FLORIDA STATE UNIVERSITY

COLLEGE OF MUSIC

PERFORMING LIVE WITH ELECTRONICS:

A PERCUSSIONIST'S GUIDE TO THE PERFORMANCE PRACTICE

OF ELECTROACOUSTIC PERCUSSION MUSIC

By

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A Treatise submitted to the
College of Music
in partial fulfillment of the
requirements for the degree of
Doctor of Music

2018

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ACKNOWLEDGMENTS

This document and degree would not have been possible without the help, guidance, and support of numerous individuals:

Dr. John W. Parks IV, my major Professor, whose teaching, guidance, and shared interest in music technology and recording helped push me to where I am today.

Lalo Davila, my undergraduate professor, who pushed us to be great performers, and even better people. I am so glad I get to work with you still to this day.

Erik Johnson, one of my respected mentors, who has always been there for advice and to keep me on track. I cannot thank you enough for everything you have done for me over the years.

The percussion faculty at the University of North Texas. Thank you for your expertise!

The friends and colleagues I have met throughout my college career at Middle Tennessee State University, the University of North Texas, and the Florida State University.

The teachers, colleagues, and students I've had the pleasure of working with in DCI and WGI.

Dr. Dan McNally and Dr. Gordon Hicken, who assisted me with proofreading this document.

To my uncle, Gil Long, for convincing my mom to not let me play drums at first. I'm super thankful that we get to play together so often. So wonderful to have a musical family!

To my grandfather, Rufus Long, for always being my biggest fan. We miss you!

To my parents, John and Vicki Jordan, who have not only been the most supportive parents I can possibly imagine but are also my most important role models. You are both incredible people with beautiful creative souls, and I cannot thank you enough for everything. I love you both!

Most importantly, to my wonderful wife, Jazmin, who put up with me working even longer hours, after being gone for months at a time, just so I could get this thing done. Your unwavering support through all of the crazy things I do means more to me than you'll ever know. I love you!

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ABSTRACT

This treatise seeks to examine performance practice of electroacoustic percussion music through the exploration of selected works for percussion and electronics, as well as provide a primer for students interested in becoming fluent in the language of music technology. The evolution of solo percussion music in the 20th and 21st centuries closely mirrors that of electronic instruments and audio technology, and several seminal works were composed due to the initially experimental nature of both mediums and the relative ease of their integration. At present, percussion works with electronic elements have all but replaced the piano accompanist for many student percussion recitals; therefore, the need for a performer's guide to the intricacies and performance practice of electroacoustic percussion music for all difficulty levels is paramount as the classical percussion repertoire and curriculum continues to evolve.

Chapter One comprises a brief summary of the history of electroacoustic percussion music, including compositional integration of electronic and acoustic elements and how technology affected the composers of these works. Chapter Two offers an overview of current music technology hardware and software required to realize these works. Chapters Three through Six analyze the four different categories of works for percussion and electronics: fixed media, electronic effects, live processing, and MIDI instruments. Suggested technical diagrams/setups and related works accompany each chapter, creating a guide for percussionists performing electroacoustic music.

CHAPTER 1

INTRODUCTION AND HISTORY

Introduction

This treatise will focus on the performance practice of electroacoustic percussion music through the examination of selected works for percussion and electronics. Due to the relatively recent and creative integration of the electronic elements within percussion repertoire, many of the pieces examined in this document have become standards for undergraduate, graduate, and professional recitals.

Most musicians do not receive music technology training in middle or high school programs, and until recently most university percussion programs did not include it as a part of the curriculum.[1] This lack of formal performance practice results in technologically-inclined students learning techniques through experimentation rather than formal training.[2] Therefore, this treatise will examine the technological challenges present in a variety of works to find a logical progression that students may follow to master the requirements for successful set-up and performance of these works. A brief technical description and series of diagrams and a short listing of related works will accompany each technological category, resulting in a catalog of options for students to reference when preparing pieces from this genre.

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[1] Lonnie Thomas Dobbs. "The Impact of Audio and Video Recording on the University Percussion Curriculum: A Case Study." (2017). Page 30.

[2] Nikolaus Adrian Keelaghan. "Performing Percussion in an Electronic World: An Exploration of Electroacoustic Music with a Focus on Stockhausen's "Mikrophonie I" and Saariaho's "Six Japanese Gardens"." (2016). Page 51.

History

The term "electroacoustic music" refers to "music in which electronic technology . . . is used to access, generate, explore, and configure sound materials, and in which loudspeakers are the prime medium of transmission."[3] Compositions for this medium utilize a live performer on an acoustic instrument along with an electronic element. This electronic element can take different forms: fixed media, electronic effects, live interactive electronics, and MIDI controllers.[4]

The development of a particular instrument's canon of repertoire is often tied to the historical context. Literature such as Luigi Russolo's *The Art of Noises* advocated for the broadening of the sonic palate of music to include industrial noises prevalent in the Industrial Revolution.[5] These changes, along with the simultaneous development of radio, sound recordings, and television had a huge impact on the style of music being made in the mid 20th century. As a result of these technological innovations, composers such as John Cage, Karlheinz Stockhausen, and Edgard Varèse explored writing music using varying electronic techniques, including that of *musique concrète*—allowing them to explore new timbres and textures that were not previously available. *Musique concrète* explored the use of recorded sounds that were manipulated in a studio and put together in varying combinations.[6] These composers treated the percussion voices in their compositions in the same way. Many percussion instruments in these composer's works were used outside of the context of their original environments, and other

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[3] Simon Emmerson and Denis Smalley. "Electro-acoustic music", *Grove Music Online* (accessed March 20, 2013).

[4] Michael Ptacin. "An Annotated Bibliography of Works for Solo Marimba and Electronics Published from 1978-2012." (2013). Page 1.

[5] Brian Bridges. "Introduction to Electroacoustic Composition." (2014). Page 1.

[6] Christine Augspurger. "Transience: An Album-Length Recording for Solo Percussion and Electronics." (2017). Page 3.

found objects such as tin cans and bean pods were treated as percussion instruments to create

new timbral possibilities. One example of this type of early electronic music is John Cage's

Williams Mix. Written from 1951-1953, it involved cutting up pieces of tape from six distinct

categories of sounds and then splicing them back together in different orders. These six

categories were city, country, electronic, manually produced, wind, and "small" sounds. This

process was done hundreds of times on eight separate reels of tape, played back simultaneously.

Percussion music developed in tandem with technology during the mid-20th century. The

constant development of experimental music composed for percussion was mirrored by the

development of new electronic technologies and instruments, including the vacuum tube,

synthesizers, Musical Instrument Digital Interface (MIDI), sequencers, and multi-track

recording, among many others. In 1957, Bell Labs in New Jersey developed the concept of

"computer music" by experimenting with computer programs for sound synthesis and

sequencing.[7] These computers were still room-sized, so were unavailable to most composers.

The advent of personal computers in the early 1980s allowed music technology to be more

readily accessible to average composers and performers, which democratized the creation of

electronic and electroacoustic music. Suddenly, composers who did not have access to expensive

experimental music studios had the ability to compose with electronic sounds or manipulate

audio. The innovation in audio and MIDI software over the past four decades has also allowed

composers to increase the quality of the electronic elements of many of these compositions.

Rather than having to splice tape and rearrange the pieces, modern digital audio workstations

allow composers the flexibility and tools to create and manipulate virtually anything.[8] Software

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[7] Bridges. "Introduction to Electroacoustic Composition." Page 2.
[8] Ptacin. "An Annotated Bibliography of Works for Solo Marimba and Electronics Published
    from 1978-2012." Page 1.

such as Max/MSP and Pure Data can be programmed to interpret the actual playing of the

performer, allowing true interaction between performer and technology.[9]

Since the development of the personal computer in the 1980s, the number of works for

percussion and electronics has increased exponentially. For example, there were 19 works

written for marimba and electronics in the 1980s. In the 1990s there were 25 works composed,

and in the 2000s there were 44 works composed.[10] While there is not yet research on the number

of works for marimba and electronics written so far in the 2010s, trends and technological

innovation would point to yet another significant increase in compositional output. This influx of

new music by composers interested in integrating percussive and electronic elements has created

a new category of percussion repertoire that many performers are interested in exploring.

