk of the same name. I constructed the radiophonic environment using a range of radiophonic textures from *The Conet Project.* The piece features eleven nodes, creating static interludes between the broadcasts. My aim was to create an engaging way to interact and experience this archive, with the participant navigating their way through the piece, like a spy searching for messages on the radio.[89] Upon the completion of my online system, BLUE, I reshaped the environment into an online exhibition. This was an attempted to address my original concern with radiophonic archives (accessibility), as the original piece existed within the physical compounds of RED, contacted my gestural controller as part of an instillation. As with all my compositions hosted on BLUE, the final piece has been optimised on the browsers, Google Chrome and Firefox, using an IOS and Android smartphone. Whilst I prefer users to rotate the virtual dial using their finger, it is possible to access the archive using a mouse on a laptop or computer. Once the webpage has been loaded, users are required to double click the dial image to start. Whilst it is very difficult to optimise an online exhibition for all devices, if no sound is produced, restarting the webpage often works.[90]

5.5: Radiophonic Fragmentation

Last year, I started my first full time lectureship position. As an academic who arrived from industry, it was tough (but very rewarding) keeping up with the weekly demand for new lecture and workshop material. However, I was invited to create a workshop for the second year, computer music technology module, Immersive Audio. The module explored music and audio experiences for emerging technologies, touching upon a range of topics such as: surround sound for moving image, generative music, webcam controllers for interactivity and video game audio design. This was the perfect opportunity to share the construction of a virtual radiophonic environment, using BLUE. The theme of the workshop, was fragmentation. My aim was to inspire students to think about sonic composition in a new way: not as part of a fixed playback environment (like starting and stopping audio in workstations such as Logic Pro and Pro Tools), but as a reaction to movement. Using BLUE, each group will create an online installation, based

[89] A video exploring *The Conet Project Interactive Archive,* RED environment: https://blocki.co.uk/hilmi/73.mp4

[90] Adem Hilmi, *The Conet Project Online Interactive Achieve* (2019): https://blocki.co.uk/B1/index.html

on sounds recorded and produced throughout the workshop. I insisted that the choice and arrangement of these sounds were important. A fast twist of the dial can shape the attack, sustain and release of the sounds, in vastly different ways to a slow rotational movement. Additionally, such tuning gestures have the uncanny ability to thread the samples together. I made a crude MAX patch to demonstrate this concept.[91] Then, I presented a Logic template to record and arrange the sounds within.

