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Towards a Postmodal Movement for Computer Musicians

DISSERTATION

submitted in partial satisfaction of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

in Integrated Composition Improvisation and Technology

by

Josh C. Simmons

Dissertation Committee:
Professor Kojiro Umezaki, Chair
Professor Christopher Dobrian
Professor Nicole Mitchell
Professor Vincent Olivieri

2019

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Table of Contents

Acknowledgements

I would like to thank God for guiding me and providing reassurance through this process.

I would like to thank the chair of my committee, Professor Kojiro Umezaki, who led me through many long discussions that helped to solidify the ideas arrived at in this work.

In addition, a thank you to Professor Vincent Olivieri for providing the equipment necessary to carry out much of this research.

I would also like to thank Professor Chris Dobrian and Professor Nicole Mitchell for their influence on my creative work throughout my time as a student at the University of California Irvine.

I thank the Claire Trevor School of the Arts at the University of California Irvine for their help in financing my research through multiple Graduate Student Research and Travel Grants.

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FIELD OF STUDY

Music and Virtual Reality

Abstract of the Dissertation

Towards a Postmodal Movement for Computer Musicians

by

Josh C. Simmons

Doctor of Philosophy in Integrated Composition, Improvisation, and Technology

University of California, Irvine, 2019

Professor Kojiro Umezaki, Chair

Due to the breadth of VR as a field of study, and its relatively young age as a medium, a set of best practices has yet to be established for computer musicians interested in integrating VR into their work. A distillation of research into music-VR study, as well as many other related fields of study is presented in order to provide a survey of literature that may aid the research of computer musicians operating in this field. Abstracted from this research is the proposal of a new concept, *postmodality,* a way of thinking about artwork that defies conventional genre-bound understanding. Building on this broad research, the creation process for a multi-iteration creative work involving VR as a central element is detailed. Both technological and artistic aspects of the work are discussed. Finally, conclusions are drawn from the research that suggest further steps to be taken in this line of inquiry.

Introduction

Virtual reality (VR) is currently experiencing a massive resurgence in popularity. Dominant competitors in the market offer hardware at consumer attainable price points that continue a downward trend. Both the descent of hardware pricing and rapid innovation on the part of VR hardware manufacturers suggest that head-mounted VR has finally poised itself for mass adoption–something it failed to do during previous waves of VR popularity throughout the last few decades. Along with these hardware developments, there have been commensurate advancements in software tools that VR developers use to create artistic experiences for the head-mounted VR platform[1]. The Unity game and code libraries, such as SteamVR, increase the ease of developing such works even for those without traditional coding backgrounds.

As with the lowering of technological barriers to entry within the sphere of VR development, in almost every artistic discipline similar phenomena have occurred and are currently occurring. One such example is the recent lowering of barriers to entry in 3D animation. I personally first became aware of this around 2013 when I began to explore 3D animation. There were two key discoveries I made around this time that suggested a larger phenomenon was occurring. Firstly, it would have been very difficult for me to incorporate 3D animation into my work even five years prior due to the prohibitive cost of reasonable hardware and software authoring tools. Secondly, after attending most of the major national and international conferences in computer music, I noticed there was an increase in the representation of work integrating non-musical mediums, most notably 3D animation. It was clear that this evolution towards what I now term *postmodality* was happening not only in my own work, but among others internationally. Put simply, *postmodal* work is artistic work that releases the

[1] For my own research, I have used the Unity game engine to develop my VR simulation.

compulsory fealty of the artist to any set medium. I claim we are already in the incipient stages of the *Postmodal Movement* with respect to creative expression and production. Computer musicians who leverage this trend have the potential to be significant enablers of the Postmodal Movement across various artistic domains. Although this dissertation focuses mainly on the music-VR connection, it is important to understand the context into which this phenomenon fits and the implications it will have for future artistic work in the community at large[2].

Chapter 1 of this dissertation begins by building a case for the Postmodal Movement, drawing from and summarizing existing research on connections between music and other mediums that help to further substantiate the case. The information presented in Chapter 1 serves to provide the beginnings of a lineage of how the Postmodal Movement came to be.

Chapter 2 explores the deeper implications of existing information on the music-VR connection and integrates more tangentially related disciplines that contain useful information. As part of this section, theoretical principles are presented which aim not to be exhaustive and definitive (as the VR field is far too amoebic to rigidly pin down), but to be considered by music-VR artists interested in beginning their own research. Studies and writings on the symbolism of dreams, the psychedelic experience, myth, opera, and multi/cross/inter-media art are examined in this section and contextualized under a framework derived from modern foundations of research on mythology, specifically Joseph Campbell's monomyth model. The intent of Chapter 2 is to detail my own research path towards creating postmodal work, as well as to provide various jumping-off points for future researchers.

In Chapter 3, I apply the model constructed in the previous section to the development of my own VR case study: *Spektra*. The iterative nature of the creation of *Spektra* will serve to

[2] Although this movement is occurring in various mediums, this document will focus specifically on its evolution as applied to the field of computer music.

illustrate a potential framework that I have found useful for creating a work that utilizes the music-VR connection. It is my hope that this work will help other computer musicians wishing to integrate VR into their own work.

Chapter 1
The Postmodal Movement

Those identifying themselves as creative practitioners in (or adjacent to) the field of computer music know it is mutating rapidly. There is a shared, palpable sense that the current rate of change and continuing dissolution of boundaries separating its constituent fields of study will render "computer music" extinct. The same fate awaits other related disciplines in the digital arts. They will cease to exist solidly as individual fields, instead integrating into a seamless continuum of practices. "Computer music" as it is known now will be absorbed into a much broader multi-disciplinary field of study and practice. The term *postmodal* will be used to describe this broader field.

Scholars who examine language remind us of how terms used to describe complex phenomena and human activity are in a constant state of flux. Steven Pinker, in his work *The Blank Slate*, describes how linguistic terms repeatedly find themselves on what he calls a euphemism treadmill:

> Linguists are familiar with the phenomenon, which may be called the euphemism treadmill. People invent new words for emotionally charged referents, but soon the euphemism becomes tainted by association, and a new word must be found, which soon acquires its own connotations, and so on. Water closet becomes toilet (originally a term for any kind of body care, as in toilet kit and toilet water), which becomes bathroom, which becomes restroom, which becomes lavatory. Undertaker changes to mortician, which changes to funeral director. Garbage collection turns into sanitation, which turns into environmental services. Gym (from gymnasium, originally "high school") becomes physical education, which becomes (at Berkeley) human biodynamics […]
>
> The euphemism treadmill shows that concepts, not words, are primary in people's minds. Give a concept a new name, and the name becomes colored by the concept; the concept does not become freshened by the name, at least not for long. Names for minorities will continue to change as long as people have negative attitudes toward them. We will know that we have achieved mutual respect when the names stay put. (Pinker 2002, 212–13)

Is “computer music” simply on a Pinkerian euphemism treadmill on its way to being labeled *postmodal art*, or is there a real and substantive shift in the way creative types are imagining and using digital tools in the arts?

One only needs to observe the massive increase in recent years in the acceptance of multimedia[3] works into national and international conferences to see that there is reason to believe the shift is real. For example, why are entire concerts at festivals, such as the International Computer Music Conference, dedicated solely to multimedia art where animation or visuals dominate the sensory experience? Could it be that there is now a critical mass of artists who, in the past, associated themselves with “computer music” but are now ready (or have been ready) to galvanize a movement towards rendering the field obsolete, or, more mildly stated, recognize that the signature part of the community’s identity–a penchant for valuing cutting-edge technology–is pointing away from unimodal (e.g. audio, music) uses of technology and more towards the multimodal, or even postmodal.

In his 2001 keynote at the International Computer Music Conference, Cycling ‘74 founder David Zicarelli highlights how the computer music community continuously pursues new developments in technology. In his speech, Zicarelli details how technology and thus the systems available to the composer are informing the evolution of the computer music genre, “Part of this explosion is certainly coming from the increases in power in hardware and software that make composition within this medium a far less forbidding prospect than it used to be.” (Zicarelli 2001) In addition to this, Zicarelli foresaw that the sonic focus of computer music would wane, and the institutions with it: “I am willing to predict that the timbre obsession’s short

[3] Multimedia here meaning works involving more than one distinct medium with little or no fluidity between separate mediums.

lifespan may well end soon, and with it, we will see the decline into increasing irrelevance of the institutions that have supported it." (Zicarelli 2001). Although Zicarelli does not foresee the dissolution of mediums, his ideas suggest the nascent stages of the Postmodal Movement via decreased dependence on unimodal art and the increase in computational power.

The preoccupation with adopting cutting-edge technology seems to be primarily focused in the domain of academic computer music, but less relevant in other genres. Most obviously this contrast between new and legacy technology appears when considering mainstream electronic dance music.[4] The term DJ is still widely used in mainstream electronic dance music. The term was conceived as technologically relevant during its first uses as it referred to the use of sound systems driven by vinyl records. Some modern DJs still use vinyl records in their live performance setup (Boiler Room 2014), while others use a modern digital adaptation known as CDJs (Boiler Room 2018). Despite being digital, CDJs still mimic precisely the form factor and control scheme of their vinyl counterparts. This is significant to note because it directly contrasts the drive to reinvent completely found in the genre-lineage of computer music. Despite the developments in DJ technology, the musical instrument design of the genre looks backwards as much as forwards.

The genre-lineage of computer music is fluid, technologically reinventing itself, and highly concerned with the prescriptivism set about by the creation tools used by the artist. Faced with a plethora of new post-computer tools, the computer music community is now seeking a new direction for development, but this path is not as clear of a next step as it has been in the past. Kim Cascone, in his paper *The Aesthetics of Failure: "Post-Digital" Tendencies in*

[4] Use of this term is to include any electronically created music disseminated with the primary intent of providing music that an audience can dance to. Whether or not this pursuit is successful is irrelevant to the term as I'm choosing to use it here.

Contemporary Computer Music writes a call to action for researchers to continue this innovation:

> … new tools must be built with an educational bent in mind. That is, a tool should possess multiple layers of abstraction that allow novices to work at a simple level, stripping away those layers as they gain mastery. In order to help better understand current trends in electronic music, the researchers in academic centers must keep abreast of these trends […] In this way, the gap can be bridged, and new ideas can flow more openly between commercial and academic sectors. (Cascone 2004, 398)

Cascone highlights the need for researchers to seek new technologies. He also suggests making the boundary between commercial and academic sectors more permeable, possibly to vet new technologies for academic research. Cascone is not the only artist working in this sphere that proposes questions about what is to come after computer music without offering foresight into this future. An entire academic community and conference has formed around this question. The annual NIME Conference is described as follows:

> The International Conference on New Interfaces for Musical Expression gathers researchers and musicians from all over the world to share their knowledge and late-breaking work on new musical interface design. The conference started out as a workshop at the Conference on Human Factors in Computing Systems (CHI) in 2001. Since then, an annual series of international conferences have been held around the world, hosted by research groups dedicated to interface design, human-computer interaction, and computer music. ("International Conference on New Interfaces for Musical Expression" 2012)

The far-reaching possibilities of what can be included under the NIME umbrella suggests that again the question of "What's next?" is posed but not answered. In 2018 there was a small VR workshop at NIME. The description of this workshop highlights Cascone's urging to bridge the gap between academic and commercial sectors.

> Leading technology companies today are growingly becoming invested in VR audio with new products, such as Facebook's Spatial Workstation and Google's Resonance Audio, that facilitate the

> use of Ambisonics and binaural audio with popular VR platforms. ("NIME Workshop on Audio-First VR" n.d.)