Additionally, the technology has evolved to the point where it is truly affordable for everyone—

allowing more opportunities to compose or perform in this medium.

A quote from Steve Reich in his essay "Thoughts on Percussion and Rhythm" perfectly

epitomizes the development of percussion and electronics—

> I think it was Varèse that said something like "percussion led to electronics." This was
> the idea that non-pitched percussion led to the use of noise, and I kept thinking, 'It's
> going to come out the other end; the progression is going to keep on going — electronics
> will lead back to percussion.[11]

Composers of electroacoustic music have typically turned to the sounds of their time. Composers

writing in the early 20th century relied on the industrial sounds of *musique concrète*, as

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[9] Augspurger. "Transience: An Album-Length Recording for Solo Percussion and Electronics."
Page 13.
[10] Yi-Chia Chen. "A Catalog of Solo Works for Marimba with Electronics and an Examination
and Performance Guide of "Flux" for Marimba and Electronic Tape by Mei-Fang Lin."
(2011). Page 16.
[11] Steve Reich. The Cambridge Companion to Percussion. "Thoughts on Percussion and
Rhythm." (2016). Page 175.

composers of the modern era write music with clear influence from electronic dance music

(EDM) genres. Composers often use sounds found in popular culture (musical or otherwise) that

help relate their work to the modern audience's musical aesthetic.[12]

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[12] Keelaghan. "Performing Percussion in an Electronic World: An Exploration of Electroacoustic
Music with a Focus on Stockhausen's "Mikrophonie I" and Saariaho's "Six Japanese
Gardens"." Page 52.

CHAPTER 2

MUSIC TECHNOLOGY EQUIPMENT

Overview of Technology

The development of the personal computer and MIDI in the 1980s gave more musicians the ability to compose electroacoustic music, but the cost of the equipment required for professional level audio/MIDI recording, editing, and playback was difficult to overcome for many composers and performers. The digital audio workstation software and audio interfaces being developed in the 1990s were for professional recording studios and priced as such, often costing tens of thousands of dollars. Recording studios initially used these new tools as an addition to their traditional analog production process.[13] As software such as Digidesign's Pro Tools and MOTU's Digital Performer became more developed and computers became more powerful, these technologies began to become affordable for individuals. The advent of PCI-based audio interfaces in the late 1990s, followed by the development of USB audio interfaces in the early 2000s, made it much easier for composers and performers to own and master the required technology.[14]

Listing of Recommended Equipment

The following equipment is recommended when performing electroacoustic music. Not every piece of equipment is necessary for all works, but access to these technological resources

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[13] Christopher DeArcangelis. "How the 1990s Changed Recording and Music Production
       Forever." (Feb 15, 2017). Web.

[14] Rich TweakMeister. "The Concise History of the Home Studio." Tweakheadz Lab. (2009).
       Web.

will facilitate performance of a wide range of works. This listing does not include any cables or stands, as those often depend on the equipment being used.

Mac or PC Running a Modern Operating System. A modern computer is necessary to run much of this equipment. The faster a computer's processor, the lower latency between the input into the computer and the output to speakers.[15] Both Mac and PC devices are capable of running most of these applications and devices. Generally, At least 8 GB of RAM and an SSD are recommended, but not required for all applications.[16] Recommended options at the time of publishing are the Apple MacBook Pro and Microsoft Surface Laptop.

Audio Interface with at Least 2 Mic Preamps and 4 1/4" Audio Outputs. An audio interface acts like a sound card for the computer, giving you professional audio input and output formats. The interface also allows use of microphones that require gain control and phantom power (+48v), and also creates the ability to send more than two audio outputs to different destinations. An audio interface that can handle low buffer sizes (the amount of time for the computer to process incoming audio and send back out) will allow performance without a noticeable latency.[17] Recommended options at the time of publishing are the Presonus Studio 2/6, Focusrite Scarlett 2i4, and Behringer UMC204HD.

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[15] Latency is the amount of time it takes for the computer to process your audio and send it back to the speakers. The performer typically has to choose between lower processor use and higher latency, and higher processor use and lower latency.
[16] Brian Li. "Choosing Hardware for Apple MainStage." 441K. (2016). Web.
[17] Ibid. Web.

Pair of PA Speakers for Audience. A pair of high-quality speakers will allow faithful reproduction of the electronic element. High-quality speakers are important, as lower quality speakers cannot accurately reproduce the entire audible 20 Hz to 20 kHz range of frequencies. Recommended options at the time of publishing are the QSC K12.2, Presonus Air 12, and Mackie SRM450v3. For most electroacoustic uses, the full range models listed above work well on their own. However, if a work has significant low-frequency content, a subwoofer is recommended. Recommended models at the time of publishing are the QSC KW181, Presonus ULT18, and Mackie SRM1850.

Pair of Cardioid Condenser Microphones. A pair of cardioid condenser microphones will allow you to amplify instruments, add electronic effects, or perform with live processing. Recommended options at the time of publishing are the Rode NT-5, Shure KSM137, and Audio-Technica AT2035.

Wired or Wireless In-Ear Monitor System. An in-ear monitor system will allow the performer to stay synced up with the electronic element, as well as add cues and click tracks for live performance. It is important to note that Bluetooth headphones will not work for this purpose, as the latency is too high to allow proper syncing between the in-ear signal and the main mix through the speakers. Recommended options at the time of publishing are Shure PSM300 (wireless), and the Behringer P2 (wired).

Audio Software Capable of Sending Multi-Output Audio. The proper audio software is the most important part of the setup. Proper software will allow signal path routing, effects,

and mix between what the audience hears and what the performer has in his/her in-ear monitors. Recommended options at the time of publishing are Apple Logic Pro X, Apple Mainstage 3, Presonus Studio One 4, Max/MSP, Pure Data, ZenAud.io ALK2, and Ableton Live 10.

MIDI Controller. Some of the advanced pieces explored in this document require the use of MIDI pedals or MIDI mallet percussion controllers. Many of these pieces leave a significant amount up to the performer, so there is often flexibility in the devices used. Recommended options at the time of publishing are the Pearl malletSTATION, Keith McMillen Instruments SoftStep 2, and Roland SPD-SX.

Overview of Equipment List. Possessing these technological resources will allow the percussionist maximum flexibility in performance and also provide the ability to play a wide range of works. It is recommended that the reader perform additional research to determine the current acceptable options as technology evolves constantly.

Common Practices

The integration of acoustic and electronic elements is of the utmost importance. There are some general setup guidelines that will assist in their integration. First, ensure that the aesthetics of the stage are suitable for a performance environment. Cables should be dressed appropriately and care should be taken to make the computers and technology appear as inconspicuous as possible to give the audience the impression that it will be a musical performance and not a

computer exhibition.[18] Additionally, whenever possible, the performer should be set as close as possible to the middle of the stage, and the speakers at least 10 feet to each side of the performer (this distance will change depending on the performance venue, but is a recommended general rule). This distance allows ample stereo width for the electronic sounds and avoids cluttering the acoustic percussion instrument timbres unnecessarily. Whenever possible, the performer should not use speakers that are significantly removed from the performer, such as speakers hung from the ceiling in a concert hall.[19] This can create too much separation between the acoustic and electronic elements, resulting in an unclear musical performance.

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[18] Mari Kimura. "Performance Practice in Computer Music." Computer Music Journal 19.1
      (1995). Page 75.
[19] Kevin Matthew Estes. "Solo and Chamber Percussion Works by Nigel Westlake: An
      Examination of "Fabian Theory", "the Hinchinbrook Riffs", "the Invisible Men",
      "Kalabash", "Malachite Glass", "Moving Air", "Omphalo Centric Lecture" and "Penguin
      Circus"." (2014). Page 121.

CHAPTER 3

WORKS WITH FIXED MEDIA

Types of Electroacoustic Percussion Music

Works for solo percussion with electronics typically utilize one of the following four types of electroacoustic accompaniment: fixed media, electronic effects, live electronics, or MIDI Controllers.[20] Each of these categories have technological requirements that can vary in complexity from simple to very advanced. The remaining chapters will analyze these categories to find the best performance practices for each.