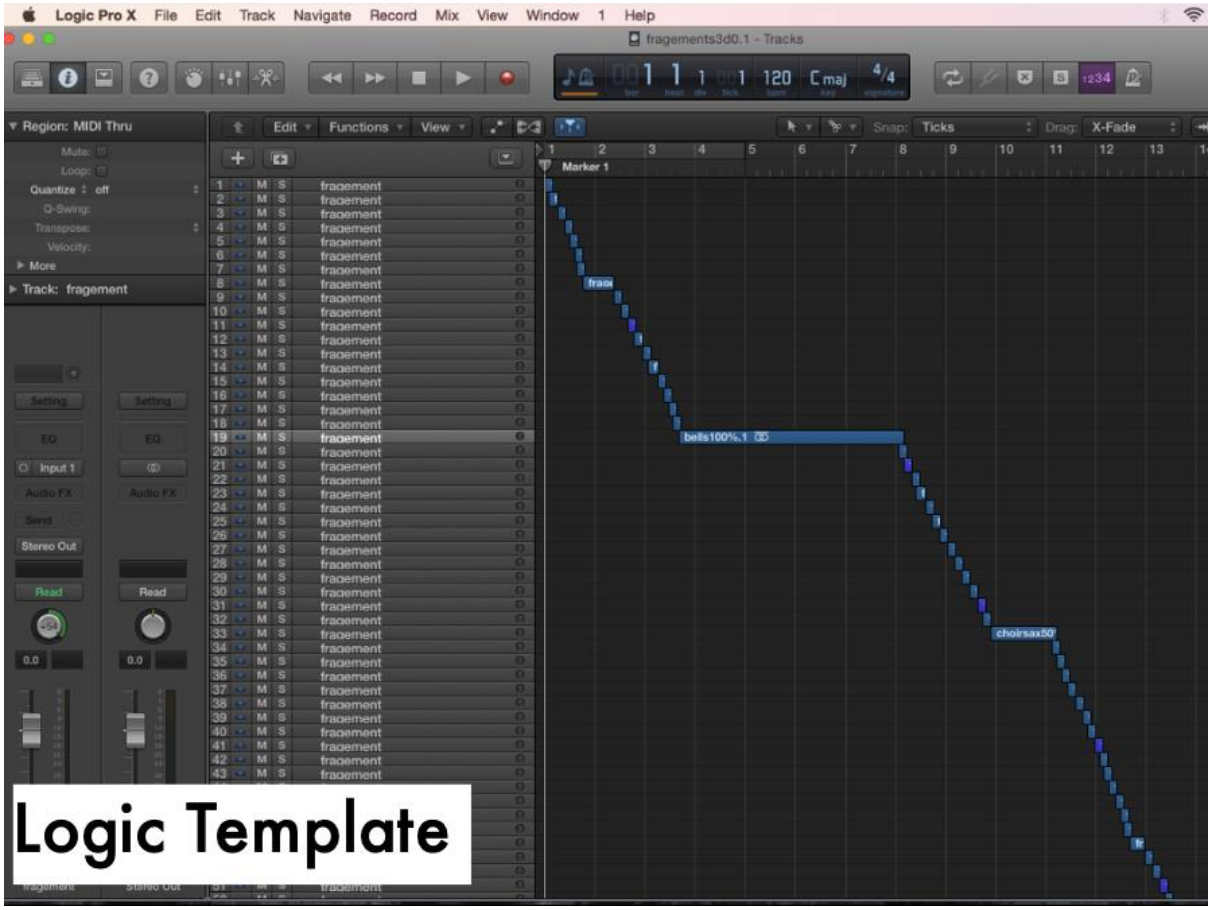


Figure 23.1: Logic Template for exhibition recording session.

As BLUE segments a radiophonic environment into seventy-two equal segments, the composition requires seventy-two tracks of audio to populate each slice. With each click of the virtual dial, a marker cycles through the segments, and triggers the loaded track.

[91] Video of the exhibitions tuning concept made in MAX: https://blocki.co.uk/hilmi/74.mp4

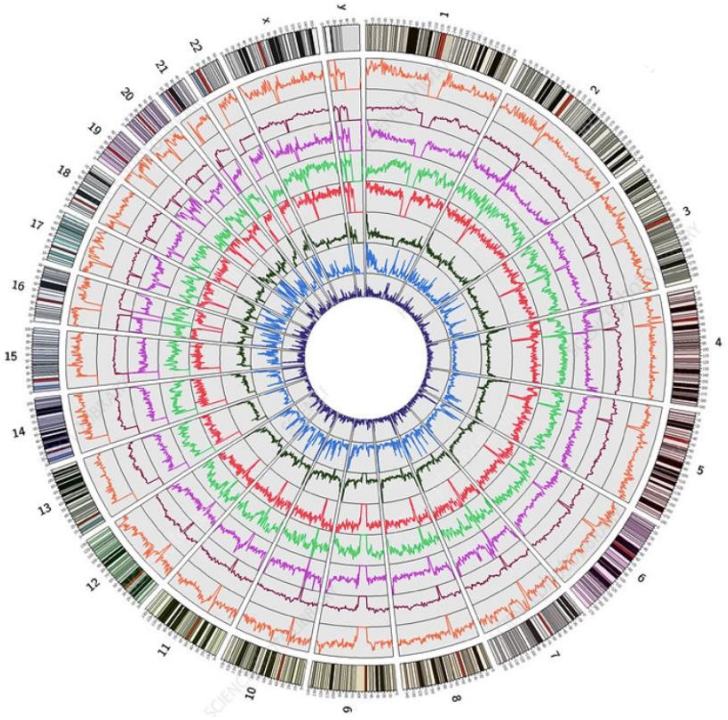


Figure 23.2: Visual representation of audio tracks loaded into each segment.

Once the marker exits a segment, the recording assigned to it is stopped. This functionality allows for creative arrangements of materials. As tuning gestures are performed, materials become connected. The pivoting motion of these gestures, triggers audio from first and last segment. Depending on the rotational speed, the sounds within these segments, become amalgamated into one.

