WHISPER: A NATURE-CENTRED GENERATIVE MUSIC PERFORMANCE

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ABSTRACT

In my research-creation project, I create a digital musical instrument, referred to as Whisper, to investigate the capacity of wind to perform. By integrating principles of digital musical instrument design and generative music, as well as exploring the decolonisation of western classical musical practices, I create a multisensory, site-specific, technology-based performance that highlights the wind as the central performer. The music performed with Whisper consists of two parts, each part using a generative music system that responds to wind speed measurements in order to trigger sound events and create musical notes whose sounds are generated by both commercially available virtual instruments and my own custom-built software synthesis engines. With Whisper, I also investigate the decolonisation of musical practices and emphasise the principle of interconnectedness that exists among all life forms and relationships. Interconnectedness holds significant importance within Indigenous worldviews in particular. I study and incorporate Niitsi'powahsin (Blackfoot language) as a vital component of nature's performance. To guide my exploration, I draw inspiration from the scholarly works and calls to action put forth by Dr. Leroy Little Bear and Dr. Dylan Robinson.

Keywords

Generative music, Indigenous worldviews, Digital musical instrument, Nature-based sound performance

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The supplementary materials consist of two excerpts of generative music performed by the wind on the Whisper DMI and recorded on video, in real-time. The footage highlights the motion of trees and foliage, providing a visual representation of the wind's conditions during the recording. A thorough analysis of the two parts of Whisper music, Embrace and Aohkíí, is presented in Chapter 7.

1. Chapter 1 – Introduction

1.1. Recognition

As a non-Indigenous newcomer, I want to acknowledge that my knowledge of Indigenous heritage is limited, as I arrived on these lands less than two years prior to writing this thesis. I must emphasise that my understanding of Indigenous worldviews is derived from the materials I have studied and my interactions with Indigenous Elders, teachers, and friends during my time in this region. If you, as a reader, lack sufficient knowledge of Indigenous heritage, I strongly advise against relying solely on my insights. Instead, I encourage you to seek guidance from Elders and explore materials written by Indigenous authors to deepen your understanding of Indigenous worldviews.

1.2. Whisper

Whisper is a digital musical instrument (DMI), which is "performed" by nature, and consists of: an anemometer (wind speed sensor), computing infrastructure (microcontroller, laptop computer), a custom-built generative music system, and sound equipment (i.e., audio interface and loudspeakers). More specifically, in my project, I consider the nature of wind. I ask whether nature performs. I draw insights from Indigenous worldviews, and from my personal experiences, and interactions, with the wind. I allow myself to conceptualise the wind as a performer. Importantly, the design of a regular acoustic instrument needs to account for the limitations of the human body. In Whisper, because nature is the performer, the limitations related to the human body are eliminated. However, new challenges arise. See Chapter 6, One sensor, one signal.

The word *whisper* denotes a gentle sound created by exhaling breath without engaging the vocal cords, conveying a sense of quiet and intimacy in communication. Within the context of my project, I employed the concept of a whisper not only to evoke intimacy, but also as an analogy for the sounds produced by wind. I developed Whisper with the intention of creating a meditative experience.

When audience members engage with Whisper music in an outdoor, natural environment, their senses intertwine with their surroundings (See Chapter 7, Whisper music). They witness the synchronised movement of foliage, wind, and music. They feel the wind's gentle touch on their body and listen to music that resonates with these sensations. They experience a fundamental Indigenous principle: Interconnectedness. For further exploration of this principle, refer to Chapter 4, Decolonising Musical Practice.

1.3. Foundational research

In the following section, I provide context and background information that informed my research. This section is organised by chapter.

In From nature to generative music (Chapter 2), I explore how John Cage, David Tudor, and Alvin Lucier incorporated natural processes into their works. I also explore Brian Eno's contributions to generative music. I study the origins of algorithmic thinking and composition, leading to a discussion about generative music. Generative music is created through computer programming, where algorithms dictate programme behaviour; an algorithm might be designed to do a simple task such as transposing a musical pitch by one semitone every second. Generative music is distinctive because it normally does not require human intervention. In the case of Whisper, wind speed readings drive algorithmic processes, influencing the generative music system.

An overview of Digital Musical Instruments is provided in Chapter 3. I consider the principles of DMI design and examine the challenges related to feedback modalities, specifically haptic feedback. I also present various mapping strategies associated with DMI design and showcase examples of DMIs inspired by natural processes – DMIs that may not require a human performer. The concepts and insights portrayed in this chapter provide the groundwork for constructing and developing the Whisper DMI.

In Chapter 4, entitled Decolonising Musical Practice, I begin by highlighting the impact of European colonialism on Indigenous nations. I introduce concepts derived from Indigenous worldviews that are intertwined with nature and human existence. In addition, I focus on Dylan Robinson's *Hungry Listening* (2020) as a central point of discussion regarding the decolonisation of musical practices. For instance, in western musical practice, there are established protocols for performance, such as providing written program notes, specific staging, or spatial, arrangements of performers and their instruments, and as well as customary gestures for both performers and audience such as bowing and applauding. There are also specific norms for experiencing and appreciating music, such as the centring of aesthetic contemplation in musical experience. With Whisper, my aim is to decolonise musical practice, interrogating the role and values of western classical music customs by introducing an approach to music appreciation that situates music within nature – outside, among the trees, grasslands, and rivers – and establishes a direct connection to natural phenomena. The ideas gleaned from my interactions with Indigenous literature, as well as the invaluable advice from of Jackson Leewen (Two Bears) and Camina Weasel Moccasin, informed my thought process while writing this chapter, as well as shaping the conceptual trajectory of my project. I conclude Chapter 4 by highlighting Cree precepts on cyclicity and sentience, aiming to familiarise non-Indigenous readers with fundamental principles from Indigenous worldviews.

1.4. Technology and music

The following section briefly introduces the technological (Chapter nos. 5 and 6) and musical (Chapter 7) outcomes of my project. This section is organised by chapter.

In Chapter 5, I identify the components of Whisper. They include: an anemometer (wind speed sensor), computing infrastructure (microcontroller, laptop computer), software (e.g., programming for the generative music system), sound system (i.e., audio interface and loudspeakers), and physical building materials for positioning the wind sensor. In addition, I discuss the installation of Whisper and the specific location where Whisper was installed.

In Chapter 6, I describe the technical design, development, and application of the generative music system. Entitled "A generative music system built in Max," Chapter 6 contains a comprehensive description of the generative music system, including its various components. I describe: the data processing patch, which includes filtering, smoothing, normalisation, and scaling of data; the control patch, which includes timing and triggering and musical note modules that govern the musical output of Whisper; and synthesis modules which include sample playback as well as audio synthesis within Max[1] and Ableton Live[2].

The influences and goals that shape the music of Whisper are firstly discussed in Chapter 7. Secondly, I describe to two musical parts, or sections, of Whisper: Embrace and Aohkíí. The first part primarily features acoustic instrumental sounds from instruments such as the Dulcimer, Mandolin, and Guitar. I reflect on my selection of instruments, discuss the compositional and

[1] Max/MSP is a real-time graphical programming environment for audio processing. https://cycling74.com/products/max

[2] Ableton Live is a digital audio workstation software that allows musicians and producers to create, record, mix, and perform music. https://www.ableton.com/

temporal structures that I employed, I also discuss the use of modes, and the synthesis aspects of my composition. The second part integrates recordings of human speech with sound synthesis that aims to emulate natural phenomena (e.g., ripping or bubbling water) and highlights Niitsi'powahsin (Blackfoot language), and Aohkíí (water) as central elements, drawing upon the calls to action put forth by Dr. Leroy Little Bear.

1.5. The premiere of Whisper at *-tzintlán*

The music of Whisper was premiered in May, 2023, as part of an event, entitled *-tzintlán*: The World's First Postcolonial Theme Park. The event featured the final projects for graduate and undergraduate students in the course Art 5355, LandMarks, which was taught by Dr. Jackson Leween (Two Bears). Art 5355, LandMarks, is a studio-based course in the Art Department at the University of Lethbridge. The course is designed to facilitate the creation of contemporary art projects in several mediums. It also explores aspects related to Indigenous worldviews and storytelling. The course also enables students to investigate the how history is embedded in the land and how the landscape is a living and embodied archive.

-tzintlán: The World's First Postcolonial Theme Park, was curated by Dr. Migueltzinta C. Solís (2023) and took place from 11 to 13 May. Approximately three hundred spectators attended the event. Dr. Solís' *-tzintlán* is a "creative take-over" of the Fort Whoop-Up replica in Lethbridge, Alberta, on traditional Blackfoot territory. *-tzintlán* explores the history of public spectacles (e.g., exhibitions, fairs, open-air bazaars and circuses, freak shows) for mass society. The western colonial creation of such spectacles is interrogated in *-tzintlán;* the role of the spectacle in shaping an understanding of time, space, and the "other", through racialised, sexualised, and territorialised narratives, is a common thread across all of the projects premiered in *-tzintlán*.

Fort Whoop Up contains living quarters, a kitchen, a trade room, a blacksmith's forge, and saloon (Galt Museum, 2022). The fort also features two bastions, which are towering structures positioned at the north-eastern and south-western corners of the fort. The fort is situated in a grassy river valley, known as Indian Battle Park. Two highways stretch across the river valley, connecting the two halves of the city of Lethbridge. In addition to the six-lane highways, a high level bridge[3] (i.e., The Lethbridge Viaduct), less than a kilometre from Fort Whoop-Up, spans the entire river valley. As trains pass on the bridge, which dominates the landscape, the valley echoes with a deep rumble as the entire structure vibrates, filling the entire soundscape. If one compares this present-day scene to the pre-colonial era, the six-lane highways and high level bridge are distinct features that serve as striking symbols of the impact of colonialism on the landscape.

The reception of Whisper was highly positive with the audience taking a several minutes at a time to listen to nature playing Whisper. Indigenous audience members provided heart-warming comments about the significance of Niitsi'powahsin being heard in the land, which touched me deeply. Whisper provided a contrasting experience to the typical theme park experience, which offers spectacles and intense, artificial, thrills (e.g., rollercoasters, haunted houses). Whisper, on the other hand, encouraged the audience to detach from external human-made stimuli and immerse themselves in nature.

I wish to express my gratitude for the opportunity to share my Master's project. The collaboration with the students in Art 5355, LandMarks, and curator Dr. Migueltzinta Solís was a

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[3] The City of Lethbridge hosts the longest and highest trestle bridge in the world. The bridge was completed in the early 1900s during the coal-mining boom.

transformative experience that allowed me to refine my art-making process and deepen my understanding of expressing Indigenous topics through art. See Chapter 5, Installation at -*tzintlán*, for additional information about the installation of Whisper.

1.6. Chapter summary

In this chapter, I introduced my research project and described in general terms, the contents of my thesis document. I outlined specific research questions which I respond to in the following chapters. Additionally, I described the premiere of Whisper at -*tzintlán*.

2. Chapter 2 – From nature to generative music

In this chapter, I investigate the connection between algorithmic compositional practices and nature. I explore the origins of algorithmic thinking and composition, culminating in the concept of generative music. By providing a contextual framework, I aim to develop understanding of the dynamic interplay between music, algorithms, and the natural world.

2.1. Nature, or natural processes, in the works of Cage, Tudor, and Lucier

According to composer, sound artist and musicologist, Matthew Rogalsky (2010), John Cage, David Tudor, and Alvin Lucier referenced natural processes as a foundational principle in their work. Each composer interpreted nature in their own particular way, however, one common theme that united their works was their use of variability and chance. For instance, John Cage created art that imitated nature using rigid structures that enabled variability. Cage embraced magnetic tape as a medium to permit nature into music, as tape is amenable and malleable, such as in *Williams Mix* (Rogalsky, 2010). David Tudor developed pieces that employed electronic circuits (Rogalsky, 2010). Furthermore, Tudor's compositions behaved like organisms in two aspects. The first behaviour arises as a result of the circuits' highly variable sonic outcomes. The second behaviour is the imbalance that arises when the circuits were modified, causing them to become unbalanced, like an eco-system. One prominent example of Tudor’s work is *Rainforest* (1973), a composition with a mimetic design. The work of Alvin Lucier includes apparatuses or processes that utilised inputs from natural processes (Rogalsky, 2010). In *Music for Solo Performer* (1965), Lucier designed a device and a set of instructions (score). The device was an EEG sensor that captured alpha waves, a natural product of a relaxed mental state. Low frequency brain waves, captured by the EEG sensor, were amplified and used to drive actuators which, in turn, caused various types of percussion instruments to vibrate. The performance required the solo performer to enter a relaxed mental state, which eventually triggered the vibration of the instruments. Another example of Lucier's exploration of nature can be found in *I Am Sitting in a Room* (1969). The piece delves into the resonance of a space and the transformation of sound through iterative recordings. Lucier's voice is repeatedly played back and re-recorded in a room, accentuating the room's resonant frequencies and gradually eroding the original voice, ultimately creating an abstract, spectral soundscape. This piece challenges conventional ideas of composition, shedding light on the importance of the acoustic environment and its interaction with the human voice.