Works with Fixed Media

Works with Fixed Media are often referred to as pieces *with tape*, *with CD*, or *with electronic accompaniment*, presented as a solo performed with a backing track. These works are by far the most common type of electroacoustic music. However, there are many different levels of setup complexity within this category—from a cell phone and portable speaker to complex click tracks, cue tracks, and multi-output speaker systems.

Works for Fixed Media Without a Cue or Click Track

The first category of work for fixed media is one without a cue or click track, which involves the smallest number of technological variables. Many students have already played these types of pieces without knowing it, as several contemporary method books have play-along tracks fitting this description. These works without click or cue track are not necessarily easy to perform, although are certainly less complicated from a technological perspective. For many

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[20] Chen. "A Catalog of Solo Works for Marimba with Electronics and an Examination and Performance Guide of "Flux" for Marimba and Electronics by Mei-Fang Lin." Page 7.

works, significant study is typically required to understand the interaction of fixed media and solo performance.

Technical Setup. The technical setup for this type of work is accessible to most performers: a device (such as a phone or computer) that can play audio files, a 3.5mm stereo headphone splitter cable, headphones (or stage monitor), and a set of speakers. The setup allows the performer to hear the audio track through the headphones, and the audience hears the track through the speakers.[21] Figure 1 shows the use of an audio interface. While this is not necessary, it is highly recommended due to the ease of adjusting the headphone volume separate from the volume of the audience mix.
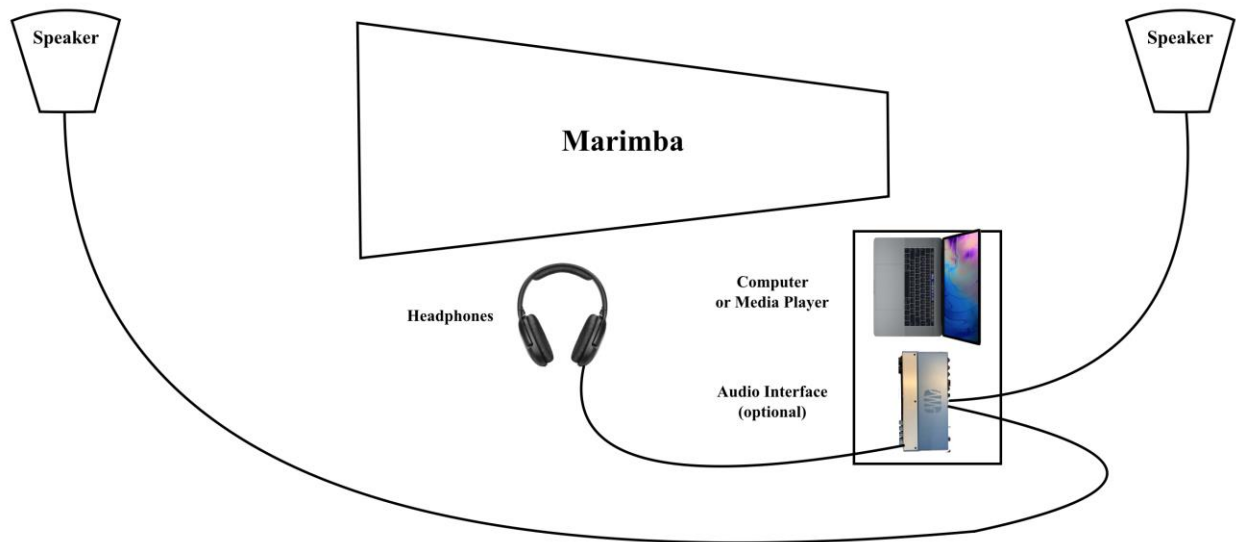

Figure 1 – Technical Setup for Works for Fixed Media with No Cue or Click Track

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[21] Keelaghan. "Performing Percussion in an Electronic World: An Exploration of Electroacoustic Music with a Focus on Stockhausen's "Mikrophonie I" and Saariaho's "Six Japanese Gardens"." Page 51.

Common Practices. It is not recommended to use consumer-grade playlist-based music software such as iTunes or Spotify in live performance. These can cause unnecessary complication with managing your files (not to mention issues with streaming/internet), and most of the features in those applications are not needed. Applications as recommended earlier (such as Logic or MainStage) are preferred.

In order to better facilitate the practice process, the performer should note the audio time codes as they relate to key landmarks in the music, such as rehearsal letters.[22] These notations will allow the performer to locate specific places in the music easily and quickly. Also, an application like Amazing Slow Downer can be helpful to practice with the audio file at a slower tempo, which allows the performer to play along with the accompaniment track before having the music at performance tempo.[23]

Just as many performers do prior to playing with an orchestra or other large ensemble, becoming familiar with all aspects of the score is paramount. Transcription of the electronic element, adding cues, and even practicing "drop the needle"[24], are all valid techniques in case you get lost and need to re-align with the electronic elements that might cause issues.[25] Additionally, practice with headphones at the same volume to assist in consistent performance.

Bell Plates **by Scott Lindroth.** This work for multi-percussion and fixed media does not use a cue or click track, making alignment challenging. Luckily, the composer includes a full

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[22] Peter Saleh. A Percussionist's Handbook. (2011). Page 88.
[23] Keelaghan. "Performing Percussion in an Electronic World: An Exploration of Electroacoustic Music with a Focus on Stockhausen's "Mikrophonie I" and Saariaho's "Six Japanese Gardens"." Page 46.
[24] "Drop the needle" in this instance would be starting the track at non-standard places to teach recovery.
[25] Kimura. "Performance Practice in Computer Music." Page 71.

score which contains all of the electronic parts, so score study is highly recommended to play this work effectively. An excerpt of this notation can be seen in Figure 2.

Figure 2 - Excerpt from Scott Lindroth's *Bell Plates*

Lindroth does not offer any specific instructions about the fixed media part, so it is up to the performer to determine balance. The sound of the fixed media part should blend together with the sound of the percussion instruments as if it were one organic instrument due to the compositional similarity of the electronic and acoustic elements. Other pieces might require different balance between the performer and the electronics, based on the composer's intentions.[26] This also requires the performer to pick out acoustic instruments that help accentuate the electronic elements. *Bell Plates* calls for a few standard instruments, along with some non-standard instruments such as aluminum fenceposts. The author picked Red Oak wood slats for the woodblocks and EMT tubing for the aluminum fenceposts called for in the work. These instruments blend particularly well with the electronic element.

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[26] Keelaghan. "Performing Percussion in an Electronic World: An Exploration of Electroacoustic Music with a Focus on Stockhausen's "Mikrophonie I" and Saariaho's "Six Japanese Gardens"." Page 44.

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Listing of Works for Fixed Media without Cue/Click. There are many works that fall into this category of fixed media works without click or cue track. A selection of some other works is included in Table 1.[27] These pieces vary in difficulty from intermediate to advanced. I recommend this type of work for students who are playing their first electroacoustic piece, as the simplicity of the technical setup allows for more focus on the piece itself.

Table 1 - Works for Fixed Media without Cue/Click

Composer	Work	Instrumentation
Paul Bissell	Hangar 84	Marimba and Fixed Media
James Campbell	Garage Drummer	Multi-Percussion and Fixed Media
Bruce Hamilton	Interzones	Vibraphone and Fixed Media
Christos Hatzis	Fertility Rites	Marimba and Fixed Media
Scott Lindroth	Bell Plates	Multi-Percussion and Fixed Media
Dave Maric	Trilogy	Marimba/Vibes/Multi-Percussion and Fixed Media
Ben Wahlund	Crystal Butterfly	Marimba and Fixed Media

Works for Fixed Media with a Split Channel Cue or Click Track

Works for fixed two-channel media with split-channel cue or click track use a single stereo signal, where the left channel is the audience track and the right channel is the click track. This category of works is a great introduction to the use of a cue or click, while still allowing for a relatively simple technology setup. Artistically, the biggest downside is the lack of stereo field in the accompaniment, which means that the left-to-right panning information is lost in the track.