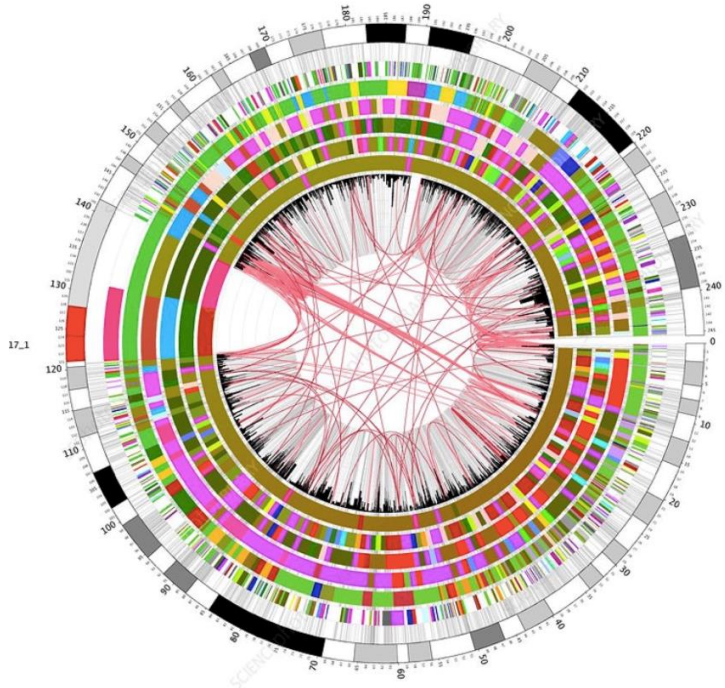


Figure 23.3: Interlocking segments based on rotational gestures.

5.5.1: Dead Air

Using this method, I have created a trio of interactive online works. The first piece, *Dead Air,* uses seventy-two fragments of broadcast noise and broadcast signal. The segments are filled with fragments of varying lengths. This is to avoid a collage of short 'choppy' sequential sounds, encouraging a more interesting performance. This set of exhibitions also feature additional visual settings. By clicking on the right-hand side of the dial, the dial-face will change. I have designed multiple dial appearances, from a graphical interpretation of the material, to a classic radio dial. When clicking the left-hand side of the dial, the dial will cease rotating. This setting works well with the graphic score dial-face (its default appearance). This setting encourages a subconscious connection between the senses- a sensation explored in Chapter 3. It aims to create perceivable resistance on your finger, as you hear the sharp flicker of radio fragments, and swipe over the granulated patterns with your finger.[92]

5.5.2: Donut

The next piece in this trio, *Donut*, is an exhibition using a similar concept. It has been created using a different set of radiophonic fragments, however utalising three-dimensional specialisation. As such, this piece has been optimised using headphones. In BLUE, each fragmented has been assigned a sequential panning position and volume level. As the participant rotates the dial, the fragments encircle the listening space. My aim was to create the illusion of a rotating sound source, positioned in front of the listener. The sounds a manifestation of the users actions, projecting their rotational movements the into an illusionary space.[93]

5.5.3: Attenuate!

The final piece, *Attenuate!,* brings both concepts together. It is an illusionary radiophonic environment where fragments are 'created', rather than 'curated'. This exhibition features longer segments of broadcast signals, transmitting in an eternal loop. A moment of loop however, has been hidden. Rather than present the listener with short fragments of audio, this method aims to influence fragmentation through quick tuning gestures. As such, the signals have been edited and arranged with brief spacings between them. Furthermore, I have manipulated the broadcast noise to have a wide stereo specialisation. As such, radiophonic behaviours created through the process

[92] Adem Hilmi, *Dead Air* (2019): https://blocki.co.uk/B2/index.html

[93] Adem Hilmi, *Donut* (2019): https://blocki.co.uk/B3/index.html

of tuning from noise to signal, starts with a wide presence, and ends with narrow field of view. In a similar way to *Donut*, the specialisation becomes connected to the user's actions.[94]