Importance for Artists

In addition to outlining the influence of the commercial sector on modern research in this field, the workshop description highlights the fundamental challenge facing artists working in VR coming from computer music fields:

> However, most modern VR systems impart an ancillary role to audio, where sounds serve to amplify visual immersion. It is up to sound and music researchers to elaborate ways in which we can think natively about VR audio, and define the role of sound in the ultimate displays of the future. This workshop aims to investigate the concept of an "audio-first VR" as a medium for musical expression, and identify multimodal experiences that focus on the auditory aspects of immersion rather than those that are ocular. ("NIME Workshop on Audio-First VR" n.d.)

A subtle but identifiable shift is taking place in the lineage of computer music. More artists are beginning to realize that a severely diminishing point of return has been reached in audio-only discoveries. For research in this field to continue to innovate, and discover new ground, it must redraw or even eliminate the boundaries between audio and other mediums.

As of this writing, it is rare practice[5] for a consumer of entertainment to single out one sensory mode of experience for their entertainment. What is much more common and accepted in society is to enjoy multimedia experiences that use multiple sensory modes at once, such as a film or a live concert. In addition to this, most contemporary people's lives are dominated by a multimedia-rich Internet content accessible on personal devices at any time. *Therefore, the audience is primed to experience multi-media as opposed to single-medium content.*

[5] With possibly the notable exception of listening via headphones.

Audio production is now one of the easiest[6] artistic mediums to produce content in. Video streaming sites such as YouTube are filled with tutorials by young gurus teaching advanced concepts in music production, concepts that until ten or so years ago would have been limited to study at the academy. There is a bevy of smartphone apps available that, out-of-the-box, can produce musical results of reasonably high quality. Video production and 3D animation will follow this same trajectory, but the limiting factor is available processing power. For such applications to become simplified and deployable on mobile devices, these devices must have sufficient processing power[7]. Once becoming available on consumer level devices, the tools will be available to and usable by a wider range of creators[8].

Many electronic musicians will argue that the research they are doing and the audio they are creating is pushing the boundary of what is possible with currently available software. However, most general listeners will never be able to hear the minute nuances that they are taking pains to create in the audio. One could argue that the listening capability of the average user will evolve to accommodate listening techniques necessary to perceive these small changes. However, this is not typically what happens in the domain of computer music. For example, when the synthesizer was invented, its audio quality was easily perceivable as different than any other acoustic instrument previously heard. This research into new sonic territories is relevant and important, but it is not suitable for communicating with a general audience. If the crusade of the composer is to more effectively communicate their ideas with a general audience, they must begin to look beyond sound as I believe many composers are already doing.

[6] i.e. requiring the least computational power and having a large set of automated tools.
[7] Even in the year since making this statement, GoPro has introduced software that allows consumers to edit 360-degree video easily on their smartphones.
[8] I am focusing here on the topic of consumer adoption of these technologies because it tends to inform what creative technologies are available to artists.

As more composers continue to look beyond audio as the sole medium for artistic creation and as these audio production techniques become more available and more simplified for a general audience to use, the barrier to entry for using these techniques, and thus their value, will lower significantly. If the composer is to continue creating art requiring a high level of skill to create that also communicates their ideas effectively, the composer will have to think about how to thoughtfully integrate ideas from different mediums. There is a lot of stumbling going on with this concept at present[9]. These are the early growing pains of this new discipline and way of understanding art. The divisions between mediums are murky or even nonexistent. These early missteps are promising. Beginning to foray into this new undivided terrain are the avant-garde composers and artists.

The existing solution for composers looking beyond the medium is to branch out into exploration with multimedia, i.e. adding more mediums to accompany audio. This is typically accomplished through their own creation or through collaboration with an artist in another medium. This is a technique that has sufficed throughout the past few decades. I assert it will fall out of favor because of how rapidly technology and new mediums are rising into eminence, and conversely, falling away into obscurity. Ray Kurzweil details this phenomenon in his work, *The Singularity is Near*. Kurzweil theorizes that as processing power grows exponentially, technological development will also grow exponentially. This is Kurzweil's adaptation of Moore's Law (Kurzweil 2005, 59–74). Kurzweil's proposed end of this phenomenon is something he has dubbed the singularity. The singularity is the point at which technological development will happen at such a fast rate that humans will not be able to perceive it. Although the validity of this theory's future implications is up for debate, Kurzweil's formulation of

[9] An example of this is the high disparity in production quality of multimedia works seen recently at large computer music conferences.

Moore's Law can be applied to technological development over the last century or so with reasonable accuracy. The implications of this are far-reaching and affect not only technology but also the artists that work with that technology.

It is due to this exponential growth paradigm and Kurzweil's formulation of Moore's Law, that artists must prepare to abandon strict adherence to a set of disparate mediums. Multimedia art is the first step in this liberation of medium. Soon, the artist will have to go further than this. The artist will have to learn how to take techniques and principles from their own discipline and rapidly apply them to new mediums, sometimes working with these new mediums for the first time (and possibly the last time).

Towards a Definition of "Postmodal"

Postmodal is the term that contextualizes my larger body of research. It is necessary to sufficiently define this term to discuss my specific work in integrating audio and virtual reality. Before defining postmodality, one must define what it is not. Postmodality is not the same term as multimedia, although multimedia art can be under the umbrella of postmodality. Multimedia art is, by its most simple definition, artwork that employs the use of two or more mediums. The term multimedia says nothing about who creates the different component parts of the work. Multimedia work can be created by a single artist working in multiple mediums, or by multiple artists contributing to the work in various capacities across various mediums. Multimedia art is often compartmentalized. This compartmentalization is most evident in the division of mediums in the work. Whether the work is created by multiple artists, or a single artist each singular medium employed in the work is typically conscious of meeting specific ideals such as best practices, established techniques, etc. For example, in a multimedia work involving video, the

video artist will be aware of one of the most basic best practices of video art: aspect ratio. Most commonly, the video artist will select an aspect ratio that has been long established in the medium. If the artist chooses to use a different aspect ratio then they are consciously going against an established tradition and are likely aware of this. In multimedia art, each medium enters the picture with all of its baggage; its history, norms, etc.

Postmodality questions the division between mediums and posits the long-term superiority of a portable aesthetic[10] over technical knowledge. My first experience with this was when I created the work *INDRA//NET* for 3D animation and digital audio. In the period before the creation of *INDRA//NET*, I classified myself as a "computer music" musician who had some experience with 3D animation. My multimedia works before *INDRA//NET* followed the typical workflow pipeline of someone creating an animation. This pipeline involved the creation of the 3D animation and then sound tracking this animation after its completion. Before beginning work on *INDRA//NET* I had a very clear image of what sounds I wanted in the work. After meditating on the sounds for some time I began to have a clear image of what the visuals should look like. This unfolding process of ideas made it clear to me that it would be useful to develop audio first in the creation of that work. After finishing the audio for the piece, I began work on the 3D animation component. During this process the audio inspired me to create elements in the animation that I believe I would not have otherwise come up with had I created the visuals before the audio[11].

In this freely configurable process of multimedia creation, the very choice of mediums, how to employ them, in what order, etc. become as much a conscious part of the work as the

[10] A portable aesthetic is an artistic sensibility that is abstracted from the concerns of any one particular medium, thus is portable to any medium.
[11] The thinking around this process would eventually change for the creative works in this dissertation project to support more elements of improvisation.

sonic material. It may be important for an artist new to exploring postmodality to work with constraints that simplify the process. This could be in the form of focusing on one medium. As new tools for creating directly within a postmodal framework emerge, it is likely that the set of constraints will shift away from one which draws from what we consider now to be multiple mediums to a singular one. Starting with simplicity will enable one to conform and/or rebel against basic assumptions built into such existing sets of constraints. This will activate pathways for the artist to discover their own aesthetic sensibilities. My aesthetic was forged within the framework of European modernist composers. Once I learned the "rules" of the game of European modernist composition I was able to begin questioning the rules that did not make sense to me and accepting the rules that made sense to my own aesthetic.

Once the artist has developed an aesthetic in a given medium, they may begin experimenting with other mediums in conventional and unconventional ways. As the artist tries to port their aesthetic from their original medium into new mediums, they will begin to form a sense of a portable aesthetic.

It is useful to foster a sense of a portable aesthetic to create work that is truly postmodal, instead of it being merely multimedia and, thus, compartmentalized. Having a unique portable aesthetic allows the artist to permeate each of the mediums employed in a work with their own unique style. Without this portable aesthetic, each of the components of the work are clearly divisible from the other components of the work.

An example of postmodal art with a portable aesthetic is the multimedia work of Ryoji Ikeda. Ikeda is a multimedia artist who primarily creates glitch art. Understanding Ikeda's work through the lens of computer music, one can quickly identify a few aesthetic features. These features include rapid on and off audio envelopes, cyclical patterns, and sonic material that

seemingly embodies the concept of purity. Examining Ikeda's audiovisual installation *Test Pattern*, one can clearly see Ikeda's musical aesthetic manifested in the visual domain. *Test Pattern* is installed in a large industrial setting such as a warehouse. Projection visuals are cast onto the floor and one wall of the space. These projection surfaces are massive with some installations measuring hundreds of meters. The projection visuals mirror the aesthetic quality heard in the audio. Rapid on and off envelopes are clearly ported to the visual domain by means of white and gray rectangles that rapidly fade on and off instead of fading in and out. Cyclical patterns are represented in the visuals through recurrence of color and shape. The piece essentially uses no curves and most of the visual material consists entirely of squares, rectangles, and lines in black, white, or some shade of gray in between. Through full integration of all elements of the work by means of a portable aesthetic that is liberated from any one medium, the entire work becomes unified in a way that encourages the audience to focus on the gestalt, instead of the individual components forming the work.

A goal of my research is to work towards creating a postmodal work from conception to realization. The two main components involved in the work are musical feature extraction and virtual reality. I have attempted to integrate these two features in such a way that the lines between the mediums are significantly blurred. At every stage of the design process I made decisions about what was most representative of my portable aesthetic. The result is a simulation that integrates the two mediums in such a forged way that the user has difficulty delineating between the two.

Lineage of Proto-Postmodal Art

Before branching out it is advantageous to look for historical manifestations of postmodal art. A notable early example of historical postmodal art is the operatic work of Richard Wagner.

> Let us therefore first agree as to whom we must consider the creator of the Art-work of the Future; so that we may argue back from him to the life-conditions which alone can permit his art-work and himself to take their rise.
> Who, then, will be the Artist of the Future?
> Without a doubt, the Poet.
> But who will be the Poet?
> Indisputably the Performer
> Yet who, again, will be the Performer?
> Necessarily the Fellowship of all the Artists. (Wagner 1892, 81)

Wagner's early experiential research and philosophy laid early groundwork for the development of postmodal art. His integration of various mediums and position as auteur of the creative process put his ideas and artistry at the center of development in all mediums to be employed during his productions. Due to the massive resources necessary to put on these kinds of productions it is not surprising that Wagner's new paradigm did not catch on outside of his own coterie at that time. The near impossibility of constructing such a media-diverse work at that point in history is undoubtedly one of the reasons his work is still considered so outstanding by many scholars. At present day, media creation tools have become more accessible to artists using technology to such a sufficient level that Wagner's concept of *gesamtkuntswerk* will finally begin to catch on in the mainstream of artistic creation.