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[27] Ptacin. "An Annotated Bibliography of Works for Solo Marimba and Electronics Published from 1978-2012." Pages 19-68.

To counteract this problem, some composers offer two versions of their fixed media tracks, one with split stereo and one with a full stereo mix of the accompaniment.[28] The full stereo mix option will be discussed later in this chapter. Some composers even prohibit the use of a split-channel track for live performance, such as Edmund J. Campion. His work *Losing Touch* for amplified vibraphone and fixed electronic sounds has the following in the technical notes: "The Compact Disk (sic) that is included in the purchase of the score of *Losing Touch* is intended for rehearsals, student recitals, and master classes only. Public Concerts of *Losing Touch* using the mono-mix CD are EXCLUSIVELY FORBIDDEN."[29]

Technical Setup. The technical setup for this type of work is accessible to most performers: a device that can play stereo audio files (such as a phone or computer), a 3.5mm stereo headphone splitter cable, a mono splitter cable (so both speakers hear the left channel only), headphones, and a set of speakers. This setup allows the performer to hear the audio track through the headphones, while the audience mix is heard through the speakers. Figure 3 shows the use of an audio interface. While this is not necessary, it is highly recommended due to the ease of adjusting the headphone volume separately from the volume of the audience mix.

Common Practices. It is helpful to ensure that the performer is listening to the track itself, rather than the click, whenever possible.[30] The same policy of learning and studying the electronic part alone still applies here.

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[28] Keelaghan. "Performing Percussion in an Electronic World: An Exploration of Electroacoustic Music with a Focus on Stockhausen's "Mikrophonie I" and Saariaho's "Six Japanese Gardens"." Page 43.
[29] Edmund Campion. *Losing Touch*. (2003). *Technical Notes.*
[30] Kimura. "Performance Practice in Computer Music." Page 71.
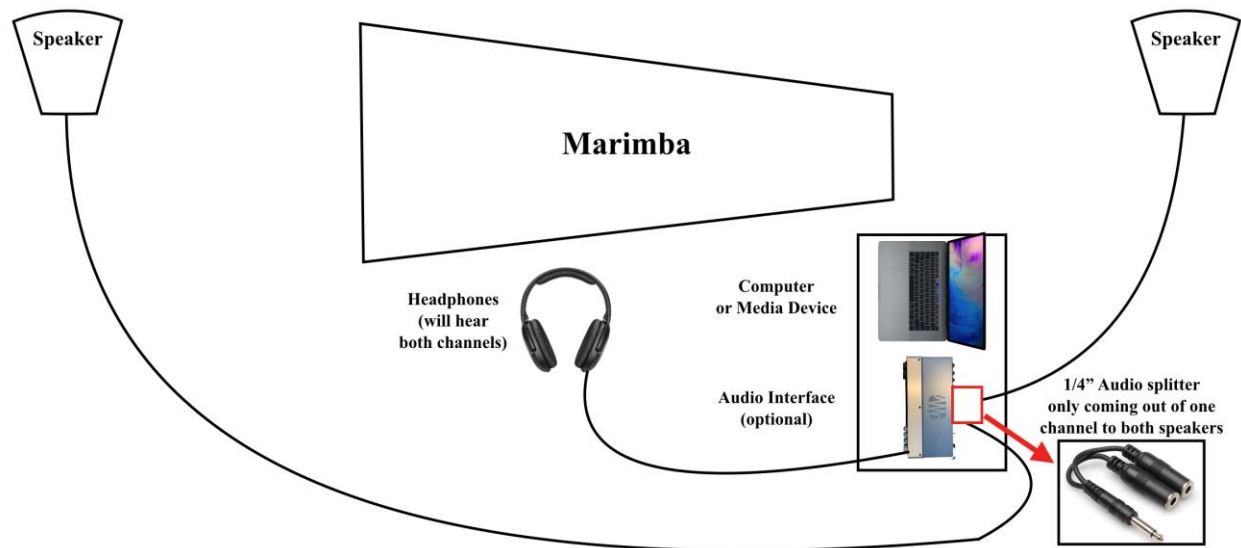
Figure 3 - Technical Setup for Works for Fixed Media with Split Channel Cue or Click Track

If using the aforementioned simplified setup, the performer should be consistent with audio output volume to the headphones. Changing the volume will also change what the audience hears. Additionally, open-back headphones are usually better than noise isolation or noise-cancelling headphones.[31] Open-back headphones will allow the performer to hear the acoustic sound of the instrument easier to blend and balance with the track.[32] If using open back headphones, be aware of the volume level as the cue/click track can bleed through to the audience.

***Electric Thoughts* by Ivan Trevino.** *Electric Thoughts* was inspired by some of Trevino's favorite electronic pop music artists, such as Radiohead and Jon Hopkins. Trevino felt these artists were especially skilled at seamlessly melding artificial instruments with real ones.

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[31] Open back headphones allow sound from outside sources to enter the cup of the headphones, while closed back or noise isolating headphones are designed to block out most sound from the outside.

[32] Saleh. "A Percussionist's Handbook." Page 89.

The idea of the work is to find a balance, using the tape part to enhance and not overtake the live performer. He does this by "coupling rhythmically articulate passages with unison drum beats and lyrical passages with electronically sustained sounds." Trevino states, "This healthy balance reflects the role I'd like technology to play in my own life; a balanced accompaniment."[33] Within *Electric Thoughts,* Trevino is successful in this seamless melding of acoustic and electronic elements.

With the provided click track, the piece is straightforward to put together and play. One of the challenges lies in counting; even with the click track there are no obvious cues to recover sync if the performer miscounts or becomes lost. *Electric Thoughts* is a great option for a younger student interested in electroacoustic music, as the pop music-based electronic sounds will be familiar.

Listing of Works for Fixed Media with Split Channel Cue/Click. There are many works that fall into the category of fixed media works with split channel click or cue track, including those shown in Table 2.[34] These pieces vary in difficulty from intermediate to advanced. This type of work is recommended for students who are playing their first electroacoustic piece with a click track. The technology setup allows these works to be practiced with a smartphone and headphones, and the performance setup for these pieces requires minimal extra equipment.

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[33] Ivan Trevino. *Electric Thoughts*. (2014). *Program Notes.*
[34] Ptacin. "An Annotated Bibliography of Works for Solo Marimba and Electronics Published from 1978-2012." Page 19-68.

Table 2 - Works for Fixed Media with Split Channel Cue/Click

Composer	Work	Instrumentation
Charles Argersinger	Celestial Dances	Marimba and Fixed Media
Evan Chapman	Like Swimmers	Vibraphone, Multi-Percussion, and Fixed Media
Steve Houghton	Oceanus	Drumset, Marimba, and Fixed Media
James Oliverio	Timpani Concerto #1	8 Timpani and Fixed Media
Attila Szilvási	Individual Lemming	Marimba and Fixed Media
Ivan Trevino	Electric Thoughts	Marimba and Fixed Media

Works for Four-Channel Fixed Media with a Separate Stereo Mix and Cue or Click Track

Works for four-channel fixed media with a separate stereo mix and cue/click track require more technical knowledge as an audio interface is required, plus a knowledge of multi-output routing in the utilized digital audio workstation and audio interface driver software. Once the technical settings are worked out, this type of piece is not much different from performing a piece with a split stereo/cue track. The main difference will be for the audience, which will hear a dramatically improved sense of dimensionality to the work due to the full range of stereo panning available to the composer. As an example—an orchestra performing in a space only one foot wide where each musician was directly behind each other would lose the sense of depth and dimensionality to their performance. That is similar in effect to playing tracks in mono rather than stereo.[35]

Technical Setup. The technical setup for this type of work is typically more involved, requiring a computer with digital audio workstation software, an audio interface with at least 4

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[35] RareRecords.net. "Stereo Records Or Mono Records - which One to Buy?". (2018). Web.