2.2. Generative music composition

In this section, I examine the impact of algorithmic thinking on music composition, presenting examples from artists spanning the 1950s to the present day. I explore how these artists employed algorithmic approaches to challenge traditional models of composition. Additionally, I briefly discuss the concept of generative music, where computer programming generates real-time musical output autonomously, eliminating the need for human intervention.

2.2.1. Algorithmic thinking

The word algorithm is derived from the name of the 9th century mathematician, Muhammad Ibn Musa al-Khawarizmi, who is known for his contributions to the study of Algebra (NASA Earth Observatory, 2017). In a sense, algorithmic music is directly tied to the codification of mathematics and programming languages that occurred in the past millennium (Mclean & Dean, 2018).

Beginning in the 1950s, artists such as George Brecht and La Monte Young used algorithmic thinking – an algorithmic approach – to create works of finite and infinite durations. Brecht’s Drip Music requires a source of dripping water and a container to be placed under it. The piece ends when the source of water is depleted. Young's *X for Henry Flynt* called for chosen musical events to be repeated *x* times, or indefinitely (Mclean & Dean, 2018).

In Xenakis' *Pithoprakta* (1956), the composer utilised an algorithm that represented Brownian motion to determine glissandi speeds for 46 instruments. In physics, Brownian motion, or called Brownian movement, refers to constant random fluctuations of physical phenomena (e.g., random motion of particles suspended in a medium such as liquid or gas). The application of this type of movement by Xenakis resulted in the formation of a complex composition that described a natural process (Doornbusch, 2002). In addition to producing electroacoustic works, the composer transcribed the outputs of his algorithmic thinking into a written form – the music score, which was playable by acoustic musical instruments (Mclean & Dean, 2018).

The US League of Automatic Composers, formed in the late 1970s, created network ensembles such as *The Hub*, and "co-improviser set of algorithms", such as *Voyager*, (Mclean & Dean, 2018, p.8). Both examples highlight a shift towards computers in realising musical materials.

2.2.2. The algorithm in generative music

Generative music is a subset of algorithmic music (Collins, 2008). Generative music is produced with the aid of computers by programming instructions (algorithms) for the computer to perform. A distinct feature of generative music usually includes the production of musical output in real-time with little live human control of the generative music system. In the natural world, (non-technological) generative processes occur regularly. These occurrences include sand dune formations and water ripple motions, for example. An ancient, human-made, example is wind chimes. Wind chimes, or wind bells, are made of resonating objects, and are often seen hanging in Buddhist temples, from trees and veranda porches. Media artist Alan Dorin (2001) argues that wind chimes are "a machine for providing aleatory in composition". A generative music program is somewhat analogous to wind chimes. In this comparison, the designing and building of the chimes is akin to the composer writing the algorithms of the generative system. The wind, which naturally sets the chimes in motion, corresponds to the composer relinquishing artistic control once the generative program is running.

2.2.3. The generative music of Brian Eno

The term generative music was popularised by Brian Eno (Eno, 1996). Eno's fascination with generative music stemmed from the idea that complex results can arise from simple rules. He likened it to *moiré* patterns, which consist of two identical grids, slightly shifted in position, and overlaid on top of one another. The interactions between the two grids are usually unpredictable, and significantly more complex than each individual grid. Eno first developed his composition, entitled *Generative Music 1 (1996)*, using the *Koan Music Authoring System*[4], which was developed by the SSEYO company (Eno, 1996). The software was designed to generate ever-changing music based on one hundred and fifty parameters, which were set by a composer. *Generative Music 1*, released on a floppy disk that contained files to be executed using the *Koan* software. The production, or creation, of a new, distinct, version of the piece each time the files were executed was a significant aspect of the generative nature of the composition. A more recent work of Eno's is *Bloom*, co-created with software engineer Peter Chilvers.[5] Bloom is an interactive, generative audio-visual artwork for the digital tablet. This digital tablet application allows the user to touch the screen and subsequently generate a tone whose pitch and sound

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[4] Koan Music Authoring System: https://intermorphic.com/archive/sseyo/koan/pro/history.html

[5] Brian Eno & Peter Chilvers – Bloom: https://apps.apple.com/app/bloom/id292792586

colour are determined by the location of the touch. Successive touches, or taps, are recorded by the application and then, played back repeatedly in a loop, which gradually changes in timbre and rhythm.

2.3. Chapter summary

In this chapter, I investigated the connection between algorithmic compositional practices and nature, focusing on the concept of generative music – wind chimes served as an early example of how systems can be designed to utilise natural forces to generate sound. I explored how artists like John Cage, David Tudor, and Alvin Lucier incorporated natural processes into their works. For instance, I delved into John Cage's incorporation of randomness as a representation of nature in *Williams Mix* (1953), revealing how order can emerge from chaos. This straightforward application of randomness illustrates the significant impact that random processes can have on music when cleverly controlled. Within my generative music system in Max, I balanced two inputs: randomness via Max's [random] object and wind speed data. Additionally, in the case of Alvin Lucier, I discussed how Lucier's *Music for Solo Performer* (1965) demonstrated real-time augmentation of a natural process through music, portraying an example of real-time control of instruments through sensors. In this work, Lucier crudely translated the ECG data, resulting in a sound that was challenging to control. This contrasts with Whisper, which leverages modern technology and programming techniques to achieve intricate control over the music. With respect to David Tudor, I explained how Tudor's *Rainforest* (1973) showcased a performance-based installation work using analogue technology (i.e., electronic circuitry). Rainforest creates lifelike impressions of a natural soundscape. In the case of Tudor's work, a rainforest was the model. In my project, I evoke the natural soundscape of a river.

Next, in this chapter, I delved into the impact of algorithmic thinking on music composition, examining examples from the 1950s to the present day. With respect to algorithmic thinking, I explored how Iannis Xenakis incorporated nature to shape a musical composition. In *Pithoprakta* (1956), Xenakis employed an algorithm describing Brownian motion, which is a natural phenomenon occurring on a minuscule scale, to yield cohesive musical results that possess both aesthetic and representational qualities that are somewhat scientifically accurate. I drew parallels with Xenakis' literal interpretation of nature; however, instead of mapping the movement of molecules to musical pitch – to be played by human performers, I introduced real-time wind speed data for controlling a DMI, whose generative music system is played by the wind.

Lastly, in Chapter 2, I proposed a link between the origins of algorithmic thinking and the concept of generative music, where computer programming generates real-time musical output autonomously. In particular, I discussed Brian Eno's contributions to generative music, showcasing his compositions like *Generative Music 1* (1996) and *Bloom* (2008) that exemplify the use of simple rules to create complex and ever-changing musical experiences. Generative music represents a new paradigm in music composition, challenging the very notion of composition itself. It operates on an upper layer of the composition process, requiring composers to think of the rules and interactions that govern a composition, rather than crafting it note by note. For example, among the musical note modules that I discuss in Chapter 6, I illustrate the rules and interactions that I refer to as note scattering. The note scattering module gathers pitch values from the outputs of three other separate musical note modules. It then plays this assembly of notes in a manner similar to wind chimes, accompanied by a transposition that corresponds to wind speed.

3. Chapter 3 – Digital musical instruments

3.1. DMI design

The process of designing digital musical instruments (DMIs) entails creating control interfaces equipped with sensors to capture human gestures. This enables the manipulation of sound and music in ways that transcend traditional instrument paradigms (Miranda & Wanderley, 2006). Since the instrumental playing gestures may be separated from the DMI's mechanism of producing sound, DMI design differs from traditional instrumental design. This leads to practitioners recombining sound, gesture, and feedback modalities in novel ways. A DMI normally consists of: a control surface (or input device), a sound generation unit (or synthesis engine), and mapping connections (i.e., paths of signal or data flow). In addition, feedback is a feature of some DMIs (Miranda & Wanderley, 2006). See Figure 1.

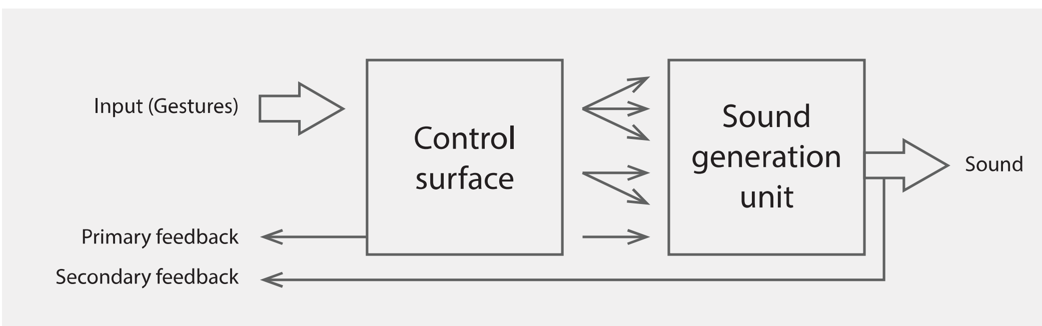

Figure 1: Components of a digital musical instrument

3.2. The challenges of feedback in DMI design

In the human body, our skin plays a primary role in transmitting information about our environment and, thus, the role of the skin (e.g., sensation of touch) must be considered as a source of feedback during the DMI design process. The skin possesses subcutaneous tissues that are distributed unevenly. These tissues include mechanoreceptors and thermoreceptors that transmit information including temperature and physical deformation (i.e., pressure on the skin,

skin stretching, and compression) to the brain. Furthermore, proprioceptors transmit information about the state of one's own body, including information about force expended by muscles and the body's position and velocity (Libretexts, 2022). Generally speaking, this aspect of feedback is referred to as haptics (Marcelo & Wanderley, 2006).

Papetti and Saitis (2018) argue that DMIs usually fail to provide the user with a natural, tangible, or tactile experience due to a lack of haptic cues, which are normally deeply connected to sound. For instance, acoustic instruments produce different types of feedback. Primary feedback often includes haptic, visual, and auditory; for example, the escapement mechanism of the piano provides both haptic and auditory feedback. Similar types of feedback need to be invented for a DMI (Marcelo & Wanderley, 2006). In addition, a primary source of haptic feedback arises from tangible sound vibrations felt through the solid material of, for example, a player's instrument, or the surfaces of a concert hall (e.g., floor, seating). Papetti and Saitis claim that creating haptic experiences between players and their instruments will enhance performance and create a more immersive experience. For instance, the authors have identified the benefits of haptic technologies, such as developing interfaces that guide novice pianists – through haptic feedback – to play the correct succession of notes in a musical composition (Papetti and Saitis, 2018).

3.2.1. Mapping control parameters to sound synthesis parameters

Most DMIs require a complex system that includes multi-layered mapping strategies: primary, secondary, and even tertiary levels of intermediate mapping layers. Furthermore, discrete mapping connections may be classified as: one-to-one, where one control surface parameter is linked to one synthesis engine parameter; one-to-many or divergent mappings, where one control surface is linked to many synthesis engine parameters; and many-to-one or convergent mapping, where many control parameters are linked to one synthesis parameter. Combinations of these connection types are referred to as many-to-many (Miranda & Wanderley, 2006). The process of designing a mapping strategy can reflect a specific interaction metaphor and can be both simple and complex (i.e., a combination of classifications: one-to-many, many-to-many, etc.). It is worth noting that complex mappings may outperform simple ones. In addition, research has revealed that multiparametric control surface enhance real-time control and are more engaging for users (Hunt and Kirk, 2000). For instance, examining acoustic musical instruments reveals a complex many-to-many mapping scheme. They feature superior interaction capabilities when compared to DMIs, as their input and output variables are physically interconnected in a complex and non-linear manner (Miranda & Wanderley, 2006).

3.2.2. DMIs and natural processes that draw from nature (nature as performer)

The examples presented below showcase DMIs or installations that harness information derived from natural processes. Certain examples necessitate human interaction to trigger their activation, while others rely entirely on nature's agency for their operation.