The Wagner quote above sets clear the path of development for postmodal art, as well as one of its central issues in development. Wagner specifies that the poet will be the artist of the future. In my work, I have chosen to interpret poet to mean a tone poet, i.e. a composer that tells

a story through music. The central challenge that this highlights is how to keep music as the central generating force of postmodal art.

Designing a Postmodal Work

To successfully design a postmodal work with a musical basis, I first defined the scope of my project. I subsequently considered which mediums might feed into the work. The bounds of the work were defined as follows: the work would be for the VR head mounted display, the system would generate a virtual world based on real-time audio input, the audio input could come from a musician wearing the headset and concurrently playing a musical instrument, or the user could stream music from whatever source they desire, such as Spotify.

After settling on such descriptors, identifying knowledge that can be garnered from each medium and how this knowledge can be transmuted among the mediums involved is critical. For example, music's primary contributions to VR-based art are that musicians already have an existing skill set that can be leveraged in the design of the work. Music's existence in a temporal framework is also a defining characteristic. Essential precursor technologies that helped to form the field of VR are also informative. Video game technology and its corresponding field of Game Studies are two foundational sources for mining the kind of knowledge that can inform the design process. This was a natural inclusion as the entire simulation would be constructed using a video game engine, Unity, in the case of this project.

The genesis of VR as a medium itself would also play an important role in my design process. The history of VR, albeit brief, is rich in detail and includes figures from the establishment tech world as well as fringe figures. Jaron Lanier and Ray Kurzweil are two figures under the umbrella of this topic who represent larger divisions in the tech world with

respect to VR. Researching the early days of VR development in Silicon Valley reveals many figures considered to be on the fringe at that time. These figures included science fiction writers and psychologists, among others. Science fiction writers active around this time functioned as journalists of a collective vision of the future of technological development in Silicon Valley in addition to larger, more decentralized countercultural movements. Psychedelic drugs and psychedelic drug culture also played an important role during this time. Psychedelic drugs served as a "unifier of mediums" for many having experiences with natural (non-synthetic) hallucinogens[12]. Many of the reports given by users taking these drugs seem to suggest that these hallucinogens are a chemical means of providing a postmodal experience–where the lines between mediums blur and meaning permeates multiple mediums making the distinction between them ultimately irrelevant. The culture surrounding these drugs is also deeply entwined and rooted in the Silicon Valley culture at that time. Counterculture figures such as Timothy Leary had distinct visions for the future of VR. It was not uncommon for counterculture figures, such as Leary and his associates, to mingle with developers in Silicon Valley working on VR (hackertrips 2015). A review of the historical origins of VR and its relationship to the knowledge produced by experts in psychedelic experiences should not be ignored when exploring useful design in VR and, likewise, design of postmodal works.

Some practical more meta-level considerations should also be taken into account when designing VR-based postmodal works. At the time of this writing, a bulky HTC Vive headset is one of several platforms providing the latest of VR experiences. Due to the sheer physical constraints of this apparatus, display ergonomics must be considered in the design process. Most concerns with the HTC Vive platform were readily apparent, but writing about and studying

[12] For more reading on this topic, the reader may be interested in Michael Pollan's book, *How to Change Your Mind*.

them explicitly aided in avoiding “accidents” in the VR lab such as running into inanimate objects in the real world while wearing the headset or tripping over the wiring tether.

In addition to serving as a proof of concept for the ideas presented in this dissertation, I wanted the VR experience to be a work of art. Aside from incorporating all of the design considerations listed above, the work would have to reflect my own personal aesthetic–a task that multiplies exponentially in its difficulty when working with multiple mediums.

Chapter 2
Notes on Research

Approaching this kind of postmodal development without any kind of existing formal framework, I found it helpful to think about the formative and pre-existing work in this domain before creating my own work and during the research phase. When doing research on art that exists outside of a strict medium, it made sense to source from a wide range of disciplines. After reading narrowly within the field of music technology, as well as widely in many other fields, it became clear to me that a survey of purely musical literature would not do for the creation of my own VR work. Bringing in knowledge from other fields seemed to be at the very core of VR innovation, so it followed that sources for design frameworks should come from various disciplines. Sourcing widely is the most important design principle for computer musicians foraying into VR territory since this medium emerges out of a number of different mediums. These various component mediums, such as game design and sound design, each lend unique perspectives that can be useful in the study of VR.

After a long period of segregation by medium, disparate fields will reintegrate. Wagner's integration of various mediums, though too futuristic for the time period he was operating in, created groundbreaking works of art, but unless one had robust financial support and extensive human resources it would have been nearly impossible for an individual artist to do this in a convincing manner during Wagner's active years, for example. Similarly, Jaron Lanier's ideas for the VR platform were visionary but unfortunately too far ahead of the state of consumer grade technology, thus prohibiting securing enough revenue to continue developing the technology that was needed for wide-scale adoption.[13]

[13] One such idea was a haptic feedback glove (thekinolibrary 2017). This concept has now been expanded from glove to bodysuit and is priced at the consumer level (Singletary 2017).

These roadblocks are becoming less imposing with the introduction of new technologies that allow creators to make aesthetically pleasing works in any digital medium, and some physical ones as well. An example of this in the physical space is the 3D printer. The 3D printer allows anyone familiar with 3D modeling software to fabricate their own physical objects, something that would have been prohibitively expensive until the introduction of this new technology. Opportunities for intersections of knowledge across fields are extensive, and have a long lineage in the arts, but are also starting to appear with more frequency in information science fields (Baguyos 2016).

When approaching creation in a new[14] medium, it can be helpful for the artist to consider what the component parts of the medium are and what might be researched to inform creation. Through the study of these component parts, the artist, applying their own aesthetic to the new field can begin to discover what rules work with their aesthetic and what rules go against it and should be broken. For this dissertation project, building a music-based VR simulation meant the decision to look at several component fields including science fiction, psychedelic drugs, video games/game studies, and music-based multimedia art.

When designing for any new technological medium, it is advantageous to look towards the writings of science fiction writers. Science fiction writings contain a wealth of insightful information about VR. A sci-fi author to study that is useful for research of future technology has an established track record of reasonably correct predictions and creates concepts that are inspiring to the reader. William Gibson meets both criteria in the field of VR. Gibson's work Neuromancer (W. F. Gibson 1997) is the seminal work of the cyberpunk genre. Gibson coined the now widely used term "cyberspace" (W. Gibson 1982), predicted the ubiquity of the web,

[14] A medium that is new to the world.

and foresaw the field of VR's expansion. Gibson also creates works that are inspiring to the reader. Neuromancer was the first novel to win the Phillip K. Dick Award, the Hugo, and the Nebula (Cumming 2014).

Music-VR and Postmodal Art

Time and data resolution are two primary elements that make musical instruments–or more broadly, musical signals–interesting input devices for VR environments. One composer and multimedia artist, Ge Wang, has experimented extensively within the topic of musical signal input on VR and written about the results of these experiments. Wang functions in a multimedia landscape that is based in music. One of Wang's own design principles is to make a multimedia experience real time whenever possible (Wang 2014, 2). This rule holds true on two different levels of development for the platform. Firstly, the environment must respond in real time to the user. This real time responsiveness invites users to play and interact as if the environment was a living thing. Overuse of fixed, i.e. non-interactive, media on such a dynamic platform creates an experience that is lifeless for the user, and immune to any interaction. An overly fixed environment, such as a 360-degree movie, allows a user to feel as though they are in the scene, but the lack of interaction creates a sense of being separated from the simulation. Secondly, the system must be as low latency[15] as possible. On the VR platform, a low latency system would be less than approximately 50 milliseconds, and a high latency system would be more than approximately 90 milliseconds (Meehan et al. 2003). If latency is present in the system, its use

[15] The term latency when referring to the VR platform in this dissertation should be taken to mean the time between physical action, and event rendered on screen, e.g. the time between a user moving their head, and the rendering of the virtual camera to represent this movement in 3D space.

should be intentional, i.e. not a failure of the technological system, and thus the result of careful consideration and conscious design. Unintentional high latency risks unwittingly making the user sick at worst and disconnected from the experience at best.[16] When in doubt, VR environments must have a high sensitivity to user input actions (such as the ability of the environment to distinguish between a gesture that takes 100ms and another that takes 20ms) and utilize low latency unless there are intentional reasons for doing otherwise.

The two primary domains the artist must keep in mind are time and data resolution. These two domains are what make the musician and the musical instrument compelling tools for VR data input. The musician and instrument then become both a high speed and high-resolution input device for the system, the kind of which is unprecedented in existing models such as the handheld controller.

VR Musical Instruments

A small amount of research has already been conducted by computer musicians in this domain.[17] Serafin et al. in their paper *VR Musical Instruments: State of the Art, Design Principles, and Future Directions* propose that the computer musician designing for virtual reality "make use of existing skills."

> Users of traditional instruments may not even be interested in using virtual replicas, since the original ones work well. Instead, we should discover the kinds of interfaces that are best suited for the VR medium. Using metaphors derived from interactions existing in the real world offer interesting possibilities. (Serafin et al. 2016, 27)

[16] Both states that may be desirable for the creator looking to intentionally invoke them.
[17] In the years it has taken to write and revise this document, this field has exploded in popularity. I served on the paper review board for the sub-topic of music-VR interfaces for both the NIME and ICMC conferences.

The gist of this observation is partially correct: VR musical interfaces should be unique to VR yet be based on existing and understandable real-world paradigms, although these paradigms should not necessarily be mere abstractions of traditional instruments. Understandable paradigms, from the musician's perspective, could be defined as using familiar gestures to the user's physical musical instrument. However, when designing for this platform, one must also consider that videogame-based paradigms have already been established. Considering that many computer musicians begin, at some point, as acoustic musicians, and at the very least are surrounded by similar colleagues during their training and studies, the point that must be discussed is acquisition of skills and techniques pertaining to video game-based VR paradigms. There are three useful acclimatization exercises for the computer musician attempting to make a foray into the VR platform: reading about VR development, experiencing VR games, and modding.[18]

Reading about VR development can equip the computer musician with a robust technical knowledge of the VR platform. The research presented by Serafin[19], et al. does a wonderful job of summarizing a wide range of papers in this vein. Yet, one should not devote all their time to this study. To use a musical comparison, devoting all of one's time to reading papers on the topic would be akin to merely reading, for example, Beethoven scores without listening to the music– theoretical knowledge is obtained, but something profound is missed.

Simply playing a wide range of VR games can be illuminating as to what game mechanics work well and which ones work poorly. After completing the game, one should immediately journal about the experience in order to look back on this documentation to observe patterns.

[18] This is gaming parlance that refers to the practice of modifying existing games.
[19] Stefania Serafin is one of the most eminent music-VR researchers.

Finally, another effective étude for computer musicians expanding into VR is to modify existing games. There is both an existing body of research on this practice[20] and a huge online community of both niche and widespread mods. Mods in this online community range from practical ones such as higher resolution textures for existing games (Livingston 2017), to entirely new games built on an existing platform (Montero 2012). These considerations guarantee that computer musicians will be able to create environments that make use of the idiomatic design elements derived from musicians as well as gamers.