5.6: Re-Imagining John Cage's Imaginary Landscapes No. 4

On May 2nd, 1951, John Cage debuted his radio work, *Imaginary Landscapes No. 4,* at Columbia University's McMillin Theatre, New York. It was a performance of twelve radios shared by two performers each: one dialling the frequencies, and the other changing the volume and tone. Whilst Cage conducted, the performers followed a score: notes expressing radio frequencies indicated on a conventional five-line staff. According to reports by Alana Pagnutti, in his book, *Reception: The Radio-Works of Robert Rauschenberg and John Cage*, he describes what would have been, a baffling experience for the 1950s audience:

> The initial audience heard bits of baseball news, parts of a Mozart violin concert and many recurrences of the word "Korea". The dial also produced much silence, a result of the piece being performed late at night when many local radio stations had stopped broadcasting. While the audience and critics were both confused and disappointed, the results did not disappointed cage (Pagnutti, 2006. p. 45).

However, this was exactly what Cage had intended. He noted "a piece for radios as instruments would give up the matter of method to accident. […] to increase the unpredictably already inherent in the situation. [chance] provides a leap out of reach of one's own grasp of one's self" (Cage, 1961 p. 63). It is no surprise that Cage became drawn to radio's transitory nature. He celebrated it by writing a range of radio works throughout his career. Pagnutti

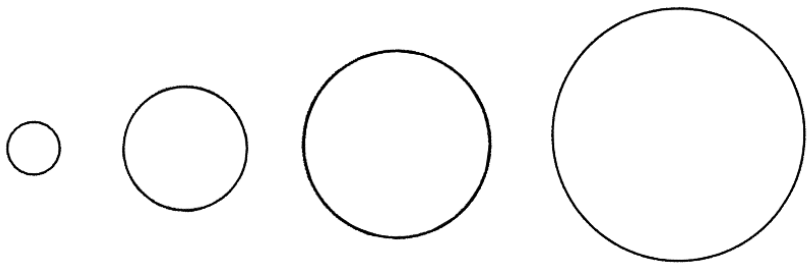
> Inherit in the radio medium is the opportunity for chance outcomes. No two experiences Cage's radio works, compositions will ever sound the sound because of the ever-changing nature of the radio medium. Chance contributes to the open environment and fleeting nature of time however it also removes the authors intention a personality. The author cannot control or choose broadcasts according to his likes and dislike and must follow the radio to function on its own accord ((Pagnutti, ibid).

[94] Adem Hilmi, *Attenuate!* (2019): https://blocki.co.uk/B4/index.html

"The author cannot control or choose broadcasts according to his likes and dislike"- well bring it on! On a more serious note, Cage did have an appreciation of the instrumental-like qualities of radio: "when I was going through the streets or when a neighbour was playing the radio, and so forth, I listened as though I were listening to a musical instrument" (Kostelanetz, 1986. p. 220). This quote fits with my early notion of defining radio as an interment. However, as previously explored by academic Lindsey Vickery, with the decline of AM transmissions, how faithfully could Cage's score be followed? More importantly, if Cage knew his radio works would consist of guaranteed static, would he still consider it a work of chance?

Re-Imagining John Cage's Imaginary Landscapes is a three-part online exhibition, created using BLUE. The first piece is an authentic recreation of a radiophonic environment, similar to the ones featured when Cage was writing and conducting the piece. I used recordings from the *New York Radio Archive,* carefully curating broadcasts from 1951. Each recording was stitched together to create a collection of pseudo radio broadcasts, featuring commercials, news, music and sports coverage. The fictitious stations were assembled within a virtual radiophonic environment, surrounded by static hisses and clicks.[95]

In the conception of this piece, I created a score to interpret Cage's original. The score is available to potential performers, via the exhibition's website link. Dissatisfied with the lack of detail with Cage's scare, I created my own notational system, unique to performing with radio. First, I designed a graphical toolset to represent a radio dial's rotational qualities. These included: dial speed, degree distance, pauses and movement patterns. My aim is to design a system that allows performers to follow the tuning indications with ease. Likewise, it also allows transcriptions of other radiophonic performances for analysis. Whilst the markings are not absolute representations of a performance, they offer enough information to follow different tuning gestures and analyse the characteristics of the dial's movements.



[95] Adem Hilmi, *Re-Imagining John Cage's Imaginary Landscapes No. 4* (2019): https://blocki.co.uk/B5/index.html

Figure 24.1: These symbols indicate a dial rotated 360 degrees from its starting position. The size of the circle indicates the rotational speed of the dial. As such, the first circle is performed faster than the last.