Global String by Atau Tanaka and Bert Bongers, in collaboration with Kasper Toeplitz (2000):

Global string is a multi-site network music installation that consists of fifteen-meter-long metal strings that are distributed in more than one location. Each string is connected to a vibration sensor that transmits vibration data through the network, which is then translated into music via a sound synthesis server. Players strike the string at one end of the network, and the resulting vibration is acquired, translated, and generated in another location at the other end of the network. In this installation, the network acts as the instrument’s resonating body (Miranda & Wanderley, 2006).

Electrical Walks by Christina Kubisch (2003):

Electrical Walks, an ongoing project by Christina Kubisch, invites participants to embark on an exploration of urban environments through the translation of electromagnetic fields to audible sound. Equipped with special headphones that capture electromagnetic waves through built-in coils, and guided by maps marking interesting electrical phenomena, visitors can engage in immersive city walks that reveal hidden sounds generated by sources such as communication systems, lighting, surveillance devices, and more. The resulting sonic experiences encompass a rich tapestry of musical tones, rhythmic loops, subtle signals, and ever-changing compositions, with each location possessing its own distinct sonic character. Through this ongoing work, Electrical Walks offers a captivating way to investigate and engage with the unseen electromagnetic fabric of our surroundings (Kubisch, 2003).

Pebble Box by Sile O'Modhrain and Georg Essl (2004):

The Pebble Box is an instrument that controls a granular synthesis sound generation module by measuring granular material (e.g., pebbles) in real-time through an inlaid actively powered microphone. The microphone "senses" sounds from the pebbles, which are placed inside a box. The user interacts with the pebbles using their hands. The sounds that result of this action are analysed to extract granular synthesis engine parameters such as grain rate, amplitude, and density (O'Modhrain and Essl, 2004).

Cloud Piano by David Bowen (2014):

Cloud Piano is an interactive installation that translates the movements and forms of clouds into musical notes played on a piano. Using a camera aimed at the sky, the installation captures real-time video footage of the clouds. This video is then processed using Max, which controls a robotic mechanism that presses the piano keys corresponding to the cloud patterns. As the clouds drift and transform across the sky, they activate the piano notes (Bowen, 2014).

The Space Between Us by Joel Eaton, Weiwei Jin, and Eduardo Miranda (2014):

The Space Between Us is a performance piece that utilises a Brain-Computer Music Interface system to measure the brainwaves of one performer and one audience member. The system generates a real-time score based on emotional features derived from the brain signals, aiming to portray and induce emotional states through music. The performance uses electroencephalogram (EEG) recordings to measure valence and arousal, mapping them to pre-composed musical phrases that contain associated emotional content. The piece consists of three movements, with the first two led by the emotions of each individual and the third movement combining their responses. This work showcases the potential for neural-emotional manipulation in live performances and presents a novel approach to affectively–driven composition in real-time (Eaton et al., 2014).

3.3. Chapter summary

In this chapter, I describe DMI design and showcase its components, specifically addressing the challenges related to feedback. I provide examples of DMIs that harness natural processes as input. DMI design served as the foundation for the creation of Whisper, a DMI intended for wind performance. During the development of Whisper, I extensively studied the behaviour of wind, just as DMI designers observe and analyse human gestures. It is worth noting that wind naturally generates a diverse array of sensory feedback, encompassing somatosensory, visual, and auditory experiences. Consequently, I took great care to incorporate these feedback types into the design process, aiming to make the relationship between feedback and Whisper music palpable.

Additionally, I showcased five DMIs that augment the relationship between feedback modalities and sound – a central concern of my own research. For example, *Global String* (Tanaka, 2000) uses the World Wide Web to transmit tactile vibrations of a steel rod onto another steel rod that is placed in a different geographical location on the earth's surface. Additionally, the Global String DMI virtually emulates the natural phenomenon of sound using a sound synthesis server. *Electrical walks* (2003) features a DMI that sonifies the electromagnetic forces in the vicinity of the portable device. During this experience, the audience is equipped with a map delineating magnetic landmarks, guiding them on exploratory walks to uncover concealed electromagnetic forces emitted by prevalent electronic equipment in urban environments (e.g., elevator car controls, ATMs, escalators, slot machines, outdoor television displays). *Pebble Box* (O'Modhrain and Essl, 2004) utilises the sound that arises from the physical interactions among granular materials to control a granular synthesis sound generation module. This DMI places somatosensory feedback from granular materials at its core, making it a central element within the context of a control surface. *Cloud Piano* (Bowen, 2014) captures the image of clouds (i.e., visual feedback) on a video camera and translates the video information into musical notes on a physical piano using actuators. In *The Space Between Us* (Eaton et al., 2014), an EEG sensor is used to measure human emotions. A computer program then maps these emotions to pre-composed musical phrases that represent them. This performance piece places human emotions at the forefront, making them a fundamental element of the music.

4. Chapter 4: Decolonising musical practice

When I first set foot on this land, the visible impact of colonialism on Indigenous communities, both historically and in the present, left a profound impression on me. Despite the significant systemic violence they endure, I couldn't help but notice a notable absence of widespread empathy towards their struggles. I felt an innate urge to stand in solidarity with them.

In this chapter, I introduce concepts from Indigenous worldviews that are related to nature and human existence. The reason for this is threefold. Firstly, I have a duty as a visitor and as a current resident of Niitsitapi (Blackfoot) territory to support the Indigenous people of this land. Secondly, I want to emphasise the importance of the Indigenous knowledge that has informed my thought process, as prompted by prominent Niitsitapi scholar, Dr. Leroy Little Bear (see Chapter 4.2). Thirdly, I wish to empower my own worldview, as well as my artistic expression and practice, through Indigenous worldviews.

4.1. European colonial contact

Indigenous nations in the present-day Americas were nearly erased by European colonial contact. Since the 1400s, the Americas have faced massive waves of immigration, the extraction of resources (e.g., furs, gold, salmon, coal, oil, etc.), and colonial expansion through land seizures (Robinson, 2020). The colonial states imposed a westernised "re-education" of the Indigenous populace. This included taking people from their towns and villages, relocating them to boarding and residential schools, and forcing them to conform to western culture, religion, and language. Re-education practices included "adopting out," or in other words, the kidnapping of Indigenous children and fostering them with non-Indigenous families and communities (Perea, 2011). Furthermore, colonial contact resulted in multiple approaches for dealing with Indigenous heritage. One approach was to erase and replace it. Another sought to document and preserve the heritage in museums (Robinson, 2020).

4.2. Indigenous metaphysics and interconnectedness

In Niitsitapi (Blackfoot) philosophy, "all things are animate, imbued with spirit, and in constant motion. In this realm of energy and spirit, interrelationships between all entities are of paramount importance, and space is a more important referent than time" (Little Bear, 2000). To truly grasp knowledge from these concepts, one must engage in holistic observations. A holistic worldview recognises the interconnectedness and interrelation of all things. These connections form the very fabric of existence, constituting a greater whole. From the human perspective, these connections manifest as readily discernible patterns, such as celestial arrangements in outer space, seasonal variations, animal migrations, and the life cycles of plants. Moreover, within this worldview, the Earth occupies a special position as the site where flux can be observed and where continuous cycles of creation unfold (Little Bear, 2000).

The term metaphysics finds its origins in the Greek expression *meta ta physika* meaning "beyond the things of nature," referring to that which surpasses nature and human perception of it (Oddie, 2018). Metaphysics delves into the fundamental nature of reality. As cultures progress and evolve, participants within a culture develop specific metaphysical frameworks shaped by ideology, religion, science, and principles. Metaphysics becomes ingrained within individuals, forming the bedrock of their cognitive processes and finding expression in their thoughts, behaviours, relationships, and societal structures. In 16th-century Europe, a notable epistemological revolution unfolded as commoners turned to measurement and pure reason as sources of knowledge due to limitations in accessing certain types of knowledge. This paradigm shift continues to exert influence on contemporary thought (Little Bear, 2016).

Little Bear (2016) asserts that western science often disregards concepts that defy empirical measurement. Theories that propose ideas related to spirituality, uncertainty, and the transgression of western European convention, are dismissed. Describing Indigenous principles, Little Bear highlights its focus on wholeness, spirituality, flux, energy waves, relational networks, and renewal. He emphasises that all individuals are interconnected within an ecological relational network. Furthermore, Little Bear encourages the exploration of language as an avenue to develop alternative interpretations and understandings of Indigenous metaphysics, fostering the enhancement and evolution of our current thought processes.

4.3. Exploring Indigenous epistemologies in sound and music

Xwélmexw (Stó:lō/Skwah) artist, curator and writer, Dylan Robinson (2020), observes that Indigenous musicians and their songs are often regarded as resources for multicultural "enrichment", but they are not fully integrated into the dominant norms of western art music. Western musical practices tend to overlook Indigenous logics and structures. However, for Indigenous artists, these structures serve as functional ontologies, providing ways of understanding various aspects of life, such as law, medicine, or history, through songs. Robinson poses the question, "What if classical music performance embraced Indigenous logics and served one of the many functions that Indigenous songs do?" (Robinson, 2020). He argues that we need to move beyond settler colonial structures in musical composition, presentation, performance, and listening. Within the context of a musical performance, western sense orientation presents music as an object to be interpreted. According to Robinson, this establishes an asymmetrical relationship between the subject (the performer) and the object (the music to be performed). On the other hand, from the Indigenous perspective, this subject-to-object relationship lacks ethical responsibility and contradicts Indigenous logics. Robinson (2020) argues for the reorientation of this encounter to a symmetrical subject-to-subject relationship, thereby giving sound life and agency. In his reframing of this paradigm, listening to sound and music is transformed to an experience that is akin to a face-to-face encounter with another human being.

4.3.1. Hunger

Dylan Robinson refers to western forms of perception, specifically audition, as "hungry listening" in his book that bears the same name. The word "hungry" emerges from the settler encounter with the Stó:lō people in 1858, in which thousands of men arrived by sea in a physical state of starvation, and with a hunger for prospecting for gold. Robinson states that "it is an understatement to say that this hunger for resources has not abated with time. [Settler] hunger may have begun with gold, but it quickly extended to forests, the water, and of course the land itself. In the twentieth century the hunger has grown for Indigenous artistic practice." For example, in the context of western art music composition, some scholars and artists attempted to extract and appropriate Indigenous heritage to achieve a national aesthetic (e.g., works by John Ralston Saul, Ernest Gagnon, R. Murray Schafer); while others isolated its processes for use as a compositional resource, breaching Indigenous protocols in the process (Keillor, 1995 as cited in Robinson, 2020).

In music compositions that aim to merge Indigenous cultural practices with western art music, many composers have failed to achieve a genuine integration of Indigenous cultural practices. For example, in *Viderunt Omnes* (1999), Christos Hatzis incorporated recordings of *kattajaq* (Inuit throat games) without revealing the underlying cultural significance or providing translations for the text. Furthermore, he acknowledged that his choice was based solely on its musical fit within the section, exposing an extractive approach. In this, and most cases, composers disregarded improvisational play and flexibility, which are vital for the inclusion of

Indigenous performers. Instead, composers imposed strict musical time that Indigenous performers needed to follow, despite the availability of aleatoric methods in western art music practice (Robinson, 2020). This format prioritises the comfort of western art music performers over the meaningful inclusion of Indigenous cultural practices, exemplifying what Robinson refers to as "symbolic violence."

4.3.2. The act of listening:

Western forms of perception often highlight the listener as the sole subject in the act of listening, while sound is objectified and analysed. For example, in a concert setting, the act of listening is often shaped by program notes, marketing, reviews, and so on. This creates an asymmetrical relationship between listener and sound, or a subject-object relationship. This is contrary to Indigenous frameworks of perception, where symmetrical subject-subject relationships are the norm. Subject-subject relationships shift the focus away from positioning the listener as the sole subject in the act of listening, instead acknowledging the life and agency of sound itself (Robinson, 2020).

To Robinson, we have become absorbed in our hungry listening practices that centre around aesthetic contemplation and theoretical analysis. Indigenous perspectives on song necessitate a change of approach; one needs to reconsider the nature of what they are listening to, and the act of listening itself. Stó:lō siyám Joann Archibald highlights the significance attributed by Elders to the act of listening with "three ears: two on the sides of our head and the one that is in our heart" (Archibald, 2008 as cited in Robinson, 2020).