Thinking more broadly about how a VR simulation is controlled, one can also explore using an audio signal as an input. This is a way of looking at the problem laid out by Serafin from a different perspective–instead of using gesture as control, what are the implications of using the sonic result of a musician's gestures? Whether music is being fed into the VR simulation from a live musician, or from a recording, the ideal simulation should be able to track significant changes in tone in a way that most accurately approximates real-time with minimal latency. What is minimal latency? Experience in music technology and digital audio can be useful here. A common introductory experiment in music technology is to play a sawtooth oscillator for an audience at its lowest frequency, for this example 5 Hz. At 5 Hz, the sawtooth oscillator produces a rhythmic clicking at the pace of 5 times per second. At this frequency every audience member can hear separate click events. As one increases the frequency of the oscillator, the clicks become faster, and eventually turns into a contiguous tone. The frequency at which this occurs can vary from about as low as 10 Hz for some individuals to about 30 Hz in others. The number most commonly given in this range as the low end of the range of human hearing is 20 Hz. The speed of oscillations at 20 Hz calculates to one oscillation every 50 milliseconds.

[20] Further reading in (Weinel 2010; Scacchi 2011).

Unsurprisingly this is the same latency time that Meehan et al. give as their proposal for latency speed in a "low latency" system. In the visual domain, other researchers have discovered that participants are able to extract some visual meaning from photos that were viewed for just 13 milliseconds (Potter et al. 2014).

The research in this dissertation suggests that to make a VR simulation perceived as real time to the user, the speed at which audio is tracked, musical analysis is performed, and a virtual manifestation of this data is created in the simulation should occur at an ideal speed of 13 milliseconds and must occur at a speed faster than 50 milliseconds. Slower speeds will be suboptimal for the user. Thus, musicians are already attuned to ideal low latency systems in the VR domain. They operate in and demand low latency and are capable of providing high resolution data at these speeds all the while maintaining artistic expressivity.[21]

Video Games

Video games are projected to fuel development on the VR platform in the coming years (Intelligence 2015; Research 2017; Gaudiosi 2016). Computer musicians that capitalize on this trend can open a massive stream of information that these artists can implement in their own works. Concepts presented by commercial video games such as 3D interface design, game mechanics, gameplay frameworks, are gradually improved through audience feedback — useful features are likely to be repeated in future games, and non-useful ones deprecated or modified for future iterations. Due to the financial incentive at stake in the gaming industry, games that successfully interact with the user typically have idiomatic game play mechanics and interface design. What might the computer music composer, interested in creating for VR, learn if they put

[21] Many data streams meet the first two criteria but will not provide much, if any, artistic gratification to the user.

a priority on playing–not only reading about–some of these notable video games? Might they then be able to take information about the success of *Rez*'s (Kobayashi 2001) audiovisual integration, and the failure of Alien Isolation's (Hope 2014) amplitude tracking mechanic (FredEd919 2014) and use this to create a more nuanced VR experience?

Game Studies

Although there is a lot of new research into the VR field from the perspective of computer music, there already exists an entire lineage of research into VR specific technology, and more broadly the game mechanics employed in these spaces. Game studies programs are becoming increasingly common. Some more forward-thinking institutions have even gone so far as to offer scholarships for students that play video games competitively (Deppe 2017; Murmane 2017).

As these programs grow, computer music composers interested in employing VR in their works can forge interesting collaborations with creators in game design programs in order to create simulations that are both well designed from a game design standpoint, and potentially utilize audio in a novel way (Simmons 2017). Many composers are already extremely adept at creating game mechanics for musicians to explore. This point has been illustrated countless times through "game pieces" (Zorn 1984), graphic scores (Haubenstock-Ramati 1976; Feldman 1951; Stockhausen 1992), and real-time interactive scores (Kim-Boyle 2014). In addition to the creative potential of these collaborations, a productive solidarity stands to be gained from forging a strong connection between computer music and game studies. Game studies is still young compared to other programs in academia. Its establishment in academia mirrors the beginnings of early computer music programs. Computer music was the product of a coming together of

engineers and musicians. At present day, one possible field of postmodal art could be the product of a mutually beneficial coming together of computer musicians that could benefit from a collaborator with more computer programming prowess, and computer programmers that could benefit from a collaborator with a sensibility for game mechanics unprecedented so far in the industry.

Papers in the game studies corpus address wide ranging topics including techniques, psychological studies, musings on artistic topics, as well as many others. Papers detailing less rigorously game-specific techniques, such as those explaining the different ways in which audio can be used to describe narrative events in a game (Jørgensen 2008), contain a wealth of information that can be abstracted into the computer music domain, even in works that only employ audio. Jorgenson states, "...the results demonstrate that audio and gameplay are closely integrated, and that the specific function of any sound signal in the game is highly dependent on contextual interpretation." (Jørgensen 2008, 5)

Human psychology is also explored throughout the game studies literature. One such compelling piece that may be useful to postmodal artists is *Balancing Risk and Reward to Develop an Optimal Hot-Hand Game* (Williams et al. 2011). The purpose of the William et al. experiment was to create a game that took advantage of the hot hand phenomenon. The hot hand phenomenon originated in basketball, and is defined as follows: if a player experiences success in a random challenge, their belief increases that they will continue to experience success. The purpose of the simulation created by Williams, et al. was to create a game that would give players the sensation of this hot hand phenomenon, and then use the game to research the statistics of the hot hand phenomenon. The implications of this research on music are plentiful. Computer musicians could use this information in the creation of their own game pieces,

including multimedia, or not, to psychologically bait players into experiencing the hot hand phenomenon. Not only is the game studies literature full of information that computer musicians can port to their own projects, it also offers a bridge between the computer music and game studies disciplines. This common understanding of jargon and concepts can more easily facilitate communication between collaborators and inspire computer musicians to create more mindfully and with more regard for established practices for the VR platform.

Lanier, VPL, and Silicon Valley Culture

Any writing on virtual reality must necessarily encompass thoughts in many different disciplines. Author, father of virtual reality, and entrepreneur Jaron Lanier serves as a connection point between many disparate disciplines. Lanier's foray into virtual reality began with his first company VPL Research. The "VPL" in VPL Research stands for "Virtual Programming Languages". Despite the company being most known for devices such as the DataGlove and the EyePhone, its original impetus was to create a programming language that used the virtual world to create programs in real time. The early products developed by VPL and early experiments conducted make up the fundamental DNA of modern-day game development. Products such as the DataGlove were far before their time and suffered from a lack of technological advancement sufficient to manufacture them in their ideal forms. Despite working in a rudimentary way, peripherals such as the DataGlove lacked the high level of data resolution that has become desirable and to a degree necessary to sustain deep immersion within a virtual simulation. Evolution and proliferation of original VPL concepts such as the DataGlove can be seen in many modern-day virtual reality peripherals such as the HaptX glove ("Haptx," n.d.).

Embracing glitches seemed to be core to the creative fabric of VPL. Unfortunately, the

process of embracing glitches in seeking to radically innovate is a drive that has become largely absent in large VR game studios. Lanier details. One of these such glitches:

> It was time for me to enter a brand-new virtual world.
> I squinted up at my hand against a perfectly clear blue sky. My gargantuan hand, soaring above downtown Seattle. It might have been a thousand feet from wrist to fingertip.
> There was a bug, obviously. A hand should be about the right size to pick up an apple or baseball, not bigger than a skyscraper. You shouldn't have to measure a hand in feet, much less thousands of them. (Lanier 2017, xiii)

Instead of most companies embodying a visceral drive towards these kinds of unique and unreal experiences, experiences that may one day inform a sort of "extended techniques" literature for the VR artist, modern-day development holds realism in higher regard.

More importantly than VPL's technological developments, was its status and function as a sociocultural hub of different ideas, and different groups of people that otherwise may have not met. These interactions between disciplines may prove fundamental for furthering innovation and allowing fields to evolve. Now more easily facilitated by technology, an increasing number of these interactions suggest that emergent forms of art will emerge so quickly and in such great number that one will be unable to document them before their next mutation. This phenomenon increases the importance of studying early collaborations that occurred during a slower rate of technological advancement. John Chowning writes about one such important collaboration at the genesis of the field of computer music:

> It is fortunate that these two scientists/engineers [John Pierce, and Max Matthews]—who cultivated a nexus between science and art, and who invited many composers and artists to their laboratories (e.g., Varese and Cage) to share the possibilities that they saw—were willing to place these nascent musical studies in the public view, confident in the intellectual content of their ideas, which few others could see (Chowning 2008, 1)

In the history of VR these collaborations are far reaching due to the fundamental nature of the platform being developed for. In the early days of Silicon Valley, Lanier had a run in with counterculture icon Timothy Leary. Lanier was required to sneak Leary out of a retreat he was leading in the trunk of a car (Lanier 2017, 150–52). After this initial meeting Leary worked at VPL (hackertrips 2015). Timothy Leary's main area of interest during this time was research on other mediums that could provide the LSD experience legally. This research resulted in a 1994 compilation of interviews and musings on this subject (Leary 1994). Included in the work are interviews with artists such as William S. Burroughs, Allen Ginsberg, Winona Ryder, David Byrne, William Gibson, and Susan Sarandon. The connection between psychedelics and virtual reality is an undeniably influential phenomenon that can be mined to engage many different groups of users through works of postmodal art.

Psychedelic Drugs

The connection between psychedelic drugs and VR is undeniable, but often, if not completely, ignored in academic literature. A full account of the possibilities for VR development must include this connection. This link has been made known at various points throughout the history of VR. Douglas Rushkoff's 1994 field report on cyberpunk culture *Cyberia* is a notable account of this (Rushkoff 1994). In this work, he interviews programmer Marc de Groot:

> "I think that people who like to expand their minds with things like higher math and computers and media are fundamentally the same people who would want to expand their minds with anything available. But this is a very bad political climate for talking about all this. You can't mix a thing like drugs with any intellectual endeavor and have it stay as credible." Yet, de Groot's apartment--which

> has one small bedroom dedicated to life's comforts and the rest filled with computer hardware--shows many signs of the alternative culture he prefers to keep out of the public eye. Dan Kottke's fractal Grateful Dead ticket is pinned to the wall next to the computer on which de Groot designed sound systems for VPL, the leading "VR" interface design firm... (Rushkoff 1994, 24)

Although de Groot's musing on the invalidity of "mixing a thing like drugs with any intellectual endeavor" was certainly true in 1994 when *Cyberia* was published, these stigmas are gradually disappearing. Psychologist Rick Strassman has begun to study one of these drugs:

> 1991 began the first new research in the United States in over twenty years on the effects of psychedelic, or hallucinogenic, drugs on humans. These studies investigated the effects of N,N-dimethyltryptamine, or DMT, an extremely short-acting and powerful psychedelic. During the project's five years, I administered approximately four hundred doses of DMT to sixty human volunteers. This research took place at the University of New Mexico's School of Medicine in Albuquerque, where I was tenured Associate Professor of Psychiatry. (Strassmann 2001, xv)

Strassman includes various session reports from his subjects. If taken out of context, most of these session reports could be understood as descriptions of a VR experience. One of Strassman's subjects, Aaron recounts, "...I saw a psychedelic, Day-Glo-colored space that approximated a room whose walls and floor had no clear separations or edges. It was throbbing and pulsing electrically..." (Strassmann 2001, 182)

The connection between VR and psychedelic drugs for artistic purposes is also undergoing a resurgence. The internet forum website, Reddit, has an entire section of the site devoted to "exploring the wonderful worlds created in VR whilst on psychedelics." (jonesRG, ShortBananaMan, and fightwithdogma 2015). In addition to this, avant-garde researchers are beginning to exploit existing games with the intent of creating "altered states of consciousness" in the user. The most eminent writer in this subfield is Jonathan Weinel. One of Weinel's experiments involves remixing the video game *Quake*. Through use of a MaxMSP patch, Weinel

creates a version of Quake that attempts to put users in an altered state of consciousness. Weinel notes that many commercial games have attempted to portray these altered states, such as *Super Mario Brothers*, *Grand Theft Auto: Vice City*, and *Duke Nukem 3D* (Weinel 2010, 23).