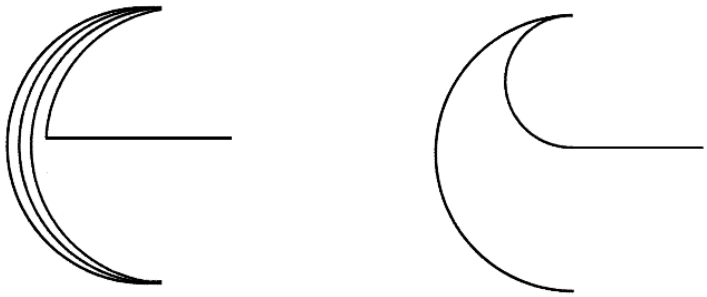


Figure 24.2: On the left graphic, the dial is pivoting back and forth. This can be transcribed as shifting between two frequencies, pivoting over one, or a combination of both indications. The right graphic indicates a 180-degree, slow clockwise rotation, followed by a 180-degree fast anti-clockwise rotation (and then a pause).

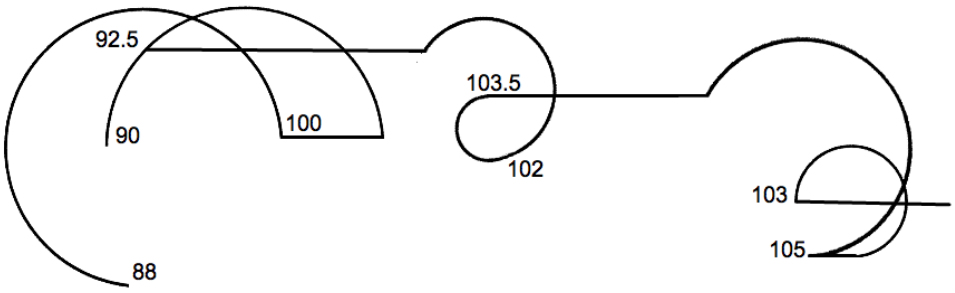


Figure 24.4: An example of segment from a tuning performance score or analysis

The exhibition can be performed with up to 6 phones. If the latter is the case, performers must carefully synchronise the start of the piece, by double clicking the dial at the same time. My graphic score allowed me to manufacture instances of synchronisation between performers. Due to the creation of a custom radiophonic environment, I have noted parts of the score to direct performers to the same frequencies, at specific moments of a transmission.

In the second piece, the 1950s broadcasts have been replaced with their modern equivalent. The new broadcasts, recorded in 2019, are in identical positions to the original, sandwiched in-between the same broadcast noise. Whilst this new environment reflects London in 2019, the content is similar. For example: The 1951 sports commentary is replaced with a Tottenham Hotspurs football match, the ragtime music is replaced with contemporary popular music and the post-war commercials replaced with adverts selling insurance.[96] With that said, I finish my portfolio with a cheeky nod to Cage's iconic piece, 4.33. My version features four minutes and thirty-three seconds of uninterrupted static, pulled live from empty parts of the radio spectrum. After four minutes and thirty-three seconds, the webpage containing the piece closes. In a similar way to Cage, this work is a commentary of the musical potential caused by silent moments, or this case static.[97] In, *The Selected Letters of John Cage*, by Laura Kuhn, Cage writes:

> Dear Helen
> (I typewrite this because the pen is so bad.)
> The piece is not actually silent (there will never be silence until death comes which never comes)' it is full of sound, but sounds which I did not think of behand, which I hear for the first time the same time others hear. What we hear is determined by our own emptiness, our own receptivity: we receive to the extent we are empty to do so (Kuhn, 2016. p. 176).

[96] Adem Hilmi, *Re-Imagining John Cage's Imaginary Landscapes No. 4.1* (2019): https://blocki.co.uk/B6/index.html

[97] Adem Hilmi, *466* (2019): https://blocki.co.uk/B7/index.html

Chapter 6: Conclusion

> You assemble, orchestrate, tie and chime. To have the technique and then have something of history, past and present, to shape and utter it so it haunts listeners with significant meaning for the hour, that is being alive (Sandburg, 1941).