By undertaking a comprehensive deconstruction of western (and other) listening practices, Robinson urges us to contemplate the essence of Indigenous song. This approach illuminates a path toward understanding Indigenous heritage. In one of his observations, he notes: "…hungry listening prioritises the capture and certainty of information over the affective feel, timbre, touch, and texture of sound. Attending to affect alongside normative listening habits and biases allows us to imagine (or audiate) otherwise – to develop strategies for different transformative politics of listening that are resurgent in their exploration of Indigenous epistemologies, foundations, languages, and sensory logics; or ones that are decolonial in their ability to move us beyond settler listening fixations" (Robinson, 2020).

4.4. Cree precepts according to Carl Urion

During a conversation between Carl Urion and Elder Walter Lightning from Samson Cree First Nation, they highlighted the significance of foundational Cree precepts for observing interconnected natural systems and the understanding that everything in nature is interconnected and "singing." (Urion, 2022) Recognising the gaps in scholarly literature on Indigenous singing and music, they suggested exploring the contribution of Indigenous teachings for a more comprehensive understanding.

In the late 1990s, discussions were prompted by the approval of a proposed coal mine in an area known for its unique medicines, designated as both environmentally and culturally sensitive. Elders Gordon Rain and Walter Lightning, along with scholar Carl Urion, aimed to holistically integrate Cree precepts and protocols, alongside science-based approaches, into environmental assessments, demonstrating the principle of interrelationship and clarifying the implications of the government's decision. Urion (2022) employed these precepts as a framework in his study on the history of gospel music. He recognised the difficulty of categorising the insights stemming from these principles. Instead, he immersed himself in a range of musical and sonic landscapes, encompassing live performances and recorded compositions, over an extended period of time.

Embracing a holistic approach that combined the teachings of the elders with western musicological traditions.

From an Indigenous perspective, Mr. Rain affirms that the observation and analysis of nature should focus on identifying cycles to gain a deeper understanding. The principle of balance, integral to Indigenous thought, is viewed as a dynamic process rather than a static state, emphasising the reciprocal relationships within these cycles. Additionally, Mr. Lightning's work, *Compassionate Mind* (1992), highlights the significance of sentient experience in unifying emotional, cognitive, physical, and spiritual aspects, establishing a foundation for comprehending Elder discourse.

I have summarised the precepts and presented them in point form for clarity.

About cyclicity:

- Look for cycles when attempting to understand nature. Examples of cycles include movement of a bird’s wings; orbits of planets around stars; orbits of subatomic particles; continental drifts; formation of rocks; seasons; heartbeats; and audible sound (sound waves).
- Look for entrainment (interdependent relationships) among the cycles you observe. Examples of cyclical entrainment include the relationship between heartbeats, breathing, and walking.
- If cycles are in complete balance, the system will stop, and if they are out of balance, the system will collapse and decay.
- Cycles move in and out of sync (entrainment) with other cycles and their balance only exists as a process – not a state.
- Cycles stretch over a long span of space-time – from Planck-time (i.e., Subatomic oscillation) to eons (i.e., Geological formation).
- There is an implausible abundance of cycles in the medium in which we exist.
- The Creator established four unexplained relational sources that govern the behaviour of cycles (Urion, 2022).

About sentience:

- When a person experiences something, their experience can be semantically organised into four domains: the emotional, cognitive, physical, and spiritual.
- A sentient experience (i.e., "feeling") consists of a unity of these experientially indivisible domains and resonates within them. For example, "feeling" is the resonating phenomenon

among the many different aspects of the act of singing (e.g., embodiment, audition, acoustics, meaning, prayer, place, repertoire).

- The resonant sentience in the four domains manifests as consciousness.
- Musicking is one way of attempting to conceive balance among the domains. Music does not bring the four domains together because they are essentially unified; however, music is a way of experiencing this unity (Urion, 2022).

4.5. Chapter summary

In this chapter, I respond to Indigenous calls to action by prominent Indigenous scholars and emphasise the importance of decolonising musical practices and forms of perception, and the need for us to reconsider what listening is. Furthermore, I discussed symmetrical and asymmetrical relationships among listeners and music, and their impact on the orientation of western and Indigenous worldviews. For example, subject-object relationships are prevalent in non-Indigenous worldviews, and in this context, music becomes an object to be interpreted. However, in Indigenous worldviews, subject-subject relationships are the norm, therefore, the relationship between listener and music becomes identical to a relationship between two humans. In Whisper, I nurtured subject-subject relationships by developing a DMI and generative music system that transforms music into a representation of nature, fostering a deeper bond between the audience member and the wind. In my perspective, this approach empowers the concept of interconnectedness, where all relationships are regarded as subject-subject interactions.

I answered the calls to action that I presented in this chapter with the Whisper DMI, where I ventured to challenge conventional musical performance and composition by delving into nature's performance and representation within these creative processes. For example, in one part of Whisper music (see Chapter 7), entitled Aohkíí, I strived to achieve a genuine integration of Indigenous cultural practices by creating a narrative that shows a relationship between a Niitsitapi teacher and a non-Indigenous learner. I then literally embedded this relationship in a musical composition. Generally speaking, in response to calls to action, I attempted to develop strategies for transforming the act of listening into a political statement by incorporating the wind within a musical performance; for instance, listening to the performance is accompanied by somatosensory feedback produced by the sensation of wind on the skin.

In this chapter, I also internalised Cree precepts and incorporated my own interpretation of them into my generative music system. For example, Whisper music never reaches an endpoint. Instead, corresponding to a Cree principle of cyclicity, Whisper music cycles between two states: sound, and silence, contingent upon the wind's presence. Furthermore, an audience member entrains both with the music and the wind's somatosensory feedback (see Chapters 6.5 and 8.1). Ultimately, the Whisper experience embodies a process – a process of embracing the present moment, immersing oneself in nature and all its relationships, and listening with the heart.

5. Chapter 5 – The Whisper DMI

Whisper is a digital musical instrument (DMI), which is "performed" by the wind, and consists of: an anemometer (wind speed sensor), computing infrastructure (microcontroller, laptop computer), software (e.g., programming the generative music system), sound system (i.e., audio interface and loudspeakers), and physical building materials for positioning the wind sensor. Whisper's setup involves various essential elements, such as an anemometer for wind speed measurements, computing infrastructure consisting of the Bela Starter Kit and a personal computer, software components including Max, Ableton Live, and Spitfire Audio's LABS VST instruments, a sound system comprising amplifiers and outdoor speakers, and building materials used for protection and mounting purposes. I discuss these components in the following sections.

5.1. Components

5.1.1. Anemometer

My DMI captures wind performances through its anemometer. The sensor itself consists of three cups affixed to a horizontal rod, which rotates in response to the presence of wind. The rotational speed of the rod is directly proportional to the wind velocity, whereby stronger winds result in a swifter rotation. By counting the number of rotations, the anemometer generates a voltage ranging 0.4V to 2.4V, corresponding to wind speed measurements between 0 and 100 km/h.

I connected the anemometer to computing infrastructure using three 22AWG 8-meter stranded wires, and three breadboard male to female jumper wires. I used two sets of wires to facilitate ease of connection between the anemometer and the Bela.

5.1.2. Computing infrastructure

To capture the data output of the anemometer, I utilised the Bela Starter Kit[6], which is equipped with a set of eight 16-bit analogue input/output (I/O) channels and sixteen digital I/O channels. The board provides access to a browser-based integrated development environment (IDE) that simplifies the programming process for the device. Despite the availability of several alternative devices for capturing sensor data, I chose this particular kit due to its allocation by the university. Additionally, I used a 13-inch MacBook Pro (M1, 2020) personal computer running Mac OS 11.7.6.

5.1.3. Software

Wind speed data from Bela's IDE is transferred via the OSC[7] protocol to Max 8.5.3, facilitating the operation of Whisper and its music. Max processes the data, generating MIDI[8] notes and audio output, which are then routed through Existential Audio's Blackhole[9], a virtual audio driver that allows for audio pass-through between applications. The MIDI notes and audio output are subsequently transmitted from Max to Ableton Live 11 Suite provides a range of built-in instruments and effects, including Spitfire Audio's LABS VST instruments.[10] The resulting sound is sent to a Focusrite Clarett 4Pre audio interface. From there, three monophonic signals are transmitted to three amplifiers using mono 6.35mm audio cables and 3.5mm to RCA

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[6] Bela: https://shop.bela.io/products/bela-starter-kit

[7] Open Sound Control (OSC) is a communication protocol used for real-time control and interaction between software and electronic musical instruments.

[8] MIDI (Musical Instrument Digital Interface) is a communication protocol that allows electronic musical instruments, computers, and other devices to interact and exchange musical information.

[9] https://github.com/ExistentialAudio/BlackHole/blob/master/README.md

[10] https://labs.spitfireaudio.com/

cables. Finally, the amplified signals are conveyed through electrical wire to six Polk Audio outdoor speakers, which output audible sound.

5.1.4. Building materials

The equipment that drives Whisper was housed within a bastion, which featured a roof made of wooden panels with small gaps between them. This design allowed water and dust to potentially enter and fall onto the underside where the equipment was located. To ensure the protection of the Bela board and other electronic components, I implemented several measures. Firstly, I placed the Bela inside a repurposed dishwasher detergent container, shielding it from potential damage. Additionally, I took precautions by covering the laptop and audio interface with a larger container, placed upside down, providing a layer of protection. The amplifiers were also carefully stored in their original packaging. These measures effectively mitigated the risks associated with exposure to light rain and dust, safeguarding the sensitive electronics. Furthermore, considering the limitations of the bastion design, which hindered the wind flow, I addressed this issue by extending the height of the anemometer. I achieved this by securely mounting it on one end of a two-meter-long wooden plank, which was then firmly attached to one of the bastion's walls using screws.

5.2. Installation at -tzintlán

Figure 2: Whisper set-up at the Fort Whoop-Up replica

5.2.1. The land and its surroundings

The music of Whisper was premiered in *-tzintlán*: The World’s First Postcolonial Theme Park, which took place in the Fort Whoop-Up replica. The fort is situated in a grassy river valley, known as Indian Battle Park. See Chapter 1.5 for a description of the event.

5.2.2. Methodology for establishing a location for Whisper

For Whisper to be played by the wind, choosing the location for the DMI required the careful consideration of weather conditions. For example, I wanted to convey a profound respect for the wind and to consider moments in the performance when the wind was entirely absent, leading to an absence of sound from Whisper. Although I recognised the inherent risk in having no wind, I believed that the absence of wind, and sound, itself, could convey a powerful statement. I considered several factors for Whisper to function properly within the context of an outdoor installation:

(1) Amount of wind to excite the sensor and activate the DMI

(2) The degree to which the natural setting enhanced audience's experience of Whisper (e.g., how the inherent beauty of the natural scene created an environment that facilitated the observation of interconnectedness and interrelation among all elements within the scene) ;

(3) Proximity to a source of power (i.e., electrical outlet)

(4) Distance between wind sensor and anticipated audience. The force of the wind, which excited the sensor, needed to correspond to the somatosensory experience of the audience member.

5.2.3. Fort Whoop-Up and its bastions

Initially, I tested Whisper inside the fort. However, the fort's walls obstructed a substantial amount of wind and made invisible the landscape's features, which were crucial for conveying the essence of my project. Whisper involves creating a multi-sensory experience that explores Indigenous epistemologies and subverts western concert protocols. As a response to this obstruction, I moved Whisper to the fort's bastions. These new locations allowed the audience to listen to Whisper from outside the fort and experience it in relation to nature.

Fort Whoop-Up has two bastions, which are towering structures positioned at the corners of the fort. One bastion is situated at the north-eastern corner and the other, at the south-western corners. The north-eastern bastion faces the trestle bridge and the valley, also referred to locally as the coulees. A tall tree grows next to this bastion. The south-western bastion is next to a large open field and looks out towards the river and the highway.

5.2.4. Location of Whisper

During my exploration of Whisper's placement, I experimented by situating it in each bastion and closely examining the outcomes. Each location possessed distinct advantages and disadvantages. The north-eastern bastion, for instance, provided a highly immersive experience where the natural environment played a significant role in shaping the environment through the swaying of trees and the gentle rustling of leaves, thereby demonstrating the interconnectedness among these elements. However, this site posed challenges regarding audience accessibility as it fell beyond the fort's designated area. On the other hand, the southwestern bastion provided an unobstructed view of both the valley and the colonial features present in its vicinity, such as Whoop-Up Drive and the Lethbridge Viaduct. This placement lacked physical elements that directly responded to the influence of the wind. Nevertheless, this location featured greater convenience for the audience in terms of accessibility. After considering these factors, I ultimately opted for the south-western location, prioritising the ease of access for the audience.