Display Ergonomics

> ...developers should be mindful of the potential strain and discomfort introduced by wearing an HMD and of the issues currently introduced by wires (e.g., a 360-degree turn can leave the user entangled). (Serafin et al. 2016, 28)

During the development of my VR environment, I began beta testing with musicians. A test with one participant, shakuhachi player Kojiro Umezaki, highlighted the importance of considering display ergonomics. Once Umezaki had put on the headset, he began with a few steady tones on the shakuhachi to ensure that the simulation was ready and tracking audio. After verifying this, he launched into a quick flurry of notes, settling on a long, sustained tone. Throughout the duration of this sustained note, Umezaki began shaking his head more and more rapidly to create vibrato on the instrument, as is a common practice on shakuhachi. Due to the weight of the HMD being used, the headset migrated out of alignment on his head. These are important considerations to keep in mind for computer musicians developing for the current wave of VR HMDs. There is an exception to this consideration if one is working on long term development. The general sentiment is that the future of VR will be on mobile devices, not on bulky, computer-tethered HMDs. Eminent figures such as co-founder of Oculus VR, Jack McCauley have echoed this sentiment (TechRadar 2017).

Aesthetics

Some Aesthetic Principles

7) Simplify: identify core elements, trim the rest

8) Animate, create smoothness, imply motion: it is not just about how things look, but how they move

9) Be whimsical, organic: glow, flow, pulsate, breathe: imbue visual elements with personality

10) Aesthetic: have one; never be satisfied with "functional" (Wang 2016, 1)

The VR platform offers several existing tools that computer musicians can use to make their environment look more visually appealing. Distribution tools such as the Unity Asset Store (Unity 2010) offer free and paid downloads of 3D models, textures, shaders, etc. With so many free tools and resources such as the Unity Asset Store on the web, even a computer musician with a weak grounding in motion graphics can create something that looks to be of a higher quality than grey platonic solids. The VR platform is designed to be an intensely visual way of presenting content to the user. Ignoring this fact is to ignore the platform being developed for.

The rapidly shifting terrain of media technologies available to the modern composer is denser than any previous era. The composer has at their disposal an unprecedented number of creative tools all with various preconfigured assets designed to make creating more rapid. This unprecedented landscape of tools subverts existing compositional approaches. In previous eras, composing for a set instrumentation, and taking months of time to work on a composition made sense. During the time of Beethoven, for example, the most immediate feedback providing tool that was at the composer's disposal was the piano. This audio feedback mechanism would allow a composer to "beta-test" pitches and rhythms but would not be capable of simulating timbre, envelope, or many other facets of sound. This rough approximation of the final composition necessitated a slower paced, more arduous compositional process. Despite the insistence of many composers steeped in this tradition, this approach must be questioned in regard to new

technology available to the modern composer. Modern compositional technology allows hyper-realistic simulation of the final composition in the case of traditional composition.[22] In many cases, such as in that of many types of electronic music, the composer now works directly with the final composition, in real-time. Applying traditional approaches of composition to these new technologies is far from idiomatic.

The adherence of avant-garde compositional tools to a strictly sonic medium appears to be dissolving in favor of more postmodal paradigms. The lineage of research becomes more obfuscated as the tools being researched integrate disparate artistic disciplines. This obfuscation necessitates branching out into tangentially related fields of study. For the electronic music composer interested in expanding into VR development, research in video games, psychedelic drugs, and other fields can be advantageous for research. In addition to these outside fields, studying writings on music technology and abstracting these concepts for introduction into the postmodal domain should occupy the core of this research.

Intermodal Connections

After having completed the music-based VR environment *Spektra*, iteratively developing it with the help of musicians and using it in live performance, I reflected on a macrocosmic sense on the entirety of the project from the viewpoint of music composition. In order to draw concrete conclusions from the work as it applies to modern music composition, I needed to strive towards the creation of a framework of terminology and understanding that had previously existed in its components but not in its totality. This is always the charge of those that venture into VR

[22] I refer to traditional compositions here as those utilizing Western standard notation intended for performance by acoustic musicians.

development. VR does not have a long lineage like other artistic mediums, and it is essentially invisible technology since it can be used towards so many different practical and wonderfully impractical ends. It seemed senseless to use the same frameworks posited by VR developers working in augmented reality surgery, or even to an extent, VR game design.[23] "VR is a hard topic to explain because it's hard to contain. It directly connects to every other discipline." (Lanier 2017, 54)

Following this argument, I conducted more research in order to forge a template for understanding a small subgenre of VR within a malleable net of definitions, and thus creating more music-based VR. The areas I researched in this pursuit included dreams and psychedelic drugs. Notable figures in VR research, such as Lanier, suggest that these seemingly disparate disciplines might be intimately linked to VR (Lanier 2017, 149).

While this research informed my dissertation work, it was not central to the findings discussed in this dissertation, so I will not give it a full treatment here. Instead I will briefly highlight formal and stylistic influences in research on dreams and the "cyberpunk" subculture. These two disciplines encapsulate findings present in many other related disciplines that I researched for my own work, and thus will provide a summarized view of this broader research. The distillation of many findings in these disciplines seem to mirror the concept of Joseph Campbell's monomyth which will be discussed at the end of this section.

[23] One should note however that there are varying levels of severity to this exclusion. VR game design provided some interesting concepts, and even basic terminology for working with music-based VR. However, it proved to be a pursuit more akin to shoehorning than science to force this genre of work into another if it was not a perfect fit.

Dreams

VR may be the most centrally situated artistic discipline (Lanier 2017, 54), but it shares a special bond with many fields. Many figures key to my VR research were involved in research spanning two or more of these topics: Douglas Rushkoff (drugs, science fiction), William S. Burroughs (dreams, drugs, science fiction), and Jaron Lanier (VR, dreams), just to name a few. This research helped to inform my dissertation work but did not make up the core of it so I will provide a brief overview of this information as presented by Lanier instead of a full treatment.

Jaron Lanier, as a figure whose research spanned multiple disciplines serves as a good starting point. Lanier's own writing suggests that the study of dreams is a useful influence on VR design:

> Twentieth VR Definition: Like lucid dreaming, except that (a) more than one person can take on roles in the same experience, (b) the quality is not as good, and (c) you have to work to program VR if you want to be in control, which you should want. Dreams, meanwhile, are often best if you don't seek to control them. Even Stephen La Berge seeks to be nonlucid in most of his dreams since it is in untethered dreams that the brain surprises and renews itself. (Lanier 2017, 149)

In order to parse out the utility of dreams in VR design, Lanier's comparison must be dissected and reconstructed through the lens of the artist. Points (a) and (b) are reasonable, but the artist will likely disagree with part of point (c). There is no "should" in art. Expectations of the audience can be constructed, but an audience member brings with them the totality of their experience when viewing a work of art. There are of course homogenizing factors between audience members (a concept that will be examined in great detail later). However, Lanier does not make a strong case for why someone "should" want to control the VR experience. The utility of this statement is clear when considering the development goals of a team working on a AAA

title VR video game.[24] A video game such as this is intended for mass markets, not intended to subvert any expectations, and supposed to fit most existing paradigms of VR use. Lanier was primarily working outside of these frameworks, thus his "should" remains confusingly motivated.

Control, understood in this excerpt to mean some kind of user-driven way of shaping the VR simulation, as opposed to passively watching a 360-degree video, is an erroneous construction. Existing research has clearly demonstrated that awareness is dynamic and not static (Chabris and Simons 2011, 18). This dynamic awareness can even be demonstrated through formats with a lower data-resolution than 360-degree VR video, such as traditional 2D video. "Your moment-to-moment expectations, more than the visual distinctiveness of the object, determine what you see—and what you miss." (Chabris and Simons 2011, 18). The users' perceptions are secondary to a goal. This influence of expectations over visual perception suggest that the locus of control is distributed between choosing what one intends to be aware of and one's own physical "control" actions. Thus, some degree of user control is still present even if the VR simulation is not designed to accommodate for it. Lanier's account of La Berge's desire to remain nonlucid in most of his dreams seeks to draw clear lines between control and non-control (Lanier 2017, 148–49). Upon waking, if some part of a dream is remembered, and another part is forgotten, there is then perhaps some control on the part of the dreamer as to how deeply to probe their memory for the "missing pieces" of the dream. These opposing states suggest that there is an ambiguity instead of a clear demarcation between what we perceive as control and non-control as it relates to a visual stimulus.

A modified definition of the link between dreams and VR might be posed as a

[24] AAA title video games are to video games what the "Blockbuster film" is to cinema.

modification of Lanier's own statement on the matter (Lanier 2017, 149) as follows (my own refactoring of Lanier's quote):

> VR is like lucid dreaming except that **it is possible to share the experience with multiple participants, as opposed to the solitary experience had in lucid dreams. Currently, VR technology cannot provide the same data resolution provided by the dream-world but extrapolating into the future the historical trajectory of technological advances, it is reasonable to assume that the data resolution of VR will be on par with the dream-world in the near future. The degree of control that the artist-developer wishes to give to the user is within their discretion and will ideally aid in portraying the modus operandi of the work of art. Simple actions such as awareness focal points, removing the physical headset, and sense-making of the experience will always be within the user's locus of control.**

Cyberpunk Culture

The collective unconscious, "does not derive from personal experience and is not a personal acquisition but is inborn." (Jung and Hull 1981, 3). This is what McKenna implies with his use of the term "Gaian mind". This can be deduced from other mentions of concepts related to the Jungian collective unconscious, such as, "[Psychedelics] cause us to connect and reconnect the contents of the collective mind in ever more implausible, beautiful, and self-fulfilling ways." (McKenna 1993, 130). In *Food of the Gods* McKenna specifically lauds some of Jung's contributions to the research of shamanism, mentioning the collective unconscious specifically (McKenna 1993, 134).

Now that one can understand what McKenna implies by his use of the term Gaian mind, one can extrapolate the implications of this concept into the domains of psychedelics, VR, and music. A very clear articulation of the link between psychedelics and VR is the cyberculture documentary *Cyberia: Life in the Trenches of Hyperspace* by journalist Douglas Rushkoff. *Cyberia* is a rare glimpse into the genesis of modern cyberculture. Written in 1993, Rushkoff

immersed himself in different tech subcultures–most of these also countercultures–in order to capture a moment of incredible idealism, potentiated by the nascence of digital technology. Rushkoff poetically describes this as, “a moment when anything seemed possible. When an entire subculture — like a kid at a rave trying virtual reality for the first time — saw the wild potentials of marrying the latest computer technologies with the most intimately held dreams and the most ancient spiritual truths. It is a moment that predates America Online, twenty million Internet subscribers, Wired magazine, Bill Clinton, and the Information Superhighway.” (Rushkoff 1994, sec. Preface).