When I started this journey, I was drawn to the vast soundscapes locked behind a radio set. This unassuming box with a unique blend of electronics and physical mechanisms seem more at home within a steampunk dystopia than to a domestic household. Yet, it is a reminder of a simpler time. As I switched on my grandfather's old Bakelite radio, it took a few moments for the valves to warm up and signals to emerge—a precious moment of concavity which the digital technology strives to extinguish on the altar of progress. Analogue Radio is a medium, full of these moments. Tuning relies on physical navigation across an expansive and volatile space. It is characterised through an ongoing struggle between noise and signal as the sound of the cosmos beating down on our earthly transmissions. Although its structure seems outmoded, surplus to fast-paced technological knowledge, nevertheless, it is precisely its archaic nature that enables us to pursue a way forward in compositional advancements. For instance, radio waves are a vital tool used in the exploration space: an industry known for its cutting-edge technology and innovation. Scientists use radio waves to communicate with spacecraft, listen to the universe, and capture planetoid data. In April 2019, radio astronomers visualised the first-ever black hole.

Throughout my research, I aimed to demonstrate how Radio encapsulates extensive opportunities through its inherent characteristics and perceptive qualities. It is this precise charm and malleability that is of interest to radio artists and media scholars. Like binary signals on a computer or the dash and dots of Morse Code, Radio can be used as an instrument for language to communicate ideas. Through my compositional framework and digital audio workstation, I created a system that allows composers and performers to experience malleable Radio. This is important because on a day to day basis, does anyone listen to the Radio? The public generally listens to radio programming, never the Radio itself. Only in unusual situations, do we hear the crackle of static, or dissipation of broadcast signals into noise. In these rare cases, it gives us the potential to understand what Radio is: an idea celebrated and cherished by radio artists. The central premise in my development of RED is to explore the boundless opportunities of Radio in the creation of radio art. RED provides such a platform that values all radiophonic material. However, through the process of its development, a series of pressing questions have arisen. Firstly, what is my identity as a composer? Through the development of my research and portfolio, my artistic identity has shifted between

the realities of authentic radio experience and the postmodern philosophy, hyperreality. Although, I must admit that my background in production influenced the latter. In my studio productions, I strip songs into their essential compositional elements, then rebuild them into hyperrealistic compositions. According to Daniel Levitin, in his book, *This is your Brain on Music: Understanding the Human Obsession*, he describes this perceptive philosophy:

> Recording engineers create what I call "hyperrealities," the recorded equivalent of the cinematographer's trick of mounting a camera on the bumper of a speeding car. We experience sensory impressions that we never actually have in the real world (Levitin , 2006. p. 108).

Likewise, Virgil Moorefield in, *Producer as Composer: Shaping the Sounds of Popular Music*, describes the hyperrealistic work of producers, Phil Spector and George Martin, as:

> Different in many ways, both their approaches to production involved replacing the quest for the ability to present the illusion of physical reality with a new aesthetic. The new sonic world they sought to create was the appearance of reality which would not actually exist- a pseudo-reality, created in synthetic space (Moorefield, 2005, p. xv).

Moorfield's artistic vision is shared by many contemporary popular music producers who realise their craft through the advancement of digital audio workstations.

Through my research, I aimed to deconstruct radiophonic environments into unique elements for composition. Using RED, I reconstructed these elements to form hyperrealistic radio art compositions. As the process of splicing multiple vocals takes into a seamless rendition- one that not just performs the correct tuning, lyrics, and melody- radiophonic material can be carefully arranged to create different compositional intensities and emotions. It is a carefully sculpted pseudo performance, made in the synthetic space of REDs virtual radiophonic environment, or as in the case of vocal production, within the recording medium.

On an analogue radio, complex radiophonic behaviours are not possible to replicate. As such, their perception feels hyperrealistic. These constrain led to the creation of my gestural controller, PINK, and the online broadcast environment, BLUE. Both platforms were designed to have realistic radiophonic interactive capabilities. Composers can use these tools to create radio art that challenges the participant's understanding of Radio. It is an interesting juxtaposition, unique to virtual analogue mediums.