5.3. Chapter summary

In this chapter, I discussed Whisper, a digital musical instrument (DMI) performed by nature. I outlined its components, including an anemometer, computing infrastructure, software, sound system, and building materials. My DMI is intentionally visually minimal, centring the audience's attention on the musical experience in nature rather than on looking at the DMI components. My approach to DMI design encourages the audience to immerse themselves in nature and also minimises e-waste and any negative environmental impacts.

Next, I discussed the installation that took place at -tzintlán, in Fort Whoop-Up's bastions, and my considerations for factors like wind conditions and audience experience. In particular, I considered multiple factors to establish interconnectedness. Factors such as the natural setting of the location, availability and abundance of wind, and sensor positioning relative to both wind flow and the audience, all play a role.

By re-framing nature, the wind, and perhaps even the Fort Whoop-Up replica with my Whisper DMI, I hope to contribute to resurgent strategies for calling attention to Indigenous epistemologies (see Chapter 4.3). One aspect of my re-framing was to relocate the performance space from a conventional concert hall, or traditional venue stage, to the natural environment of the Lethbridge coulees. In a concert hall setting, audience members are required to sit and adhere to western concert protocols (e.g., responding at precise moments to the artists and to the music). This normative behaviour reinforces a type of objectification; that is to say, an audience member, in a way, merely responds to a musical-object (i.e., artists and music on stage) particularly when a performance is framed by program notes, expected customary gestures, and the restriction of noise or verbal expression. In contrast, Whisper's "stage" does not demand, or require, the audience to follow a normative behaviour. Here, the audience is free to sit down, lie down on the grass, gaze at the sky, and even choose whether or not to engage with the music. The stage includes the sounds of birds and rustling leaves, which may compete with a backdrop of noises from passing cars and trains. This framing invites the audience member to contemplate the interconnectedness of all these subjects.

6. Chapter 6 – A generative music system built in Max

The generative music system for Whisper consists of two main Max patches: (1) a controller patch that receives and processes data from the wind sensor; (2) a synthesis patch that controls sound synthesis parameters based on sensor data.[11] Importantly, the controller patch contains all of the essential modules for the generative music system. The patch determines: timing and triggering, and musical note values. The term module is used in this document to refer to a Max subpatch, or a collection of subpatches, within the controller patch.

6.1. One sensor, one signal

The Whisper DMI makes use of a single sensor, which outputs voltage ranging from 0.0 and 2.4 volts (V). This voltage reading, is the one and only input into the controller patch of Whisper. Extensive experimentation was essential in order to exploit the data signal fully.

For example, wind speed patterns exhibit notable variations depending on the specific placement of the sensor. Figure 3, below, presents wind speed measurements over 5-minute intervals. In Figure 3, the left diagram illustrates data that was extracted after the sensor was fully installed at the exhibition site (see 5.2). The wind speeds averaged 20 km/h. The right diagram of Figure 3 illustrates data obtained during a Chinook event. The sensor was placed on the windowsill of an open window at my residence in downtown Lethbridge. Outside of my residence, the wind conditions averaged 30 km/h with occasional gusts reaching 70 km/h. Notably, despite the Chinook winds having significantly higher wind speeds, the sensor registered maximum gusts of only 20 km/h due to its positioning on the windowsill.

[11] In Max, a patch refers to a self-contained programme that is edited in a patcher window. A patch exists as a single programme or as a nested programme, referred to as a subpatch, inside another patch.

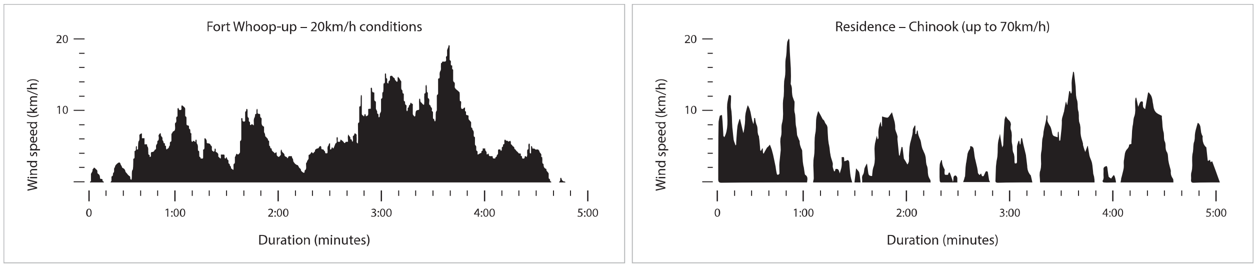

Figure 3: Wind speed readings at the fort and a private residence

Another feature of the sensor's behaviour that required extensive experimentation was what I refer to as the "phantom" state, which occurs when the sensor's rotation is a result of inertia and not the wind. For example, if a gust of wind abruptly ceases, the cups of the sensor continue to rotate, gradually decelerating until their momentum is fully dissipated (See Figure 3). Consequently, this phenomenon introduces phantom readings, which I considered data errors. To mitigate these errors, I programmed the Max controller patch to register readings exclusively during ascending or sustained trends. In this case, I borrowed the idea of trends from CNMAT's (2023) [trend-report] Max object[12], which is an analytical tool for examining numerical data.[13] [trend-report] discerns a tendency for values to increase or decrease. The resulting trend indicators were then mapped to distinct parameters within the Max controller patch to: account for the phantom error by gating incoming data from the sensor; and change parameters in musical note modules (i.e., change modes and scales when a descending trend is observed for specific durations).

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[12] Center for New Music and Audio Technologies. (2023). CNMAT-Externs GitHub repository. Retrieved from https://github.com/CNMAT/CNMAT-Externs

[13] Please note that brackets are used to specify a Max object. Objects represent the basic programming functions within Max.

6.2. Data processing

Multiple layers of programming in the form of Max subpatches are involved in the processing of wind speed data. Before discussing the modules – collection of subpatches – of the controller patch, I identify four data processing techniques consistently used: filtering, smoothing, normalising, and scaling.

For example, the initial processing in the controller patch includes a "denoise" filter from the Digital Orchestra Toolbox (DOT) – a set of Max externals (i.e., patches) (Malloch, Sinclair, and Schumacher, 2023). The denoise patch is an averaging filter that rejects outliers (i.e., data at undesirable frequencies).

In another example, the DOT external for calculating the mean value from a continuous signal is used to smooth the data responsible for generating melody. Melodies performed by the wind require a high degree of smoothness in order to avoid rapid and abrupt note transitions.

Additionally, wind speed is normalised to increase the sensitivity of Whisper in low wind conditions. This involves calculating the average wind speed over a two-minute period and mapping it to a range between 1.0 and 2.3. The resulting value is then multiplied by the actual wind speed. For instance, in the lowest wind conditions, wind speed is multiplied by 2.3, while in the highest conditions, it is multiplied by 1.0. This amplifies the sensitivity or "expression" of all modules that rely on wind speed.

Scaling data is another example. Scaling wind speed data ensures that its output range matches the required input range of other modules. For example, the note sequences and module (see 6.3.2.2) requires an input range of 0 to 35.

6.3. The controller patch

In Whisper, all musical material (e.g., pitch, velocity) is generated in the controller patch, it contains timing, triggering, and musical note modules. Creating a controller patch, which effectively responds to sensor data across different wind conditions, proved to be a time-consuming, but successful, endeavour. The wind manifested a wide range of "gestures", including prolonged gusts with constant speed and brief, intense gusts lasting only a few seconds. In the following sections, I provide a detailed presentation of the modules within the controller patch.

6.3.1. Timing and triggering modules

Whisper does not incorporate a central timing clock or timing system. Instead, anemometer data is used for the logical organisation of sound over time. Additionally, in order to emulate the timing deviations of a human performance, the output data from the musical note modules, which is in the form of pitch values, is always randomly delayed using [random] and [pipe]. [random] produces random pitch values within a specific range and [pipe] delays the output of the pitch values, ensuring that a variety of notes consistently play with a slight timing variation, mimicking a human performance.

The wind's tendency (or trend) to become active, or inactive, was measured. The triggering module of my controller patch contains a subpatch for measuring this trend. The subpatch operates as follows. An increasing, or sustained trend, is detected when the wind becomes active, and a decreasing trend is detected when the wind becomes inactive. A counter (i.e., [counter]) starts once a decreasing trend is detected and the vector – measured in seconds – between each new count is compared to a specific threshold value. Passing the threshold value triggers a process in the controller patch. A process may include, say, generating a random number that is used as an index into [coll]. Subsequently, the output of [coll] might trigger a process in the musical note module.

In addition to measuring the wind's tendency to become active or inactive, wind speed is constantly evaluated. For instance, wind speed is mapped to the input of [metro], whose function is to output a trigger signal, or "bang", at regular intervals. Next, the output of [metro] triggers a pitch (i.e., musical note) value to be sent to the synthesis patch. See musical note module, below. Importantly, the timing of musical notes is governed by the wind.

The timing, or transition, between the two parts of Whisper, Embrace and Aohkíí, is also determined by anemometer data; by transition, I mean stopping one part and immediately starting the next part. See Chapter 7 for a description of the parts of Whisper. Once again, [counter] is activated when wind is detected by the sensor. Wind speed sets the rate at which [counter] progresses. As the output value of [counter] increases, the value is compared to a specific threshold number representing duration. After reaching the threshold (i.e., duration) the generative music system "waits" for the wind to subside before transitioning to the next part of Whisper.

6.3.2. Musical note modules

The musical note module of the generative music system produces the following.

(1) Note flourishes and sequences (motion and growth processes)
(2) Note scattering
(3) Parallel note sequences

6.3.2.1. Note flourishes and sequences (motion and growth processes)

Wind speed measurements affect the selection of pitch materials (i.e., musical notes) in Whisper. Forceful gusts lead to a rapid succession of notes that ascend from very low to very high. In contrast, wind measurements that represent relatively calmer periods (see Figure 4, below) generate a narrower range of pitches, characterised by a more gradual note sequence.

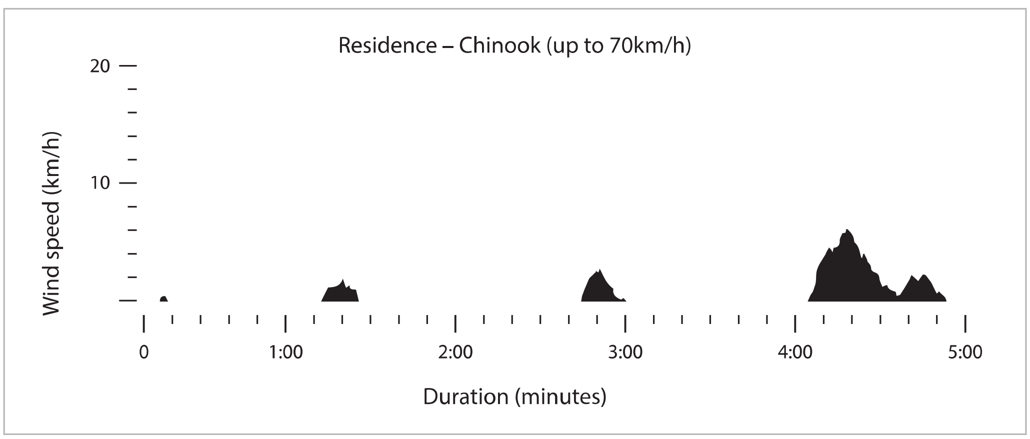

Figure 4: Wind speed during the calm period of a Chinook

In this module, I map wind speed values to notes from a melody. The process of creating a melody starts with scaling wind speed values (0.0 to 1.0) to a range that represents 36 scale degrees (0 to 35), and then smoothing the output (see Chapter 6.2). This data is used as an index into a [coll] object that contains composed note sequences; by composed note sequences, I mean the sequences form motivic-like patterns. Additionally, the melodies are expanded by repeating them over octaves at higher wind speeds. Figure 5 shows a demonstration of this module; a generated melody is yielded in accordance with wind speed values. The composed note sequence (i.e., motif) is shown at the bottom of the diagram.

The note sequences module, when combined with output from the timing and triggering modules, yields long melodic passages that traverse multiple modes, which occur when new note sequences from [coll] are triggered.