Based on Rushkoff’s well-researched definition of the titular concept, Cyberia, one can easily see the similarity between this tech-inspired concept, McKenna’s drug-induced Gaia, and Jung’s collective unconscious:

> The people you are about to meet interpret the development of the datasphere as the hardwiring of a global brain. This is to be the final stage in the development of "Gaia," the living being that is the Earth, for which humans serve as the neurons. As computer programmers and psychedelic warriors together realize that "all is one," a common belief emerges that the evolution of humanity has been a willful progression toward the construction of the next dimensional home for consciousness. We need a new word to express this boundless territory. The kids in this book call it Cyberia. (Rushkoff 1994, 4)

Furthermore, it is clear that Cyberia can operate on a symbolic or nonphysical level, although many figures in this subculture saw Cyberia as a physical implementation. For example, Eric Gullichsen’s writing in a work compiled by Timothy Leary viewed Cyberia as an “isomorphic mapping of neural structure to silicon […] a reification of Jung’s collective unconscious: the global information network.” (Leary 1994, 201). The definition reached in Rushkoff’s work is more nuanced and explains Cyberia as a Novakian transphysical space (Novak 1996, 3)

> Cyberia is the place a businessperson goes when involved in a phone conversation, the place a shamanic warrior goes when traveling out of body, the place an "acid house" dancer goes when experiencing the bliss of a techno-acid trance. Cyberia is the place alluded to by the mystical teachings of every religion, the theoretical tangents of every science, and the wildest speculations of every imagination. Now, however, unlike any other time in history, Cyberia is thought to be within our reach. The technological strides of our postmodern culture, coupled with the rebirth of ancient spiritual ideas, have convinced a growing number of people that Cyberia is the dimensional plane in which humanity will soon find itself. (Rushkoff 1994, 4).

One can derive from Rushkoff's definition and Gullichsen's, then, that Cyberia is currently a conceptual space. This conceptual space is tentatively transphysical, and this transphysicality is increasing over time. At some point Cyberia may become a physically inhabited place through some kind of human-computer interface, or it may remain a dialogue between humans and technology creating a kind of third unembodied consciousness.

The manifestation of the collective unconscious is regularly found in improvisation between two or more artists, or, a more Cyberian distinction, between artist and technology. This concept is eloquently put in the work *The Third Mind* by William S. Burroughs and Byion Gysin:

> While the history of painting and the plastic arts shows them generally to have been a collective affair in their conception and their realization—even after the notion of the artist-paradigm came to dominate every other mode of representation—literature has been a solitary practice, an ascesis, a withdrawal, a prison of words. Collaborations in this domain were rare. If we except certain accidental associations, the value of which is open to question, we find that few works have been composed as the result of a joint effort. (Burroughs and Gysin 1978, 9)

For *The Third Mind* Burroughs and Gysin developed a technique of literary improvisation, allowing the two to interact in real-time. In addition to fighting the "ascesis" of literary solitude, this practice allowed the writers to form a collective consciousness between

them. Although Burroughs and Gysin do not discuss this process in depth past the excerpted passage, research into musical improvisation shows similar trajectories:

> The success and coherence of our quartet improvisation then relies on the fact that each player in our group has a highly distinctive musical "signature" and that each makes consistently strong and imaginative musical gestures. Curiously, this creates a kind of structure that is both dialectical and narrative. It is narrative because the sound- action archetypes form a kind of "collective conscious," a developing story or, more broadly, a narrative arc which is understood as the background against which events take place. At the same time the structure is dialectical because new archetypes can be introduced and meanings and archetypal roles may shift. The structure will also be dialectical in the sense that the kinds of archetypal meanings that may arise and the kinds of reactions to or manipulations thereof are fundamentally dependent on the cumulative experience of the individuals involved... (Burrows 2004, 11)

One can easily see the methods and discoveries of Burroughs and Gysin on display in this writing by Burrows. Burrows writes that each member of the quartet has their own style. Constituting this style is a series of gestures unique to the proclivities of each musician (individual cognition), and also a collective mind (group cognition, third mind) (Burrows 2004, 8). It is this collective mind that ultimately guides the micro-actions, or individual cognition of the ensemble members into a unifying, narrative structure.

I wish to now draw the reader's awareness towards two key points derived from studying the research in numerous fields through examples of creative practitioners both sober and under the psychedelic drugs. Firstly, Jung's collective unconscious can be seen masquerading as many different terms such as, but certainly not limited to, Gaian mind, third mind, and Cyberia. Secondly, this collective unconscious mind, posited by McKenna to be readily accessible through the use of psychedelic drugs, also appears accessible under other conditions. Eminent psychedelic researcher Rick Strassmann observed startling similarities between the psychedelic drug states and traditional Eastern meditation (Strassmann 2001, 25). It is not an unwarranted

connection to make, then, that activities such as the linguistic improvisation observed in the example of Burroughs and Gysin, or musical improvisation demonstrated by Burrows also embody these characteristics. Although psychedelics provide users with a facile method of accessing this state, other activities such as creative improvisation with a group, or with technology, also afford this possibility.

It is my assumption that there is little research in the subfield of musical collective unconscious due to its taboo nature. A robust and expanding tome of psychedelic research exists despite the fact that even undertaking research in this field remains to a large degree still itself a taboo act. It is my hope that through drawing these clear parallels between practical musical study and states experienced under the influence of psychedelic drugs, we can shed this taboo and acquire the knowledge there that is ripe for harvest. Timothy Leary puts the impetus for this taboo most eloquently in the introduction to *Chaos and Cyberculture*:

> For centuries there existed a fanatic taboo against scientific understanding. Why? Because of the fear of Chaos. The facts about our (apparently) insignificant place in the galactic dance are so insulting to the control freaks who try (so manfully and diligently and seriously) to manage Chaos that they forbade any intelligent attempts to look out there and dig the glorious complexity [sic].
> At one point consciousness-altering devices like the microscope and telescope were criminalized for exactly the same reasons that psychedelic plants were banned in later times. They allow us to peer into bits and zones of Chaos.
> Galileo got busted and Bruno got the Vatican microwave for showing that the Sun did not circle the Earth. Religious and political Chaos-phobes naturally want the nice, tidy, comfy universe to cuddle around them.
> In the last century science has developed technical extensions of the human sensorium that specify the truly spooky nature of the complexities we inhabit.
> Stellar astronomy describes a universe of fantastic multiplicity: a hundred billion tiny star systems in our tiny galaxy, a hundred billion galaxies m our teeny universe. (Leary 1994, xiv)

Monomyth

Joseph Campbell's *monomyth* can serve as a helpful device for structuring a postmodal work. The monomyth, also known as *the hero's journey*, can be visualized as a circle, with various component parts of the cycle placed proportionally around the circle. A story can begin at any point in this cycle, and the cycle can, and often does play out on many time and magnitude scales. Typically, a story begins at the 12 o'clock position of the cycle and progresses in counterclockwise fashion. A call to adventure is foisted upon the hero.[25] The hero acquires one or more helpers. There is a threshold crossing that can manifest in many forms; some commonly used ones such as the night-sea journey[26] or whale's belly[27]. There are further tests, or trials for the hero and helper(s). Further helpers are acquired at this point, sometimes a deus ex machina, or conveniently encountered helpful figure.[28] A number of symbolic apotheotic things can occur at this point. There is then a flight and some kind of returning action. The hero returns to their community with an elixir[29] won as a result of their trials which is shared with the community.

Campbell's research advances and refines the ideas about archetype put forth by Carl Jung. Instead of focusing on multiple archetypes like Jung, Campbell narrowed his research to that of one archetype, the hero. Other Jungian archetypes make appearances in Campbell's research such as the Divine Mother or the Wise Old Man, but these characters are always

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[25] Of course, the protagonist can bow-out once approached by the call to adventure. This does not make for a notable story, and thus is not written. If it is written, it is not well received, and disappears. This mythological Darwinism is a key reason that Campbell's monomyth is universal. In J.R.R. Tolkien's fictional universe in *The Lord of the Rings* trilogy, the story focuses on the protagonist Frodo because he heeds the call to adventure, along with associated characters. The comprehensive universe created by Tolkien could have easily focused on Rosie Cotton who remained in her homeland and did not accompany Frodo on his journey, but this would not have formed a particularly interesting story.

[26] Hemmingway's *The Old Man and the Sea*

[27] Pinocchio

[28] In *Harry Potter and the Chamber of Secrets* these helpers come to Harry during a battle with the basilisk. Just as Harry is about to be vanquished, Fawkes the Phoenix brings Harry the Sorting Hat, from which he pulls the Sword of Gryffindor. Fawkes wounds and distracts the basilisk so that Harry can stab it with the sword.

[29] Elixir could be an actual elixir, new knowledge, etc.

ancillary and presented as in-relation to the hero.

In Campbell's most detailed work on monomyth, *The Hero with a Thousand Faces*, he details seventeen potential mythemes that fit under three larger gestures that make up the monomyth. In my description of how this concept applies to postmodal creation, I have narrowed the seventeen components down to only the most relevant. The three larger gestures which have already been detailed in this writing by different terminology are Departure, Initiation, and Return in Campbell's parlance.

The artist must start somewhere–Campbell's "departure." Any artist who has been creating for some time realizes that one of the hardest parts of the creative process is getting started. Oftentimes, genuine creativity arises for the artist when he makes a mistake that leads him into uncharted territory. "A blunder—apparently the merest chance—reveals an unsuspected world, and the individual is drawn into a relationship with forces that are not rightly understood." (Campbell 2008, 42). Regardless of whether the artist begins with a blunder or direct intention, in our Western education system, a mentor is usually present, "…a protective figure (often a little old crone or old man) who provides the adventurer with amulets against the dragon forces he is about to pass." (Campbell 2008, 57). This Departure stage symbolizes the passing of the artist from the world as they know it into the unknown—Orpheus crossing into the Underworld, the drug taker leaving the garden and entering past the hagazussa into the wilderness, or the artist willing a new piece into existence:

> …the hero goes forward in his adventure until he comes to the "threshold guardian" at the entrance to the zone of magnified power. Such custodians bound the world in four directions—also up and down—standing for the limits of the hero's present sphere, or life horizon. Beyond them is a darkness, the unknown, and danger; just as beyond the parental watch is danger to the infant and beyond the protection of his society danger to the member of the tribe. (Campbell 2008, 64)

The artist enters the world of the unknown, where he will be tested through a series of trials (initiation). Here the artist may be aided by advice or wisdom imparted by the protective figure he may have encountered during the departure phase. These trials for the artist can range from the trivial to the severe. Things such as computer problems or running out of art supplies could be seen in the vaguest sense as minor trials. More significant trials have notably been encountered by many artists—the fact that we have remembered and reported these details throughout history is a testament to the importance of the monomyth framework.

Terminology that Campbell uses to refer to these trials include belly of the whale and road of trials. The resolution to these low points includes father atonement, which is a reckoning with the archetypal father, or tradition, and apotheosis, which is a nullification of opposite-pairs, such as the Buddha's realization during his enlightenment.

Ceremoniously or unceremoniously, the artist finishes their work, or performance, and subsequently returns to the ordinary world. This ordinary world in artistic terms, could include interacting with the audience after a live performance or releasing an album. In any of these cases, it is the point when the work largely leaves the control of the artist, or when the artist returns from the creative role. Ostensibly the artist brings something of value, an elixir back to the community. This elixir renews and reinvigorates the community that receives it, even if it is bitter medicine.

Of course, the artist can also refuse the responsibility of returning. "Even the Buddha, after his triumph, doubted whether the message of realization could be communicated, and saints are reported to have passed away while in the supernal ecstasy." (Campbell 2008, 167)

Chapter 3
Synthesis of Research and Creative Work

I utilized the framework most succinctly put by Campbell in my development of the audio responsive VR environment *Spektra*[30]. I found Campbell's framework to be particularly useful when venturing into this mostly foreign and uncharted territory of development. Virtual reality, as explained throughout this writing, has a lineage, a set of preconceived notions and "best practices", but at its current state offers to wipe the slate clean again.