separate outputs, headphones, and a set of speakers. The setup seen in Figure 4 allows the

performer to hear the audio and click track through the headphones, and the stereo audience mix

is heard through the speakers.[36]
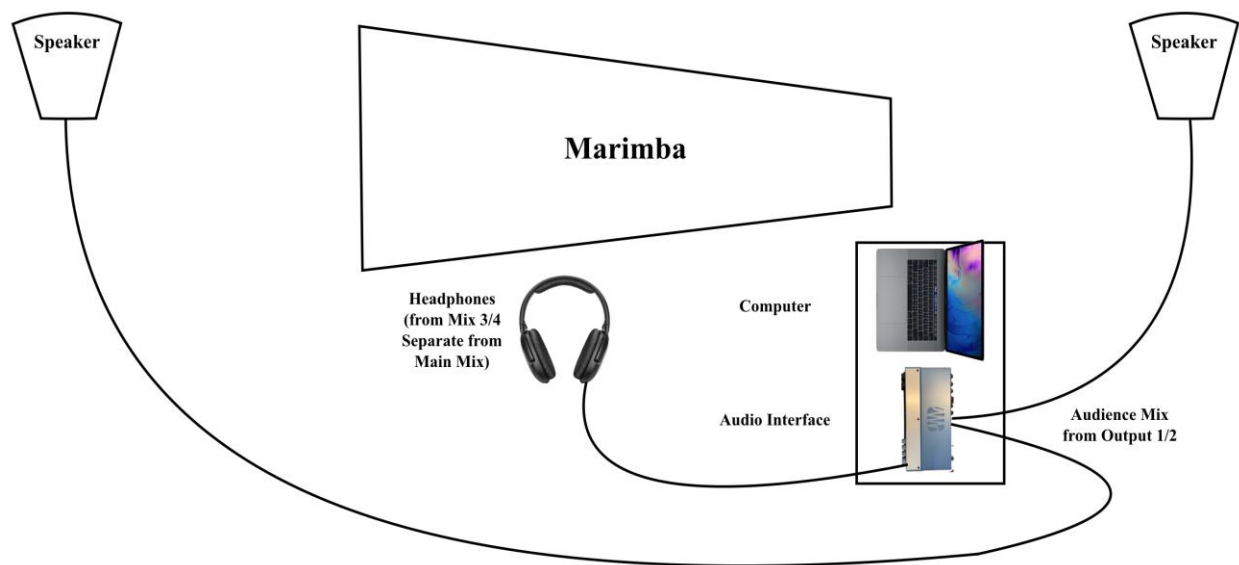
Figure 4 - Technical Setup for Works with Separate Stereo Mix and Cue/Click Track

The setup also requires the use of digital audio workstation software allowing for multi-

output routing. The performer will typically need to access the audio interface's software and

change the internal routing to different outputs from the computer. Whether the routing needs to

be changed varies based on the manufacturer—it is worth performing additional research based

on the particular audio interface being used. The author's audio interface requires that each audio

output pair have the mix defined in the audio interface driver software.

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[36] Keelaghan. "Performing Percussion in an Electronic World: An Exploration of Electroacoustic
    Music with a Focus on Stockhausen's "Mikrophonie I" and Saariaho's "Six Japanese
    Gardens"." Page 43.

Common Practices. Many of the common practices mentioned previously still apply to this type of work. However, since these works require digital audio workstation software and an audio interface, it opens up additional options for the performer. One option is setting up a mobile device as a wireless 'Front of House' (FOH) mixing device, which allows a trusted colleague in the audience to control the balance of the track to your acoustic mix. Many audio interfaces and audio software offer a remote mixing application for Mac, PC, and iPads. Having this ability to mix is necessary because unlike a performance with a human partner, the performer does not have the ability to make the same on-the-fly changes and adjustments to account for a different acoustical environment. What might sound balanced for one part of the accompaniment in one venue might sound completely different in another venue. The FOH mixing device allows the performer to have someone help maintain that balance throughout a performance.[37]

Microphones can also be utilized to balance to the level of the track. Many tracks need to be at a certain volume to communicate the "energy" of the composition, which the performer can set first, then balance the acoustic instrument to the track.[38] Similarly, certain parts of fixed media accompaniment tracks can be either too loud or too soft to balance with the acoustic instrument. Using automation in the digital audio workstation software may assist in making those adjustments.[39] The use of track markers in the digital audio workstation software will allow the performer to locate different sections of the pieces for rehearsal purposes, which is more efficient than recalling a certain timecode. Also, many digital audio workstations have an

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[37] Kimura. "Performance Practice in Computer Music." Page 64.

[38] Ibid. Kimura. Page 71.

[39] Keelaghan. "Performing Percussion in an Electronic World: An Exploration of Electroacoustic Music with a Focus on Stockhausen's "Mikrophonie I" and Saariaho's "Six Japanese Gardens"." Page 47.

application for iOS or Android mobile devices that allows the performer to remotely activate the audio transport controls and skip to different track markers.

Bounce! by Anthony DiBartolo. *Bounce!* was inspired by the dubstep and electronic music worlds. The composer considers the electronic accompaniment part of the solo, so balance is important to portray the track as a shared primary voice in the work.[40]

The composer includes an detailed setup guide for all of the technological elements, along with three tracks—a stereo mix for the audience, a click track, and a separate vocal cue track for one section where there is no electronic track. The setup guide walks the performer through the process of setting up the headphone mix for *Bounce!*, which requires setting up an auxiliary send, also known as an audio bus. The auxiliary/bus acts like a separate mixer within a mixer to send audio information to another destination in the software.

Figure 5 shows the audio track layout in Logic Pro X, where the files provided by the composer have been put on separate tracks. In Figure 6, the stereo mix is being routed to Aux 1 through a bus send. The click and cue tracks are also being sent to Bus 1 for the performer's in ears. Aux 1 is routed to Output 5/6, which is the headphone mix on the author's audio interface.

Figure 5 – Audio Track Layout for *Bounce!* in Logic Pro X

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[40] Anthony DiBartolo. *Bounce!*. (2014). *Program Notes.*

Figure 6 - Cue Mix for *Bounce!* in Logic Pro X

Listing of Works for Fixed Media with Separate Stereo Mix and Cue/Click. There

are an increasing number of works that fall into the category of fixed media works with a

separate stereo mix and cue track. A selection of works is listed in Table 3.[41] This type of work is

becoming more accessible to students due to the increased integration of music technology as

part of the standard university curriculum.

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[41] Ptacin. "An Annotated Bibliography of Works for Solo Marimba and Electronics Published
from 1978-2012." Page 19-68.

Table 3 - Works for Fixed Media with Separate Stereo Mix and Cue/Click

Composer	Work	Instrumentation
Brian Blume	Strands of Time	Snare Drum and Fixed Media
Edmund J. Campion	Losing Touch	Vibraphone and Fixed Media
Anthony DiBartolo	Bounce!	Snare Drum and Fixed Media
Dustin Lowes	Fear of the Hunted	Multi-Percussion and Fixed Media
Francisco Perez	Tesseract	Vibraphone and Fixed Media
Attila Szilvasi	Unreal Motorway	Marimba and Fixed Media

Works for Fixed Media with a Performer Created Cue/Click Track

These are pieces that were intended for performance without a cue/click track but benefit from the addition of a performer-created cue or click track. Some of these pieces are difficult to perform consistently and accurately due to the challenges of performing with a computer. For example, space in an electronic track is much harder to deal with than if playing a duet with a human partner, who can breathe and listen naturally to the variations in tempo that are present in live performance. Additionally, adding cue tracks or click tracks does not add any technical requirements to the previous set up.[42]

Common Practices. There are some important things to consider when adding cue or click tracks to a work that was not intended to have them. First and foremost, adding cues should be approached like a musician in a chamber group. Typically, in this environment the performers would have places where they all have a nod, mallet cue, breath, or other type of cue. Because the computer does not have the ability to receive communication back from the performer (at

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[42] Keelaghan. "Performing Percussion in an Electronic World: An Exploration of Electroacoustic Music with a Focus on Stockhausen's "Mikrophonie I" and Saariaho's "Six Japanese Gardens"." Page 42.

least in fixed media electroacoustic works), adding cues is a way of converting those gestures into an audible format.[43]

It is important to play to the music itself rather than the click whenever possible. Only add these types of cues or clicks when it helps solidify the consistency of performance. Oftentimes, audible reference points such as rehearsal numbers and letters can be infinitely helpful to a confident performance, as they provide checkpoints should the performer separate from the track. Additionally, the performer should feel free to be creative with the types of cues being created. The cues do not have to always be vocal or metronomic. Sometimes using an instrument such as a shaker can help solidify a groove more than the alternatives.