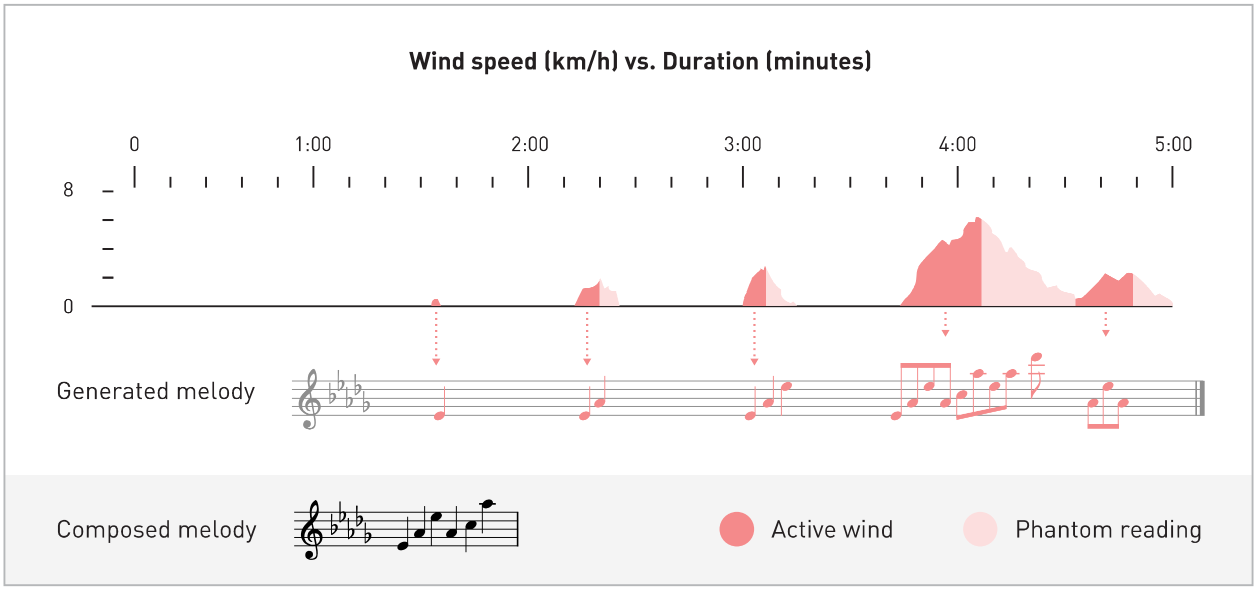

Figure 5: Note flourishes and sequences

6.3.2.2. Parallel note sequences

One of the note sequences modules includes a subpatch for creating parallel motion; parallel motion in music part-writing is the simultaneous melodic movement of two or more parts in the same direction and at a distance of the same interval or intervals. Parallel motion is created when a transposed version of a note sequence is heard at the same time as the original sequence. [random] is used to determine the degree of transposition (e.g., +3, +7, -5). Parallel motion occurs with approximately half of all note sequences and is triggered by the output of the timing and triggering modules. See Figure 6, below.

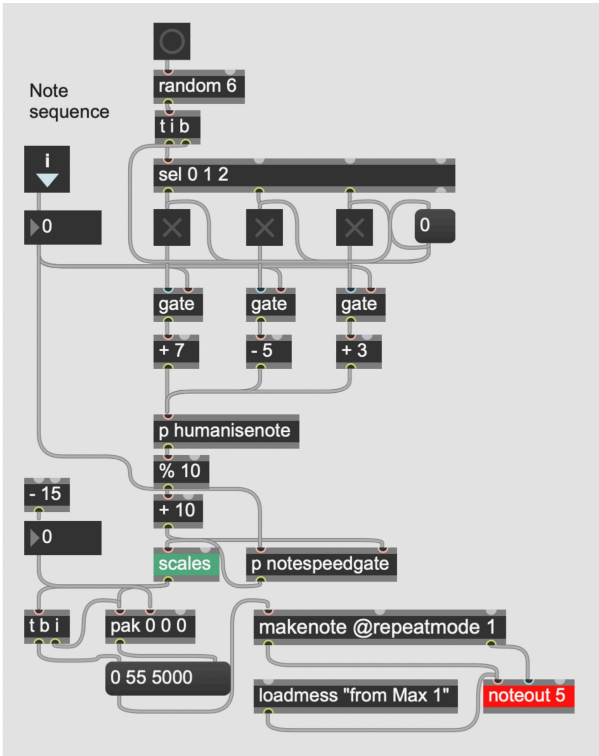

Figure 6: Parallel note sequences

6.3.2.1. Note scattering

This module retrieves pitch values from the outputs of the three preceding musical note modules mentioned in this chapter, preserving them within a [coll] object. These stored values are then transposed according to the current wind speed, with a larger transposition interval corresponding to higher wind speeds. Following this, the module merges and randomises these two sets of values, ultimately resulting in the playback of sparse melodies resembling those of wind chimes. See Figure 7, below.

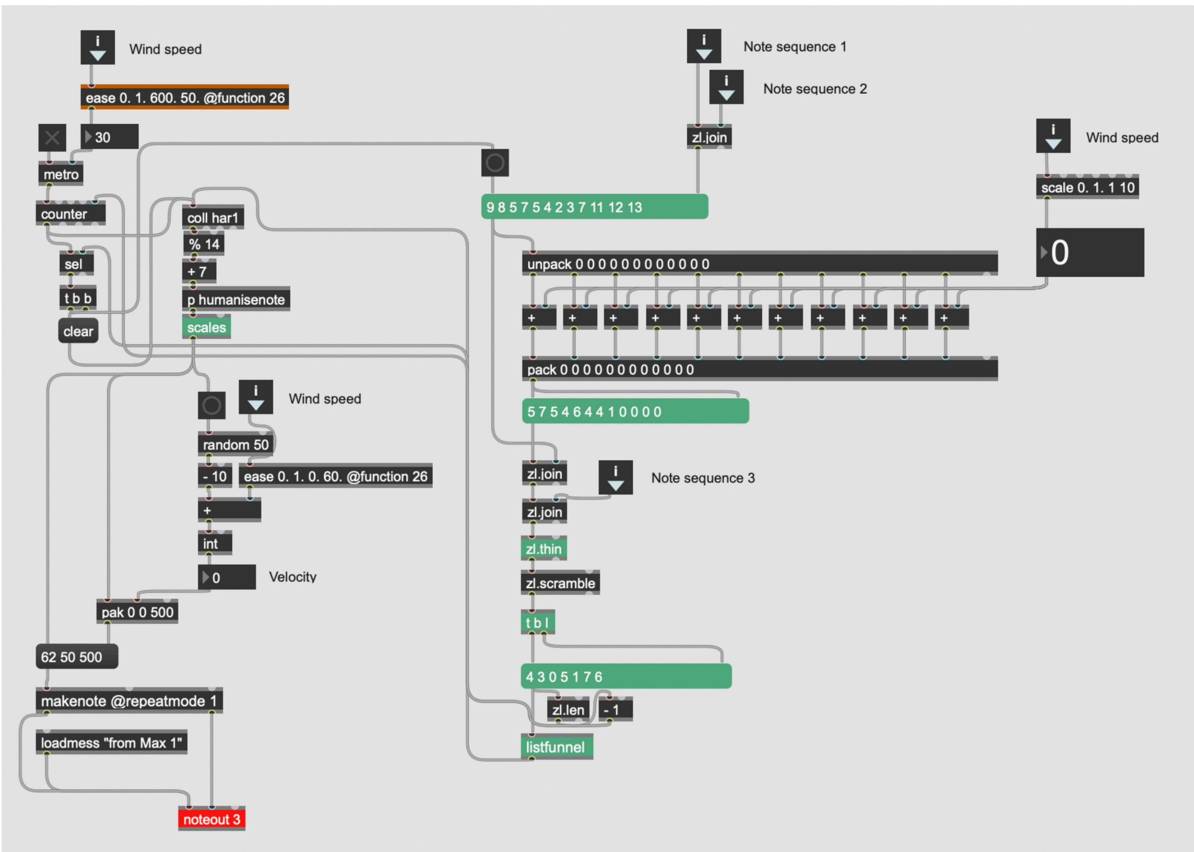

Figure 7: Note scattering

6.4. Synthesis engines and audio processing

For the synthesis engines of the generative music system, Max and Ableton Suite are used in tandem. In the case of Max, I created both a sample/audio file playback system and an audio synthesis subpatch. With respect to Ableton, six virtual/software instruments, four of which are sample-based string instruments, are used; instruments are developed by Spitfire Audio LABS[14], specifically the Mandolin, Dulcimer, Guitar Harmonics, and Moon Guitar, I also employ Ableton's Operator for frequency modulation synthesise and Collision, a physical modelling instrument. Furthermore, all synthesis within Ableton, in addition to samples played in Max, are treated by audio processing in Ableton. Audio processing techniques include: equalisation (EQ), compression and limiting, delay effects, artificial reverb, EQ, and chorus.

6.4.1. Sample playback in Max

My sample playback system is used in Aohkíí. This part of Whisper contains a sound layer based on recordings of a Niitsi'powahsin (Blackfoot language) lesson, which I recorded myself in collaboration with Camina Weasel Moccasin, a Niitsitapi, and the Indigenous Curator for the Galt Museum. See Chapter 7, Niitsi'powahsin.

Before implementing my Max playback system, I isolated the individual voices of the lesson and organised the speech into short phrases, which were exported to separate audio files. [sfplay~] is the main Max object used for accessing the audio files. For each speaker in the language lesson, I create a two identical subpatches that control the file selection and play state of [~sfplay], one for each speaker. In addition, [urn], which generates a set of random numbers within a specified range and without any replication of any number within the range, is used to

[14] https://labs.spitfireaudio.com/

choose a spoken phrase from the language lesson. Once a number (e.g., phrase) is chosen, one instance of the lesson is played. In each instance, a word in Niitsi'powahsin is spoken first by the teacher, followed by its repetition by the student. These words include: niitsi'poyit (speak Blackfoot), isstsííyit (listen), saitami (breathe), ksááhko (land), niítahtaa (river), aohkíí (water), iiníí (bison), ksikkihkíni (bald eagle) ka'ksimiis (sage) (see Chapter 7.3.1).

6.4.2. Synthesis in Max

Sound synthesis in Max is strongly based on techniques described in Designing Sound by Andy Farnell (2010). Farnell's implementation on running water in Pure Data was informative; the author provides Pure Data examples in his book. The sound of running water is characterised by the resonance of numerous small air cavities that form inside turbulent water bodies (Farnell 2010). To digitally recreate these cavities, a sine wave is modulated by low frequency noise following a bilinear exponential distribution. Unlike a random or uniform distribution, a bilinear exponential distribution centres around a specific frequency, resulting in the creation of droplet sounds that are distributed within a narrow frequency range. Figure 8 includes one layer of droplet sounds.

Based on Unriginal's (2015) Max adaptation of Farnell's Pure Data examples in *Designing Sound* (2010), I programmed my own water system for Whisper. To replicate the characteristics of running water, seven instances of droplets are combined to create the impression of a flowing river. In addition, I introduced an extra layer comprising a pink noise generator and a low-pass filter. This augmentation of pink noise enhances the depth and richness of the sound's frequency content, while modulating the cut-off frequency of the filter in response to the wind speed influences the perceived scale of the river's surrounding environment.