The hardware used for the project consisted of an HTC Vive headset, two HTC tracking base stations, and a modern computer using a Radeon RX480 graphics card. More peripherals were available, but since the hardware had to be moved from the laboratory into the performance space, economy of size was of the utmost importance.

The first prototype I constructed to test audio-tracking in VR was a complex and obtuse pipeline. The initial beta involved both my personal MacBook Air for musical information retrieval, and the aforementioned VR-capable PC for data sorting, mapping, and live VR rendering. I initially used various audio-tracking libraries in the MaxMSP programming language to perform basic musical feature extraction. The importance of using MaxMSP in this context was to leverage its inherent design as a real-time processor and generator of media. This would keep open options for including improvisation in subsequent works. The audio tracking data was scaled to values residing between 0.0 and 1.0, the resolution of this range consisting of single-precision floating-point numbers. I provided fine-resolution interpolation to this data to smooth transitions. The smoothed data was then packaged into OSC format and broadcast over a local, ad-hoc WiFi network being hosted by the rendering PC.

[30] Spektra can be downloaded for free at this link: https://github.com/jcpsimmons/spektra-public-prerelease

The render PC was running Unreal Engine 4, a game engine software used for Real Time VR rendering. Unreal Engine 4 natively includes a graphical programming language called Blueprints for rapid prototyping. Using UE4-OSC, an "OSC plugin for Unreal Engine 4 to send and receive OSC messages with blueprints!," I built a Blueprints script to receive the OSC data coming from the laptop (Buisson 2014). Then I mapped this data to the Y position of four cubes spaced proportionally in virtual space and rendered using Unreal Engine.

The prototype served as a working proof of concept, but the reliability of UE4-OSC and the use of an additional computer were both suboptimal features. At the time of this writing, the UE4-OSC code has not been updated on GitHub in over a year. Sometimes it would abruptly stop receiving data or behave in other unpredictable ways despite network speeds and fidelity that proved to be more than adequate in tests run outside of Unreal Engine.

My decision to work towards having the entire tracking and simulation operation run on one machine was a more philosophical one. I was interested in using VR for many reasons. One of which was the solitary experience it provided. In my research, this sort of out-of-the-ordinary experience had in solitude seemed to resonate with many shamanic traditions written about by figures such as Terrence McKenna, Richard Alpert, and Timothy Leary. Honoring this choice of medium, I extrapolated that the entire simulation should be a solitary experience. Many well-meaning voices during this development stage urged me to make the experience social, to somehow include other musicians, or other virtual avatars, but I wanted to employ the use of abstract symbols, gleaned from mythological and psychedelic drug research, to provide the user with a more solitary and introspective experience.

I decided to continue to utilize musical information retrieval as a means of controlling the virtual world, but in honoring the solitary aesthetic suggested by the VR headset, I wanted the

entire experience to be self-contained, imperceptible to anyone outside of the headset. Through using a virtual loopback audio interface freely available on Windows (VoiceMeeter), I was able to reroute local audio, in most test cases from the Spotify app running in the background, directly to the VR simulation, and also to the headset-wearer's headphones.

At this point of development, I began to work with a colleague in the PhD program and competent C# programmer, Mark Micchelli. Micchelli's mastery of musical improvisation combined with his programming ability made him the perfect complement to the project. With Micchelli's coding ability in C#, we were able to use the Unity game engine. Unity is comparable to Unreal Engine but does not natively include a visual scripting system. Thus, the game developer must use C# for all game scripting. After testing numerous candidate libraries, we settled upon one named "Reaktion".

Reaktion was developed by Keijiro Takahashi and is distributed freely on GitHub (Takahashi 2014). Takahashi works for Unity, and his GitHub is full of repositories of avant-garde Unity engine technology and scrapped development trees from earlier ideas. It is an important resource for any modern Unity developer. Reaktion is a Unity library dedicated entirely to receiving OSC data and mapping it to various game parameters. Furthermore, the software is open source, so with Micchelli's coding abilities, the possibility of modding and interpreting Reaktion data was available. The resulting simulation went through many iterations of development.

Showcase I Development Pipeline

At this point, the OSC data import problem, and local audio routing problems were both solved and development on a usable version of *Spektra* could formally commence. The development pipeline progressed in this manner: I would make rough paper sketches for a scene to be integrated into *Spektra*. I would then work on the 3D art for the scene and import it as discrete game objects into the Unity engine. After creating the static scene, Micchelli and I would brainstorm mappings to be made between audio stimulus and 3D reactivity. We would A/B test these mappings in the simplest form and choose the more effective ones. These would then be added to the code by Micchelli. We would perform further testing, and then fine tune the mapping values and ramp functions.

I completed all scene sketches for *Spektra* with Campbell's Hero Cycle in mind. The user would begin inside a large structure floating in outer space. This structure was symbolic of the womb, home, stasis, conception, a buffer against the freezing cold of outer space. To further enhance this connection, I created an egg-shaped assembly inside the structure that the user could walk into and be inside, and floating semen-like beams recurrently swimming towards the egg.

After this home/starting point scene, a lottery system was implemented in the code to select random scenes without repeating scenes until the entire aggregate had been completed. The inspiration for this development came from the serialists' use of the tone row in musical compositions. This slight randomization would become a core concept of the work. I wanted to project a clear message through *Spektra*, that of Campbell's Hero Cycle, but to also allow for two user freedoms: liberty to interpret the experience according to the user's own personal background and the freedom from having the same experience repetitively. A 360 video would

have been a far better medium choice for presenting a self-similar, repeatable experience. Slight, thoughtfully constrained bits of randomness in the scene order and other facets of the code afforded numerous exploratory possibilities to the user over multiple uses of the simulation.

Restraining the amount of randomness to an acceptable amount, i.e. not utilizing a total range such as in Schoenberg's case, I was able to shape a story arc that changed slightly from viewing to viewing but would always provide the same Hero Cycle trajectory. After the womb scene, there would be a white flash to transition to the subsequent scene. This flash was to represent the "boundary crossing." There were four potential scenes that could then appear in any order for the duration of the simulation: tunnel, astral landscape, Godsphere, and asteroid field. Each of these scenes featured quick dynamic animation that was both randomized and responsive to the music. The only sonic input being actively tracked in the simulation was amplitude at about 120 Hz. The audio input was run through a narrow bandpass filter at this frequency and the resultant amplitude was then scaled, inverted, and/or mapped depending on what virtual-physical parameter it was to be mapped to.

While doing extensive testing Mark and I determined this frequency to be extraordinarily significant across various examples of recorded music in terms of programming form detection. The amplitude in this frequency area averaged over a two second time window was a reliable form trigger in almost all test cases involving distinct song sections. This trigger was used to force scene changes so that they coincided with switches between song sections such as the verse and chorus.

Along the lines of subtle randomization, another musical idea was integrated into the simulation. I have had a longstanding fascination with analog modular synthesizers. One of the subtle control mechanisms in that medium is the LFO, or low frequency oscillator. Micchelli was

able to create a reusable, duplicatable, variable rate, oscillating sine wave function within the code. An infinite number of virtual LFOs could then be mapped to various facets of the virtual world in the simulation. As the terminology implies, these were used in order to create extremely slow changes in VR attributes such as object colors, density of objects, XYZ position of objects, etc. The slow pace of some of these oscillations, especially around the 0.25 Hz to 3 Hz range created synchronistic effects where the music and an object in the VR simulation would appear to interact, although in fact the LFO was the driver of the object, not the music. Even slower speed LFOs were experimented with in the 0.01 Hz to 0.08 Hz range. LFOs running in this range of speed produced changes in object attributes that were below detection thresholds for most users unless they were indicated to directly observe the changing attribute. These ultra-slow LFOs served to create a more atmospheric background effect to the work.

For the audio component of Showcase I, an analog synthesizer, drum machine, and looper software were used. These instruments seemed to reflect the grid-based and digital nature of the visual environment. In addition to this, real-time response to the changes in VR scenes was important. As mentioned above, the lottery system that selected scenes and therefore guided the overall macro-level form of the work necessitated the real-time response. Development of technical ability on these audio instruments to be able to shift rapidly to new timbres to support the randomized selection of scenes was essential.

Showcase I Findings

Outside of in-lab development, *Spektra* was showcased publicly as part of a large-scale multimedia work titled *MKUltra: Form Constant*. The full work was presented in the xMPL performance space at the University of California, Irvine. The *Spektra* apparatus was set up next

to the performance area. Spectators could wander the space freely during the performance and put on the VR headset to experience *Spektra* in real time as it reacted to the live musical performance.

Reception at this event was generally positive and a number of viewing modalities were demonstrated by the various headset wearers.[31] Upon interviewing those that used the headset at some point during the performance, I discovered that most users had felt vulnerable when putting the headset on. This was primarily due to the fact that the headset completely obscures vision. Not only would the headset wearer have to stand in front of the entire audience, they would have to do so without being able to see the audience and infer their reactions from nonverbal cues.

Although I initially considered this to be a design flaw on my part in placing the headset at the front of the performance space, I have come to see it in a different light. Having an audience member come up on stage, next to the musical performer is a nonstandard practice. Having them voluntarily obscure their field of vision goes against two of most peoples' fundamental instincts; social anxiety and a base anxiety of having one's primary sense obscured. I found that most users were able to relax into the experience after an initial increase in their anxiety when first donning the headset. This is akin to the boost of energy a performer feels before going on stage, or even in the initial moments of a performance. Providing audience members the opportunity to experience the same emotional trajectory, i.e. pre-symbolic story, not only represents Campbell's Hero Cycle on a microcosmic level, but also provides an emotional cohesion and investment with the musical performer. This is a concept that can be ported to various other mediums in the future, and I believe the initial investment, or leap of faith, encouraged the participants to view the entire performance in a more positive light than if

[31] This can be seen throughout the full video of the performance here: https://www.youtube.com/watch?v=ex4d8l_EPjQ

they had not made this investment. Niiya's experiments in the area of social psychology are instructive here:

> This study demonstrated in a laboratory experiment that recipients of requests can increase their liking of the requester, find the requester to be more affectionate and sociable, and feel closer to the requester because of the affiliative motive that the request conveys, rather than because of cognitive dissonance or self-perception that results following the helping behavior. (Niiya 2016, 217)

One of the more common ways in which performers make an early request of the audience is through charging for admission to performances. My own research extracted from the user experience of *MKUltra: Form Constant* suggests that other requests, especially those involving voluntary confrontation of base anxieties may enhance this effect further.

Showcase II Development Pipeline

A few main design challenges became evident after the presentation of *MKUltra: Form Constant*. These challenges arose from my own critical view of the performance, audience feedback, and committee insights. The main challenges were as follows:

1. Simplify.
2. Integrate music in a more dynamic capacity.
3. More clearly emphasize postmodality.

Many participants seemed to be very confused about how to approach the *MKUltra* performance. As the art director of all technology and mediums being used in the performance, this insight personally eluded me until several months after the performance had occurred. Viewing the project through a less technologically encumbered lens I was able to understand how the poly-directional nature of the work could have confused participants. Walking into the space was itself overwhelming. The participant would find themselves dwarfed by three floor-to-

ceiling projections of flickering, vaguely prophetic phrases; individuals lying on the ground with their smartphones lying over their eyes; less mainstream and loud synthesizer sounds swirling around the space; and a cyberpunk VR apparatus with wearer at what one would likely perceive to be the "front" of the space. I loved the chaos, and in a more open-minded time period of "be-ins" and "happenings" this open-format concept could have succeeded, but for many of the participants experiencing *MKUltra* in 2018, in a traditional performance space, this kind of saturated and expansive non-narrative, multisensory experience proved to be confusing.