The Alabados Song **by Paul Bissell.** An example of a piece that benefits from added cue/click tracks is *The Alabados Song* by Paul Bissell. This work for marimba and tape was intended to be played without a cue/click track, which is certainly possible—but the overall effect of the piece is lost without perfect alignment in certain sections. Not much added information is needed in the work, but those added cues/clicks make a dramatic difference in the performance. Additionally, the author has routed the marimba mics into the Logic Pro X file, which allows automation of the reverb and levels of the microphones, and can assist in creating an in-ear mix for the performer using the mics. There are a few sections of *The Alabados Song* that benefit from the use of added cue or click tracks. These sections have extended periods of silence in the electronics, or not enough musical material to establish timing for the performer.

There are a few strategies that the author has employed on sections of *The Alabados Song*. Countdowns are typically preferable to counting measures of rest or a number of

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[43] Ibid. Keelaghan. Page 41.

repetitions, because the performer does not have to memorize the number and can focus on other elements of the music. During the *Allegro* section, there are multiple measures at a time without musical material in the electronic element, and then the track reenters on a syncopated marimba note. Unfortunately, adrenaline caused by live performance may cause an inaccurate entrance from the performer. There are also a few moments in the piece where the rests in the track itself are not metronomically accurate. Having the cue track match perfectly to what is actually in the accompaniment is preferred over guessing and trying to remember how a space feels in the moment.

Here is an example of one of the more active moments of the added click track. The amount of space between phrases can be seen on the waveform in Figure 7. These additions aid the performer in an accurate performance—adding just a few moments of cues or clicks can help tie the performance together, similar to adding physical gestures in chamber music performances.
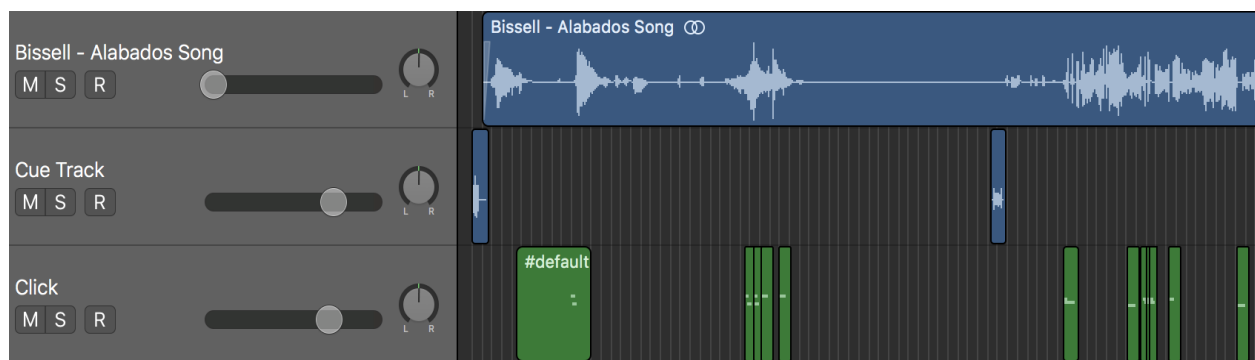

Figure 7 - Overview of Performer Added Cues/Clicks in *The Alabados Song*

Listing of Works That Benefit from Performer Created Cue/Click Track. There are a number of works that benefit from the addition of a cue or click track.[44] Even works that do not

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[44] Ptacin. "An Annotated Bibliography of Works for Solo Marimba and Electronics Published from 1978-2012." Page 19-68.

require them can still often be improved by using them in some way. The works listed in Table 4 are ones that have particularly difficult tape parts, or where getting lost makes it especially difficult to realign with the track. Once a performer has one of these cue tracks created, it is recommended to export the audio file to save for future performances.

Table 4 – Fixed Media Works That Benefit from a Performer Created Cue/Click Track

Composer	Work	Instrumentation
Paul Bissell	The Alabados Song	Marimba and Fixed Media
Nathan Daughtrey	Halcyon Deconstruction	Marimba and Fixed Media
Daniel McCarthy	Warhammer	Marimba and Fixed Media
John Psathas	One Study, One Summary	Marimba and Fixed Media
Steven Ridley	Animism	Timpani and Fixed Media
Wesley Smith	For Marimba and Tape	Marimba and Fixed Media
Ben Wahlund	The Whimsical Nature of Small Particle Physics	Snare Drum and Fixed Media

Works Adapted from Acoustic Accompaniments into Electronic Accompaniments

One common usage of electroacoustic music is the replacement of acoustic accompaniment with electronic tracks, and can many times allow for more timbral possibilities than a piano accompaniment. Most of the concerti written for percussion use many "color" instruments, which are lost when only using piano as an accompaniment. Some composers solve this problem by adding percussion ensemble alongside the piano, but for student recitals it can often be difficult to assemble large groups both for space and scheduling considerations. Electronic accompaniment is often an appropriate solution to allow these percussive colors to be present.

The process of adaptation can be done by the composer, or by the performer. If done by the performer, it is up to them to make sure the proper permissions are obtained from the publisher. Some composers explicitly mention this possibility in their works, but others do not.[45] This document does not aim to cover the copyright implications of these adaptations—it is up to the performer to do research into applicable copyright law as it pertains to this process.[46]

Common Practices. There are some common practices that should be followed when adapting an acoustic work for electronics. Most of all, it is important to keep the context of the original work in mind when adapting an acoustic work to an electronic one. Electronic accompaniment does not mean it has to sound electronic—oftentimes sampled orchestral or acoustic instruments will be appropriate for the task at hand. It is important to emphasize—if a work's intent is being dramatically changed by the accompaniment, be sure the publisher of the work has given written permission, as it becomes a derivative work that falls under "permission to arrange." Additionally, the solo instrument should be considered when choosing instrumental timbres—orchestration issues can inadvertently be caused by not paying attention to timbre choice.

***New-Thaan* by Bob Becker.** One example of a work that benefits from an electronic accompaniment is *New-Thaan* by Bob Becker. *New-Thaan* was originally written for snare drum or tom with acoustic or electronic accompaniment and is based on North Indian Tabla styles and

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[45] This does include composers who require that performers make their own realization of the electronic track, such as Bob Becker, Bill Cahn, and John Cage.

[46] Keelaghan. "Performing Percussion in an Electronic World: An Exploration of Electroacoustic Music with a Focus on Stockhausen's "Mikrophonie I" and Saariaho's "Six Japanese Gardens"." Page 48.

forms. The melodic ostinato is a traditional North Indian melody based on the concept of Raga.

There are instructions in the program notes of the work about what should happen in the

accompaniment, which may be either acoustic or electronic.[47] These instructions were used by

the author to make an appropriate performance track for the piece. The melody is played by a

synthetic instrument layered with a gamelan sound, and the drone is played by a synth pad drone.

Both of these continue throughout the piece. Since the piece was inspired by North Indian tabla

playing, samples of tabla were added that accent certain beats in the snare drum part. These

accents make the track feel less like a backing track for snare drum and more like a composed

track that fits the music. Additional electronic grooves were added to create interest in the

accompaniment for certain parts of the work. Form delineation was handled through the use of

gamelan gongs to accent certain key phrases.