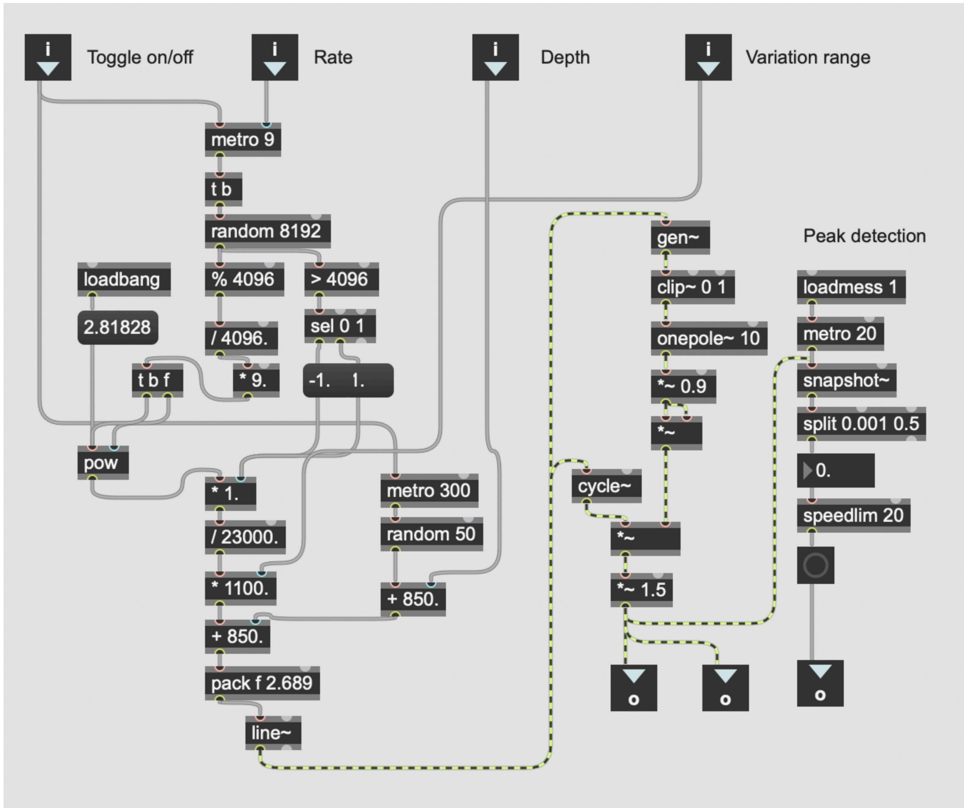

Figure 8: Water droplet generator

The behaviour of water droplets is managed and controlled with [pattrstorage], which allows for the recalling of droplet control parameters (i.e., presets) during Whisper. I use [pattrstorage] to recall distinct parameters, such as the rate of water droplet, and the depth and the range of their frequencies, to control each water droplet sound. For instance, the first preset represents a quiet river, while the fifth preset embodies a large and loud river. Importantly, [pattrstorage] also generates interpolating data; [pattrstorage] is able to insert interpolated values when moving from one present to another preset. The control of this transition – one preset to another – is enabled by the anemometer. Wind speed is mapped to [pattstorage] object and as wind speed fluctuates, it moves between the [pattstorage] presets, thereby shaping the resulting sound. See

Figure 8, below, for an overview of the water droplet controller patch, which includes preset interpolation.

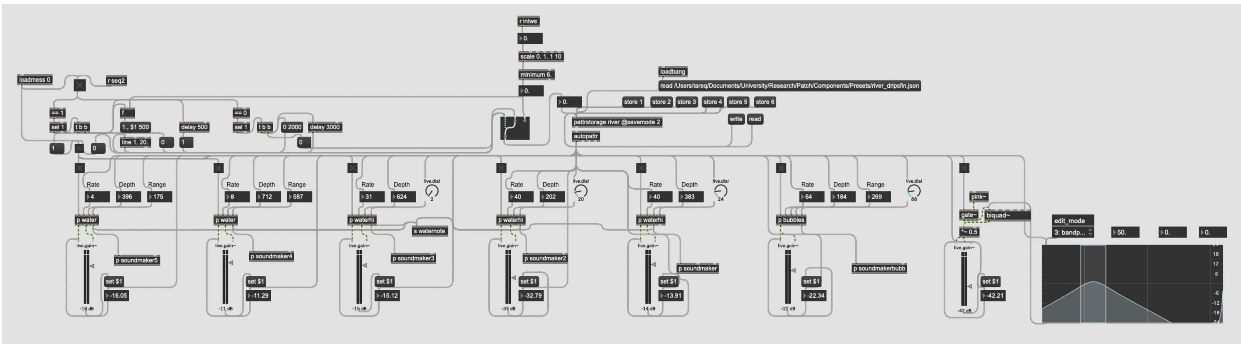

Figure 8: Water droplet preset interpolation

6.5. Chapter summary

In this chapter, I discussed the various components of my generative music system. I highlighted the use of a single sensor and signal as my main data input. I described the processes within Max that are used to achieve the musical output of the system, starting with data processing, timing and triggering, musical note module logic, and finally, synthesis. This chapter offers a deeper look into the mechanisms behind Whisper music.

As previously discussed, David Tudor's *Rainforest* behaved like an ecosystem. When Tudor modified his system, he noted that it often fell out of balance. Similarly, my generative music system exhibits this behavior. Whenever parameters were altered within one process of my system, it caused the entire system to lose balance, as all modules were literally interconnected. For instance, in the note flourishes and sequences module, wind speed values (0.0 to 1.0) are scaled to represent 36 scale degrees (0 to 35). Adjusting this scaling to (0 to 25) would constrain the output note range and density, necessitating higher wind speeds to transition between scale degrees. Consequently, the parallel note sequences module would produce melodies adhering to this limitation. Likewise, the note scattering module, fed by input from the two preceding modules, would reflect the changes imparted unto them.

Tudor's work served as an inspiration, not only due to its technical manipulation of analog circuitry – a parallel to my endeavors in Max – but also because both Tudor's and my themes revolve around nature. While Tudor's creations simulate and mimic nature, my work goes a step further, aiming to not just simulate, but to genuinely represent nature.

In consideration of Indigenous precepts, the elements within my generative music system were conceived with a focus on cyclical patterns and interconnectedness. I aimed to tangibly reflect these abstract concepts into the philosophical foundation of my Max programming. For example, the note flourishes and sequences module (see Chapter 6.3.2.1) cycles through a collection of composed note sequences (i.e., motifs). Next, the selected motif is expanded cyclically across octaves. Furthermore, the governing modes of these melodies also undergo cyclic variation, and finally, the generative music cycles between the two parts of Whisper music.

In developing Whisper, I embraced DMI design principles to forge an instrument capable of controlling my generative music system. I decided to cater to feedback, a vital, and often overlooked component within DMIs. I did so by integrating the inherent somatosensory feedback stemming from wind-skin contact into my DMI design, consciously aligning the primary and secondary feedbacks – somatosensory and Whisper music (i.e., sound). To achieve this alignment, I regularly conducted real-time tests with the wind and closely observed the feedback it provided, refining my programming accordingly. This effort aimed to create an immersive sensory encounter, fostering a sense of interconnectedness (see Chapter 4.2). Conversely, I observed that a lack of alignment between primary and secondary feedbacks can lead to a more cerebral, detached musical experience, akin to Robinson's concept of a subject-object relationship (refer to Chapter 4.3.2). I propose that entrusting the wind with complete control of the system and synchronising its feedback with the music transforms Whisper into a subversion from conventional DMI design.

7. Chapter 7 – Whisper music

The music of Whisper is in two parts: Embrace and Aohkíí. The first part cycles between a homophonic and polyphonic texture, involving two intertwining melodies played by string instruments in the foreground and a scattering of notes reminiscent of wind chimes in the background. The melodies directly emerge from the shifting winds (see Chapter 6.3.2.1), while harmonies form through the random interactions of multiple melodies, resulting in a fleeting quality. This part primarily contains instrumental sound colours (e.g., Dulcimer, Mandolin, Guitar). The phrasing, rhythmic structures, and the spectral qualities of these instruments change in sympathy with the wind. For example, at times, the piece struggles to commence due to minimal wind, resulting in the generative music system playing brief, and soft cadence-like sequences with each gentle gust.

The second part draws inspiration from Niitsitapi culture and language, emphasising the resurgence of Niitsi'powahsin, symbolising the sacred importance of water, and portraying a relationship between an Indigenous teacher and a non-Indigenous student, through recordings of language lessons accompanied by a synthesised soundscape of a river. The music for Whisper is created by a digital musical instrument (DMI), which is "performed" by the wind. This DMI consists of: an anemometer, computing infrastructure, and software used to design a generative music system that responds to wind speed.

7.1. Influences and goals

In Whisper, I aimed to cultivate a meditative experience through the music, drawing inspiration from a diverse range of genres and artists. Examples include Chick Corea's *Crystal Silence* in Jazz, Nadi Qamar's *The Nuru Taa African Music Idiom: Played on the Mama-Likembi* in traditional music, Brian Eno's ambient generative works such as *Bloom* (see 2.2.3), and Joanna Brouk's "The Space Between" in New Age music. These musical influences emphasise fluidity and the deliberate avoidance of rigid compositional structures, creating a sense of timelessness through their inherent processes.

For instance, take Nadi Qamar's *California Sutra #1* as an example. While the primary texture is monophonic, the instrument itself (The Mama-Likembi) conveys a rich timbral quality. The composer employs "freely meandering melodies" (Qamar, 1975) that are improvisational in nature, comprised of phrasing that embraces extended silences, and evokes a sense of contemplative emotion. Additionally, the composer avoids strict tempo, and the speed of his phrases fluctuates significantly. In the liner notes of his album, Qamar reflects on his compositional process, highlighting the human tendency to generate unnecessary urgency and stress by excessively quantifying time. Consequently, he advocates for an approach that embraces timelessness and ease when urgency lacks valid justification (Qamar, 1975). I suggest that the other aforementioned musical influences adopt similar approaches to impart a sense of timelessness. In this light, embracing Qamar's method nurtures a meditative experience, which is particularly resonant with the concept, and context, of Whisper.

Because Whisper is played by the wind, one primary goal was to explore how wind might express itself musically. In Whisper, I want the audience to understand that the wind can be expressive and perhaps covey concepts of human emotions.

The generative musical system, which responds to the wind, is designed to reflect concepts that are a part of human musical expression, including emulating the timing deviations of a human performance. This approach aimed to honour the indigenous worldview, which perceives wind as animate and imbued with agency. Through Whisper, I intended to emphasise and acknowledge the subject-subject relationship (see Chapter 4.3).

In addition, throughout my exploration of the concepts discussed by Leroy Little Bear, Carl Urion, and Dylan Robinson, the significance of interconnectedness is consistently emphasised (see Chapter 4). In my artistic process, I consistently examined how Whisper music, when combined with the wind's participation as a performer, conveyed a strong sense of interconnectedness. This exploration was an intriguing experiment, involving the comparison of a musical performance with interconnectedness – an immeasurable concept. Essentially, I engaged in a cycle of computer programming, observing how the wind performed, and analysing the accompanying physical and affective qualities while experiencing Whisper music. When considering interconnectedness within the context of Whisper music, exploring the holistic experiences was crucial.

The music of Whisper, which I discuss below, was premiered in May, 2023, in *-tzintlán*: The World's First Postcolonial Theme Park (see Chapter 1.5).

7.2. Embrace

7.2.1. Compositional process

To compose music for Embrace, I initially explored the works of western composers, with a particular emphasis on American experimental sound art and the minimalist movement (see 2.1, and 2.2.3). I also delved into western musical improvisational practices, particularly in the realm of Jazz, and attempted to translate those experiences in my Max programming (i.e., adopting western systems into my generative music system). However, a significant shift has occurred in my approach to thinking about western cultural influences due to the realisation of the oppressive imposition of western values on Indigenous communities. This new awareness instilled in me a sense of caution and reluctance towards following western musical practices.

One of the goals of my compositional process included re-creating aspects of my musical influences (irregular rhythm, melody, use of modes), which I explored/studied, with my own generative music system, such as the sparse textures of Nadi Qamar's *After Glow*, and Brian Eno's *Bloom* (see Chapter 7.1). The outcomes of this compositional process were tightly controlled, highly stylised generative music compositions that incorporated elements of "embedded" human agency within their structures. The term embedded is used here to signify that the compositional and improvisational structures were initially established through a human-centric listening of the music, above, and then coded into the Max patch.

7.2.2. The experience of time, form and structure

With respect to time (e.g., duration of music), once Embrace begins – by activating the generative music system in Max, wind will play indefinitely. As a result, any perception of a formal musical structure is an artefact imagined by the listener. On the one hand, form and structure is malleable in Embrace. Musical materials (e.g., pitch modes, sonorities, rhythmic structures) change in accordance with wind speed values and trends, or tendencies, in wind behaviour. On the other hand, any sense of form and structure is fleeting, or ephemeral. The unpredictability of the wind's behaviour leads to the formation of random variations in musical structure, including long moments of silence.

7.2.3. Virtual instruments, texture, and density

In Embrace, I used six virtual, or software, instruments. They include a virtual Mandolin, Dulcimer, Guitar Harmonics, and Moon Guitar (See Chapter 6.4, Synthesis engines and audio processing). My design for musical, or instrumental, textures included assigning some instruments to the foreground, while other instruments play accompanying roles. For instance, the audience may perceive highly random and sparse melodic patterns, reminiscent of wind chimes, as a middle ground or background layer. Listeners might also hear a bass accompaniment from time to time. The overarching goal for musical texture was to create an alternation between homophony and polyphony.