The simplification of this setup took place in two phases. Firstly, I began with a negative process of removal. Considering that the scope of my dissertation was to mainly be focused on the relationship between music and VR, I stripped away all unrelated elements first. I decided that the next iteration would not contain machine learning, non-VR visuals, lighting design, Google Cardboard applications, or even print materials. The second phase of simplification involved a more robust integration of music and virtual reality, which resulted in a more postmodal experience.

In *MKUltra* the improvised synthesizer music dynamically affected what the VR-wearer saw in the headset. In the revised performance, titled *Abstruse*, I wanted to more clearly link the two mediums. In *MKUltra* the synthesizer music fit within the aesthetic that I was composing in at the time: heavily beat and drone based electronic music. In order to more closely mesh VR with the music, either the VR simulation or the music would have to be modified. Due to the degree-focus being on music, and the advice of committee members to more completely develop and integrate the musical component of the work, I decided on modifying the music to more closely fit the simulation.

Instead of operating in a beat-based paradigm, I tried to exemplify various facets of the

VR work through sound design. I drew on inspiration from the visual elements, as well as the technology used to generate them. Visually, and technologically, it is obvious that the most used animation technique in *Spektra* is particle physics. From both a technological and aesthetic standpoint, the analog to particle physics in the audio domain is clearly granular synthesis. In each technique, variably sized bits of a whole are being rendered over time according to rules that are typically systems-based, i.e. turbulence in a particle system, or speed of sound grains in granular synthesis.

Using this technique, I developed an Ableton Live environment, utilizing multiple instances of MaxMSP to create a multi-track, high-density granular synthesis array. The source material to be granulated was largely unrecognizable after it had been granularized, so this afforded me a good deal of creative liberty to choose from a wide variety of source sounds. I chose a selection of psychedelic era music as homage to the extra-musical concept I attempted with *MKUltra*. For additional raw granular material, I used audio selections from the performance recording of *MKUltra*. Granulating across adjacent areas of this audio ensured that I would be able to create harmonious mixes of granularized material if the visuals called for it.

Apart from granular synthesis, I also used of software loopers, delays, and various other timbre shifting effects in the Ableton Live environment. These effects primarily served as real-time timbre modifiers on the raw output of my high-density granular synthesis array, allowing me to more tightly interweave the audio with the visuals.

The concept of postmodality was at the core of *MKUltra* although it was not commonly understood by participants. Paring down the mediums used for *Abstruse* would help to more clearly communicate this concept, however I felt as though to make it abundantly clear I needed

higher order integration[32] of VR and audio. *MKUltra* featured lower order integration of many different mediums, briefly put, many mediums emerging from the same conceptual starter. *Abstruse* would attempt the opposite strategy: just two mediums featuring a very high order integration to address the core concept of postmodality. The questions, then, were how to more sufficiently link VR and audio, and how to best present the linkage.

Typically, in an improvisation between two musicians there is bidirectional communication. This bidirectional communication is arguably one of the facets of musical improvisation that makes it enjoyable and complex. Considering just the music and VR elements, there was only unidirectional communication between musician (myself) and the VR simulation (headset wearer). The headset wearer could navigate the experience in their own way by moving in 360 degrees, but other participants, not wearing the headset, couldn't see the output of this navigation, and it only controlled the VR environment. In order to establish bidirectional communication between headset wearer and musician I designed and implemented a number of interventions.

Firstly, the VR headset wearer had to graduate from participant to performer. I attempted this during the production of *MKUltra* by placing the headset wearer at the "front" of the performance space next to my synthesizer setup, but most participants concluded that the headset makes any participant look unflattering, such is the current state of VR hardware… For *Abstruse* I decided to place the headset wearer behind the audience seating so that they were out of view. In order to highlight the headset wearer's participation, the live output of the headset was displayed on a floor-to-ceiling wall projection only a few yards in front of the audience (a technique to more fully immerse audience members with just a 2D display).

[32] i.e. more robust connections between audio and visuals.

In addition to this enhanced display output, I coded a script to be executed inside of the VR software that would send packets of OSC data over an ad-hoc WiFi network containing pitch, roll, and yaw data of the headset. These packets of data would be received by custom software running inside of an instance of MaxMSP within Ableton Live that would control binaural spatialization of a virtual listener, thus changing the apparent location of the different granular sound sources in real-time and under the control of the headset wearer.

To complete the postmodal improvisation loop, I, as performer, would be able to view how the headset wearer navigated the space by means of the projection screen, and respond in real-time to scene and navigation-style changes. In turn, my musical changes would inform the headset wearer how to navigate the virtual space. In this way, a postmodal realization of existing music-only improvisational models such as Burrows's Mediational Triangle (Burrows 2004, 3), or even the model of Group Cognition (Ibid, 8) would be reached. More user research is necessary to determine which model *Abstruse* fits into better, although the components and general relations exist for both.

Showcase II Synthesis of Elements

Apart from the three design principles already laid out[33], a more overarching principle emerged during the development process. The main driving purpose of *Abstruse* was to test the theories presented in my research. Many pieces of tangential knowledge were acquired along the writing and production process, but the core theory that *Abstruse* would serve to illustrate was that of postmodality. As an artist, this divide between aesthetically true artwork and technological exercise presented me with a fundamental decision to make in the production of *Abstruse*: develop the piece to be an authentic realization of my artistic sensibilities or a

[33] Simplify, integrate music in a more dynamic capacity, and more clearly emphasize postmodality.

technological manifestation of the theories put forth in my research. There was a grey area to be found in this divide, but I chose to emphasize the latter.

MKUltra was an artistic work, and in such work, I prefer to incorporate elements of fringe-culture[34]. I also enjoy creating a sense of ambiguity for the audience. In *MKUltra* I was able to create false expectations and surprise the audience by breaking them[35]. While *MKUltra* was a very artistically fulfilling work for me, it did not sufficiently illustrate my dissertation research. It is for these reasons that I chose to present *Abstruse* in a session-format instead of a performance. Participants were able to volunteer to use the headset, and there was open communication between myself and the participants between improvisations, which was very unlike the rigid fourth wall maintained in *MKUltra*. In order to very clearly illustrate the connection between the downsized number of technologies being used, I briefly talked the participants through the setup before beginning, as opposed to "just starting" as I did in *MKUltra*.

Ultimately these considerations made *Abstruse* less artistically fulfilling, but a better and clearer representation of the core concepts laid out in my previous research. In future iterations of this performance, I would attempt to reintegrate more artistic elements, and some ambiguity back into the setup. Bringing the functional and creative elements into a more perfect balance would make the work fulfilling to me as creator and audience as more than simply a technical exercise.

[34] Including research discoveries by figures such as Jaron Lanier.
[35] Such as allowing audience members to come and go as they pleased.

Chapter 4
Summary and Conclusions

Over the course of my research in conceptualizing, developing, and deploying music-first VR software, many different conclusions, major and minor emerged. The two that best sum up the research are the audiovisual connection, and a new way of thinking about the use of medium.

Audiovisual Connections

Despite only two mediums being present in my research, i.e. music and VR, a third element, user interaction, emerged as an important additional area of research. Due primarily to the technical overhead necessary to create content in VR, it was clear that the VR environment should dictate initial considerations in the music and in the user interaction.

As laid out in the *Showcase II* details, one of the main integrative strategies was the generative technique for visual and audio material. In the VR domain, particle physics dominated the visual landscape in most of the scenes. To mirror this in the audio domain, granular synthesis was used to create a shifting turbulent texture similar to those created by the particle physics. My research, not unlike those by other like-minded artists of the past and present, held firmly to the idea that audio and visual components must, to the best of the artist's technical ability be developed ideally or at least conceptually in tandem.

For my own work, this meant using analogous technologies in each medium, such as the particle physics and sound file granulation mentioned above, to create a sense of perceptual homogeneity as opposed to tending more towards a soundtracked visual or animated electronic music. In addition, I took advantage of stylistic analogues, psychedelia specifically, to add another layer of cohesion. Through using these techniques, I attempted to create *Abstruse* as a

step towards full medium-liberation.

The Medium is the Message

At a very early conceptual stage of this work, the work of media theorist Marshall McLuhan seemed as though it would provide a strong basis for my own research. McLuhan became a distant memory while developing this dissertation project, but in writing this conclusion it has re-emerged with renewed value. While not central to this dissertation, future investigation on how relevance of message changes dynamically with the increase in the number of mediums included in a postmodal work would be of interest.

At an early stage of development, I constructed a design persona for the purpose of being able to clearly articulate development goals and shape creative decisions. This persona would be an individual that enjoys listening to electronic music genres, perhaps even those more experimental ones, but does not have significant formal training in music. Having a persona ensured that development and artistic goals did not shift too dramatically during development, or if they did, it was a reasoned and purposeful shift.

Most of the work's target users, or those that more closely resembled my persona remarked both in usability testing sessions and demonstrations more often on the VR experience in itself, performance space, and interactivity than on the component audio and visual elements. This feedback echoes McLuhan's assertion that the medium conveys more information than the message. Through receiving this feedback from user testing at multiple stages of development, I thought more broadly about how exhibitions of the work could be framed to have a more significant impact on users.

Krug suggests conducting usability testing in a nondescript environment to avoid

contaminating user experience results (Krug 2000, 150). My lab testing setup was not in a nondescript office room, it was in a recording studio, an environment that musicians such as myself feel so at home in that the room's influence barely registers as notable or exceptional. To those unfamiliar with such environments however, this space undoubtedly set up some kind of framing for non-musician users. I attempted to exploit this framing in the presentation of my first showcase by creating a medium-rich space to begin to coax users towards altered states of mind. The inclusion of so many mediums (projection visuals, VR, dynamic lighting, improvised music, optional smartphone VR, no set or persistent seating arrangements) seemed to be so overwhelming that few users spoke of the content, and primarily noticed and reported on the technologies present.

In the second showcase-iteration of my work in the Spring of 2019, I gave thoughtful consideration to which mediums would be included, and to how they would be framed by a physical space. For lighting, I chose to have a dim blue lighting for the xMPL black box theater where it was presented. This served to create a distinct and immediate separation between the world outside of the performance space, and inside of it.

The audience seating for participants not currently wearing the VR headset was put mere feet from a two-story tall projection screen that showed the inside of the headset. This proximity somewhat mirrored the full visual field one sees when wearing a VR headset, also preparing the participants for a gradual transition into the VR space.

Towards Postmodality

It is possible that the high degree of current private sector investment in VR technologies will be the main driving force in galvanizing a movement towards the postmodal. Across universities, there remains a degree of confusion about how to successfully embrace a more

postmodal approach to artistic creation without completely abandoning a traditional delineation between mediums and disciplines. There is a growing number of programs at academic institutions that identify themselves with descriptors such as *multimedia art*, *experimental media*, etc. However, these programs seem to emphasize adoption of one or more mediums instead of seeing the whole range of mediums as a continuum. It is my hope that these disciplines will continue to look across traditional intermedium divisions while still placing its highest values on artistry, not falling prey to temptations induced by the cultural dominance of technology in our contemporary times.

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Appendix A: Digital Resources

- Final concert version of VR software (Windows executable):

  https://github.com/jcpsimmons/spektra-public-prerelease

- Video explaining the setup and performance of *Abstruse*:

  https://www.youtube.com/watch?v=X-lh3indluo

- Full-length performance of *MKUltra: Form Constant*:

  https://www.youtube.com/watch?v=ex4d8l_EPjQ