     Overall, the track captures the essence of the original composition while adding

additional nuances to make it feel like it was originally composed for the medium. Electronics

utilized to replace acoustic accompaniment, when used appropriately, can be very effective in

communicating the energy of a piece. The author's version of *New-Thaan* was selected to be

used in the Division I Finals of the 2011 Modern Snare Drum Competition in Atlanta, GA.
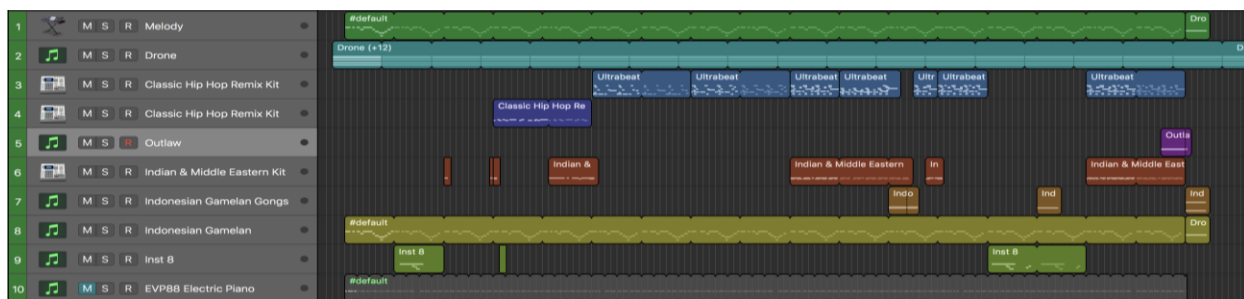

Figure 8 - Overview of the Logic File for the *New-Thaan* Accompaniment Track by the Author

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[47] Bob Becker. *New-Thaan*. (1998). *Program Notes*

Listing of Works That Benefit from the Adaptation of Acoustic Accompaniments into Electronic Accompaniments. There are a number of works, some of which are listed in Table 5, that benefit from the replacement of acoustic accompaniment with an electronic version.[48]

Table 5 - Works That Replace Acoustic Accompaniment with Electronic Accompaniment

Composer	Work	Instrumentation	Original Instrumentation
Bob Becker	New-Thaan	Snare Drum and Fixed Media (performer created)	Snare Drum and Percussion Ensemble
Paul Bissell	The Alabados Song	Marimba and Fixed Media	Marimba and Percussion Ensemble
Nathan Daughtrey	Halcyon Deconstruction	Marimba and Fixed Media	Marimba and Percussion Ensemble
James Oliverio	Timpani Concerto #1	8 Timpani and Fixed Media	Timpani and Orchestra
John Psathas	Planet Damnation	Timpani and Fixed Media	Timpani and Orchestra

Chapter Summary

The types of works explored in Chapter 3 offer a logical progression through the performance practice of music for percussion and fixed media. These works merit further study and performance, as the examples in this chapter have been a look at just some of the challenges that exist within these types of pieces. Each piece presents different challenges due to the flexible and ever-evolving nature of music technology, and many require creative solutions.

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[48] Ptacin. "An Annotated Bibliography of Works for Solo Marimba and Electronics Published from 1978-2012." Page 19-68.

CHAPTER 4

WORKS WITH ELECTRONIC EFFECTS

Overview

Electronic effects are defined as "a technique where the computer or device amplifies and modifies the sound of the instruments without necessarily adding any additional unique sounds."[49] Electronic effects are different from fixed media works, as they alter the signal from a microphone with effects in real time, rather than relying on pre-recorded or pre-composed electronic elements.

The most common type of electronic effects are reverb (which makes the instrument sound like it is in a bigger hall) and delay (which adds an echo-like effect).[50] Neither alters the original acoustic sound itself—they simply add an additional parameter to the sound. As works for electronic effects are analyzed in this chapter, it is worth noting some elements that overlap into the next chapter concerning live interactive electronics.

Technical Setup

The technical setup required for an electroacoustic work that uses electronic effects can change dramatically based on the instruments and electronic effects being used. For the purposes of this document, an examination of two pieces for marimba and digital delay will provide a framework for similar works. The required equipment typically includes microphones, an audio interface, a computer with the effects running in digital audio workstation software, and speakers

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[49] Chen. "A Catalog of Solo Works for Marimba with Electronics and an Examination and Performance Guide of "Flux" for Marimba and Electronics by Mei-Fang Lin." Page 7.

[50] Brett Bernard Landry. "The Electric Marimba: A Study of Selected Works for Marimba with Electronic Effect." (2016). Page 21.

for the audience to hear the affected effects signal. Occasionally a MIDI foot controller is necessary to turn effects on and off within the DAW framework.

Figure 9 shows the use of a computer and audio interface. The use of a computer is highly recommended, as it utilizes the same tools as found in other types of electroacoustic music explored in this document. However, it should be noted that many pieces in this category may be realized with standalone guitar effects processors/pedals instead of the computer and audio interface. Even so, the author highly recommends the use of a computer in the majority of contexts to allow for consistency in set up between the different types of works.
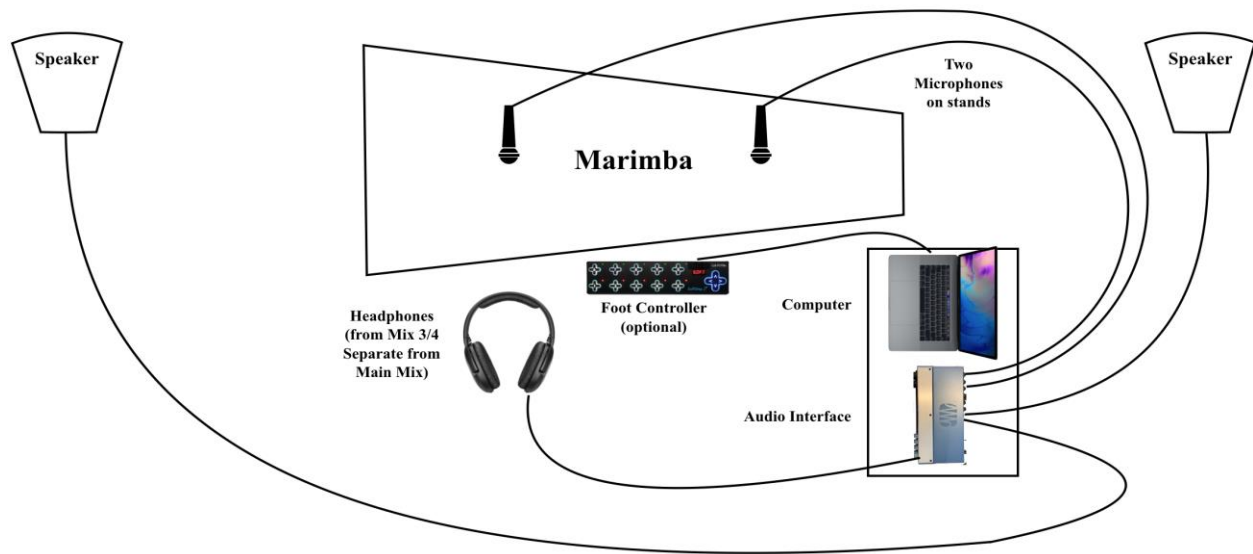
Figure 9 - Technical Setup for Works with Electronic Effects

Common Practices

As a general rule, works with electronic effects tend to leave many parameters up to the performer. However, some composers provide a wealth of detail concerning what the audience should hear, including delay time itself (how long it should take for the first delayed signal to be heard). Other parameters include delay feedback level (the number of times a note will repeat), wet/dry mixture (whether the speakers send only the affected signal or include both wet and dry

signals), panning (whether there is stereo separation between the acoustic instrument and the delay signal), and reverb (whether to add reverb to the dry sound only or also to the delayed signal).

Of paramount importance is the in-ear mix for the performer. Generally, the performer will need to hear more of the "wet" signal, so they may accurately align at all dynamic levels with the delayed signal. If the "dry" signal is too loud, it may obfuscate delay impulses necessary for the performer to execute perfect rhythms. One unfortunate side-effect of delay is that mistakes will be heard multiple times! Therefore, accuracy of notes and rhythms is of the utmost importance.

For performance purposes it is also helpful to have a muted patch/track before and after the piece, so you do not ruin the effect of the piece with footsteps, mallets clicking, etc., as the audience can hear the delay effect with any non-musical sounds that are produced by the performer.