The development phase led me to question the medium that I am using, and what the kind of art that I am creating Is my practice radio art or a hybrid of live electronics, coding, and laptop music? Following my research, I contend that the art form I am creating is radio art. However, when comparing my practice with radio art manifestoes penned by Robert Adrien and Tetsuo Kogawa, it is evident that my claim breaks most of their rules. The most obvious one is the lack of radio hardware. However, through the development of my compositional framework, I have argued that radio art has the unique opportunity to evolve into an art form, unshackled by its technology. It is a framework that fully embraces the characteristics and functionality of analogue Radio. There also seems to be some predisposition towards fully digital music in the radio art practising community. In her book *Re-Inventing Radio: Aspect of Radio Art*, Anne Thurmann-Jajes comments that "works by sound artists or musicians who work exclusively with digital music, for example, are not classified as radio art" (Thurmann-Jajes, 2008, p. 394).

Nevertheless, she also admits that defining radio art is difficult as it exists in an artistically interdisciplinary sphere that includes visual art, experimental literature, and new music. The safest definition, therefore, is to position radio art as a found medium. Nevertheless, due to the continually expanding works that feature cross overs between radio technology and digital technology, I have argued for radio art's redefinition, as an instrumental art form. Rather than dilute the analogue medium, digital practices allowed us to analyse and control radio signals critically.

The redefinition of radio art leads to the question, what is the future of radio art? By following its creative trajectory, I argue that radio art will continue to evolve, repurpose and redefined. It has had growing success as part of an interdisciplinary art form that includes: exhibitions, surround sound installations, and audio-visual art. More excitingly, when unshackled from its analogue form, the potential for future radio art seem boundless. For example, in the SteamPunk inspired award-winning video series, *BioShock*, Radio is heavily featured. The 3D models of radio sets are periodically placed in the virtual world. When interacted, the broadcast triggers a public service announcement and produces an echo throughout the cityscape. They form an integral part of the game's world-building. The game further features the nostalgic sounds associated with analogue Radio. More pressingly, in the third instalment, *BioShock*: *Infinite*, the game has a puzzle in which the Radio sits in the middle of a large room. Its dial is rotated through the interaction with the Radio. There is a remarkable amount of detail and realism within this interaction. Based on the operator's input, the tuner shifts across the radio frequency indicators. Through this interaction, the room begins to spin. Once the desired frequency is reached (indicated by a broadcast signal

rather than noise), one progresses to the next story. Through the new electronic mediums, therefore, Radio can continue to cement itself as a resilient force with a striking presence.

Moreover, I have found that radio art is a useful practice to help teach sound and interactive design. For example, I used BLUE to lecture students on audio fragmentation and morphological threading. Radiophonic material is an ideal substance to describe sonic concepts such as dissipation, granulation, and noise.

That said, can I also speculate upon the future of Radio? As I discussed previously, Magz Hall imagines a world where FM has been 'switched off', "radio after radio" as she puts it (Hall, 2015). She describes this phenomenon as an exciting place to create new work as, "radio has become, as it was at its inception, an open audio space on which anyone can play, provided they have the means to do so, means that are ever more accessible now that people can record and edit work via mobile phones and that a simple micro transmitter is very cheap to make" (ibid). There are also two opposing views regarding Radio's future. The first view is to continue establishing itself away from digital services, as a unique medium to consume music and information. Because, since its beginnings, the Radio's advantage has been its ability to tap into the public's consciousness. It has also developed a strong identity as a safe platform with quality content. Moreover, given Radio's portability, it has the uncanny ability to be anywhere at any time. Finally, the accessibility of Radio occurs in places where other media may have difficulties to reach.

Conversely, there has been a growing consensus by broadcast industry practitioners that envisions a evolving radio, as an integral part of the digital revolution. Applications such as *Future Radio,* seek to create a more customisable and interactive broadcast experience. According to the official body in charge of measuring radio audiences in the UK, *Radio Joint Audience Research* (RAJAR), in future radio listening is likely to be via a hybrid of smart radio devices that switch between the most reliable signals, this being analogue or digital.

All said, it is unclear which path will secure Radio's future. Through my research and experimentation in the development of RED, I have underlined that Radio offers an ideal platform for repurposing within digital practices. Finally, it is an instrument that offers boundless compositional possibilities for radio artists. to paraphrase late Joe Strummer, Radio's feature is still unwritten. If approached correctly, it shall emerge like a caterpillar transforming into a butterfly, a beautiful construct. Conversely, the result may evolve into a faster caterpillar.

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