The overall density of sound(s), as well as musical dynamics (i.e., variations in loudness), are controlled by wind speed; for example, with respect to density, higher speeds lead to a more close-packed presentation of sounds; more sounds occur in a shorter span of time. In addition, instrumental timbre and its evolving spectral shape are also controlled by wind speed. For example, each of the software instruments includes parameters for shaping its sound, including envelope generators, velocity control, and resonance, which are all mapped to wind speed.

7.2.4. Modes

I use traditional musical modes, or scales, in Embrace. Throughout my life, I have been exposed to a variety of musical cultures, including Middle Eastern, African, and European styles. Consequently, my own emotions, which are brought to the surface with traditional modes, are firmly rooted in my experiences with music from diverse cultures. In Embrace, I decided to work in the Aeolian, Phrygian, and Dorian modes. I chose the Phrygian and Aeolian modes because they are commonly associated with feelings of sadness, melancholy, and darkness. The Dorian mode, on the other hand, has a minor third and a major sixth. The minor third interval is commonly associated with sadness in western classical music. The inclusion of a major sixth interval in the Dorian mode introduces a characteristic of the Ionian mode, or major scale. The major scale is commonly associated with joy in western classical music. This combination of minor (minor third) and major (major sixth) creates a complex emotion.

Furthermore, the major quality in particular, provides relief from the darker qualities of the other selected modes: Aeolian and Phrygian. For instance, in Embrace, the suggestions of darkness (Aeolian and Phrygian) is a metaphor for a troubling past: the historical burdens borne by this land and its Indigenous people in the face of colonialism. The qualities of Dorian help to juxtapose the melancholic emotions of Aeolian and Phrygian. Dorian may provide a sense of introspection, timelessness, and tranquillity with respect to the past.

7.3. Aohkíí

7.3.1. Overview

Aohkíí is part 2 of Whisper. Aohkíí, which is the Niitsi'powahsin (Blackfoot language) word for water, draws inspiration from Blackfoot culture and pays homage to the enduring spirit of the land and its Indigenous peoples. In Aokhíí, I want to draw attention to Niitsi'powahsin and the near erasure of Indigenous heritage, which includes language. Aohkíí serves to celebrate the resurgence of Niitsi'powahsin, and to underscore the profound importance of water, which is revered as a sacred, life-giving force symbolising purity, renewal, and interconnectedness. Aohkíí integrates two interwoven sound elements: recordings of a language lesson, and synthesised sounds that emulate a flowing river.

7.3.1. Niitsi'powahsin

The role of Niitsi'powahsin (Blackfoot language) was made apparent through my course work at Iniskim (The University of Lethbridge), where I actively explored ways to align my studies with Indigenous values. One notable example occurred in Art 5355, LandMarks, which is taught by Dr. Jackson Leween (Two Bears). For this course, I created imagery intending to support a project concept, believing my work would be well-received. To my surprise, I was informed that my visual art work had the potential to evoke highly negative emotions among Indigenous individuals. From this experience, I realised the importance of having a further, deeper, understanding of Indigenous culture and the people with whom I had hoped to be involved.

I reflected on the knowledge I had acquired through contact with Dr. Leroy Little Bear at Iniskim, Dr. Little Bear's calls to action regarding Niitsi'powahsin resonated strongly with me. Consequently, I contemplated ways to centralise language within my work and eventually decided to incorporate a recording of a one-on-one language lesson, symbolising a resurgence of Blackfoot heritage. With support from Dr. Jackson Leween (Two Bears), I reached out to Camina Weasel Moccasin, a Niitsitapi, and the Indigenous Curator for the Galt Museum in Lethbridge, Alberta. Camina and I actively participated in discussions centred around the contemporary realities and difficulties stemming from colonialism. I shared personal experiences and stories about my homeland in Palestine. I conveyed the objectives I aimed to accomplish through my project and sought her perspectives. For instance, I believed that my use of Niitsi'powahsin should go beyond the mere utilisation of words; I aimed to encourage Indigenous and non-Indigenous individuals to learn the language.

Throughout our discussions, I acquired knowledge of the correct pronunciation of Blackfoot words. These words include: niitsi'poyit (speak Blackfoot), isstsííyit (listen), saitami (breathe), ksááhko (land), niítahtaa (river), aohkíí (water), iiníí (bison), ksikkihkíni (bald eagle) ka'ksimiis (sage).

Incorporating Niitsi'powahsin into my composition required establishing a link between the recordings of a language lesson with Camina Weasel Moccasin and the wind. I determined that each gust of wind would trigger the playback of a single instance of the lesson. In one instance, the word is initially spoken in English and then repeated in Niitsi'powahsin twice by Camina, the instructor, and once by myself as the student. The instance concludes with Camina saying sokapi, which means, all is well (i.e., good job).

7.3.1. Water

Water holds immense cultural and spiritual significance for the Niitsitapi. For example, water is seen as the source of life. Water also symbolises purity, renewal, and healing. Water is animate, playing a crucial role in ceremonies and rituals. The Niitsitapi recognise the need for respect, reciprocity, and sustainable practices regarding water, understanding its vital role in maintaining ecological balance and sustaining life for all beings. In Aohkíí, I use water to exemplify the interconnectedness of many parts. For example, Farnell (2010), in his sound synthesis techniques for water, illustrates how continuous streams of independent events, such as individual water droplets, are perceived as a single coherent source.

7.3.2. A soundscape approach

Aohkíí and Embrace have similarities. For instance, both parts of Whisper exhibit a malleable and ephemeral approach to the structuring of sound. At the same time, unlike Embrace, Aohkíí takes on qualities and uses of sound that are more consistent with soundscape music, rather than relying heavily on traditional pitched elements.[15] For example, Aohkíí uses sounds in their natural forms, exposing the source bond, or the source of each sound. Moreover, sounds in Aohkíí often suggest the real-world sound landscape (i.e., soundscape) in which to find the sounds (e.g., human conversation, running water, flowing rivers, waterfalls, etc.). In addition, the awareness of landscape is promoted by the relationship to somatosensory feedback; gusts of wind felt by the listener coincide with played segments of the Niitsi'powahsin (Blackfoot language) lesson. Increases in wind speed, captured by the anemometer, change the frequency range and density of the running water sounds.

7.4. Chapter summary

In this chapter, I connected important influences with project goals, and I explained the key music and sound synthesis choices for both Embrace and Aohkíí. For Embrace, I described aspects of the compositional process, the experience of time, instrumentation, and the use of traditional modes (or scales). In the case of Aohkíí, I showed how recordings of Blackfoot speech and synthesised water sounds relate a soundscape approach for this part of Whisper.

[15] Soundscape music focuses on creating atmospheric and immersive sonic environments.

8. Chapter 8 – Conclusion

In this concluding chapter, I focus on my central research directions once again: nature as performer, DMI design and generative music, and the impact of colonialism. I also review the reception of Whisper, including responding to Whisper through Indigenous worldviews.

8.1. Nature as performer

Does nature perform? This question prompted deep contemplation on the nature of performance (and musical composition) and challenged my preconceived notions of music creation.

I argue that nature possesses performative qualities. While I establish the constraints under which nature, and more specifically, the wind, performs, the overall experience of time, form, and structure are conveyed – I would argue even controlled – by nature. Therefore, the creative process behind Whisper involved a dynamic dialogue between design (i.e., the generative music system) and the performative qualities of wind. The underpinning of my generative music system relies on current thinking about the application of DMIs. In the context of dealing with a DMI, which possesses only one, single, stream of data (see 6.1), my approach to design revolved around ensuring wind data processing techniques resulted in a DMI that produced tangible musical results. I have effectively achieved this objective, as demonstrated by the consistent performance of Whisper during *-tzintlan*, which lasted approximately ten hours.

As discussed in Chapter 3, generative music is produced through computer programming instructions that allow for real-time musical output without human intervention. The programming process proved to be intriguing and required imaginative solutions. In addition, creating the generative music system demanded a broader perspective on musical composition, leading me to consider the creation of a system that, in and of itself, composes. For example, during the programming of the Max patch, I repeatedly tested my programming with the presence of wind. There came a point where the patch began to materialise and respond to the wind, and everything just "clicked." I still recall the smile on my face when I first experienced the interplay of wind and music, because the experience instilled in me an immediate appreciation for every gust I felt on my skin, each playing its own melody. I genuinely felt that nature was performing its own music.

To address nature as a performer, I also immersed myself in learning about the history of colonialism in present-day Canada, delving into its historical context and Indigenous heritage. Additionally, I strived to understand Indigenous protocols and sought to perceive existence from an Indigenous standpoint, as reflected in the materials discussed in Chapter 4. These experiences have informed my thinking on how to approach future artistic and scholarly endeavours in music on this land in a manner that respects Indigenous values.

8.1. Reception

Robinson (2020) posits that western art music emphasises aesthetic contemplation, whereas Indigenous cultures employ song as a means of historical documentation and ceremonial expression. I would like to emphasise that my project does not discard the concept of aesthetic contemplation in music; instead, it embraces it wholeheartedly. However, my aim was to establish a relationship between the performer (i.e., the wind) and the audience. I sought to transcend the fixation on listening that often revolves around the consumption of musical material. By consumption, I mean the celebration of music for either its theoretical accomplishments or its commodification, as seen in popular music, for instance. In Whisper, my intention, for the audience, was to foster dynamic and responsive connections between the audience's senses, the wind, and the music, thereby illustrating the interconnectedness between them. Furthermore, Whisper is designed to be wholly dependent on the presence of natural forces; without wind, Whisper remains silent. Finally, the music alone does not encompass the entirety of the Whisper experience. It is the multisensory reception of both the wind and the music that generates the intended experience.

8.2. Challenges and sustainability

A number of technical staging and musical challenges will be addressed in future iterations of Whisper. With respect to technical staging, or the installation of Whisper in nature, further experimentation on how to guide an audience member to an optimal location is needed. For example, I have observed that the anemometer captures only the immediate area around the sensor. Therefore, if an audience member is standing a few meters away from the anemometer, they might not experience the actual sensation of wind, which is setting the anemometer into motion. Additionally, depending on whether an audience member is downwind or upwind from the anemometer, the music could be activated either before or after they feel the wind. To address these challenges, a solution would be to position the audience among a set of three or four anemometers, whose data output would be mathematically averaged, increasing the probability that the averaged value would be a good representation of the wind speed felt by the audience member. An alternative approach to address the positioning concern could involve running independent instances of the Whisper DMI for each anemometer, each DMI presenting different music.

Concerning musical and sound challenges, my initial impression, after several extended listening sessions with Whisper, was that the generative music could benefit from more extensive algorithmic programming in order to create more variations in its sonic output. For instance, in the part, Embrace (see 7.2), I could introduce additional compositional elements to enhance the melodic and harmonic complexity of the music. In Aohkíí, I could also incorporate more words in Niitsi'powahsin and introduce additional natural sounds, such as the rustling of leaves, the gait noise of moving buffalo, or the crackling of a fire.

Throughout the building process, assembling the physical components of Whisper, I considered how my project was environmentally sustainable. I wished to reduce any negative impact on the environment. I refrained from purchasing any unnecessary materials. The laptop used for the project was my personal computer. The Bela microcontroller was borrowed from my supervisor and will be returned once my project has been completed. The anemometer and wiring will be repurposed for future projects.

9. APPENDIX

9.1. Generative Pre-trained Transformer (GPT)

I utilised two GPT (Generative Pre-trained Transformer) websites to assist in the writing of this thesis document. The two websites were: OpenAI's ChatGPT[16] and ChatPDF[17], which runs on OpenAI's GPT 3.5 large language model. Both websites were free of charge.

GPT was primarily used for proofreading my document during the writing process. My first language is not English and so, GPT assisted with diction, grammar, and sentence structure. In one instance, I employed GPT to generate content by requesting a description of Alvin Lucier's, *I Am Sitting in a Room* (1969). I integrated this description into my own explanation of the work. I carefully reviewed all material processed by GPT to ensure the accuracy and coherence of the text.

On fewer than five occasions, I utilised ChatPDF, which utilises the same version of ChatGPT to generate responses. The unique feature of ChatPDF is its ability to process PDF content uploaded to the ChatPDF website. This process proved instrumental in determining whether to expand my literature review to include additional papers. It also enhanced my comprehension of the material and informed my decision-making process.

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[16] https://openai.com/chatgpt

[17] https://www.chatpdf.com/

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