The Hinchinbrook Riffs **by Nigel Westlake**

The Hinchinbrook Riffs was originally composed for classical guitar and digital delay, then transcribed by the composer in 2009 for marimba and digital delay. Westlake provides great detail about the digital delay effect, defining the delay time as 600 milliseconds (this equates to a quarter note in the work), and the frequency of delay (one time only). Westlake also asks for the live marimba to be panned "hard" to the left, and the delayed marimba panned hard to the right in order to get the most separation between the live and delayed signals (hard panning refers to panning 100% in those directions), and also that the performer should monitor the work using in-ear monitors rather than a stage monitor to avoid feedback of the delayed sound, therefore adding

another delay repetition.[51] Westlake also intends the delayed signal to be heard at the same level as the acoustic sound. The precise interactions of rhythmic and harmonic delay in *The Hinchinbrook Riffs* cannot occur without these voices being equal.[52]

Due to the combination of the long delay time but single repetition of the delay, there is a very clear compositional interaction between the acoustic marimba and the delayed signal which allows these two voices to "surge and ebb in wave-like formations."[53]

Delay Routing and Settings for *The Hinchinbrook Riffs*. The delay routing for *The Hinchinbrook Riffs* is shown in Figure 10. In this example, the two marimba microphones are on different channels to control the amount of signal being sent from each microphone through the auxiliary/bus to the delay channel. Routing the signals this way allows the delayed signal to be balanced and adjusted to each performance space. The two marimba microphones are panned hard to the audience's left, and the delayed signal is panned hard to the audience's right. This creates the separation in the stereo field that the composer requests. Additionally, the marimba mics and the digital delay have been routed to a reverb effect plug-in, which helps make the channels blend together and sound more natural. As seen in Figure 10, all of the channels except the reverb are being sent to the in-ear mix. This method of routing is used so the performer has the most accurate and rhythmic representation of the delayed signal, which can be significantly easier to align with.

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[51] Nigel Westlake. *The Hinchinbrook Riffs*. (2009). Performance Notes.
[52] Landry. "The Electric Marimba: A Study of Selected Works for Marimba with Electronic Effect." Page 29.
[53] Westlake. *The Hinchinbrook Riffs.* Performance Notes.

Figure 10 - Delay Routing in MainStage for *The Hinchinbrook Riffs*

For *The Hinchinbrook Riffs,* a digital delay plug-in within MainStage called "Delay Designer" was selected, allowing the performer to set a number of delay parameters per impulse basis, meaning each repetition of the delay can have the volume, pitch, panning, and filtering set to different settings. For this particular work, it allowed setting a single-delay impulse with the volume and panning parameters required by the composer. These types of granular controls over each delay impulse are not often available in other plug-ins. The settings for the delay plug-in are shown in Figure 11.

Figure 11 - Delay Designer Settings in MainStage for *The Hinchinbrook Riffs*

Echoes No. 1 by Greg Harrison

The next work for percussion with electronic effects being examined is *Echoes No. 1* for marimba and digital delay by Greg Harrison, written in 2012, with the American premiere in February 2013. The work was originally intended to be performed with a Boss DD-20 'Giga Delay' guitar pedal.[54] The Boss DD-20 pedal has a 'warp' setting that allows the performer to temporarily change the feedback value to 100%, creating the illusion of a sustained sound once it has repeated enough times.

Unfortunately this pedal has been discontinued, so the performer must find a suitable alternative. The composer invites the performer to experiment with different settings on their particular pedal to find something similar, but also states that if that function is not available then

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[54] Greg Harrison. *Echoes No. 1*. (2012). Performance Notes.

the markings may be disregarded, noting the delay is only there as an effect—and not intended to be equal to, or overpowering of, the acoustic marimba.[55]

'Warp' Pedal Settings for *Echoes No. 1*. The 'warp' effect from the Boss pedal can be reproduced in MainStage by mapping multiple delay effects to a foot controller. One delay is set to a short delay with only a few repetitions of the signal, while the other is set to a long delay with a much longer feedback time that approximates the 'warp' of the Boss pedal. The foot controller is then set to control the following parameters-

1. Volume for Short Delay (at 0 dB when pedal is up, and -30 when pedal is down)

2. Volume for Long Delay (inverted—off when pedal is up, at 0 dB when pedal is down)

3. Feedback of Long Delay (35% when pedal is up, 75% when pedal is down)

4. Bus Send to Short Delay (at -1dB when pedal is up, at -6.4 dB when pedal is down)

5. Bus Send to Long Delay (inverted—off when pedal is up, at 0 dB when pedal is down)

The combination of commands above is to ensure there are no pops and clicks in the audio when the pedal is pressed or depressed. Often, a process of trial and error is needed to find the best combination of settings that can emulate the original pedal. Research was done on YouTube and Sweetwater's website to understand how the 'warp' function on the pedal affected the sound, and then attempts were made at recreating that effect using MainStage.[56] This emulated 'warp effect' is then assigned to the foot controller. The foot controller being used is a

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[55] Ibid. Performance Notes.

[56] Exfidevivit. "Boss DD-20 "Warp Feature" demo." *YouTube*. (2013). Web.

Keith McMillen Instruments SoftStep 2, which prevents any audible clicking of the pedal itself

from being picked up in the microphone. Due to the intense delay feedback using the 'warp'

emulation, any noise from the pedal is obvious to the audience and gets looped for the entire

duration the pedal is held. The 'warp' pedal settings established by the author in MainStage may
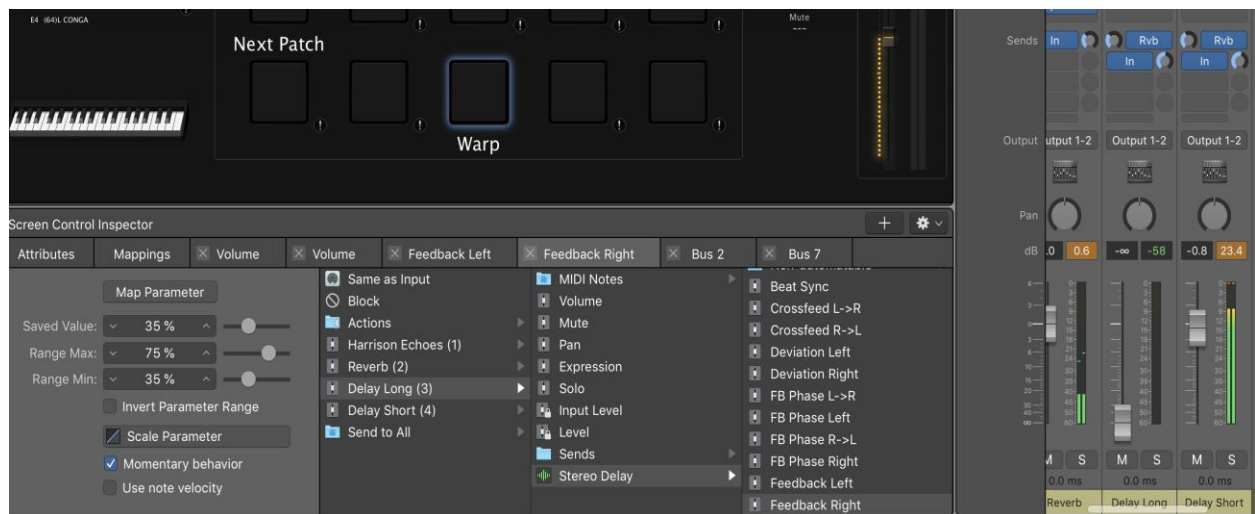
be seen in Figure 12.

Figure 12 - 'Warp' Pedal Assignments in MainStage for *Echoes No. 1*

Figure 13 shows the settings for the long delay on the Stereo Delay effect plug-in within

MainStage. The Stereo Delay plug-in was chosen for separate feedback control, which Delay

Designer does not have. The short delay uses the same effect plug-in, but with a shorter feedback

percentage. The stereo capabilities of this delay were not utilized for *Echoes No. 1*.

The 'warp' delay effect in *Echoes No. 1* adds to the aesthetics of the piece by creating

different textures, and also helps break up the monotony of the work. Works for digital delay can

often become monotonous due to the similarity of texture and pulse throughout a work.
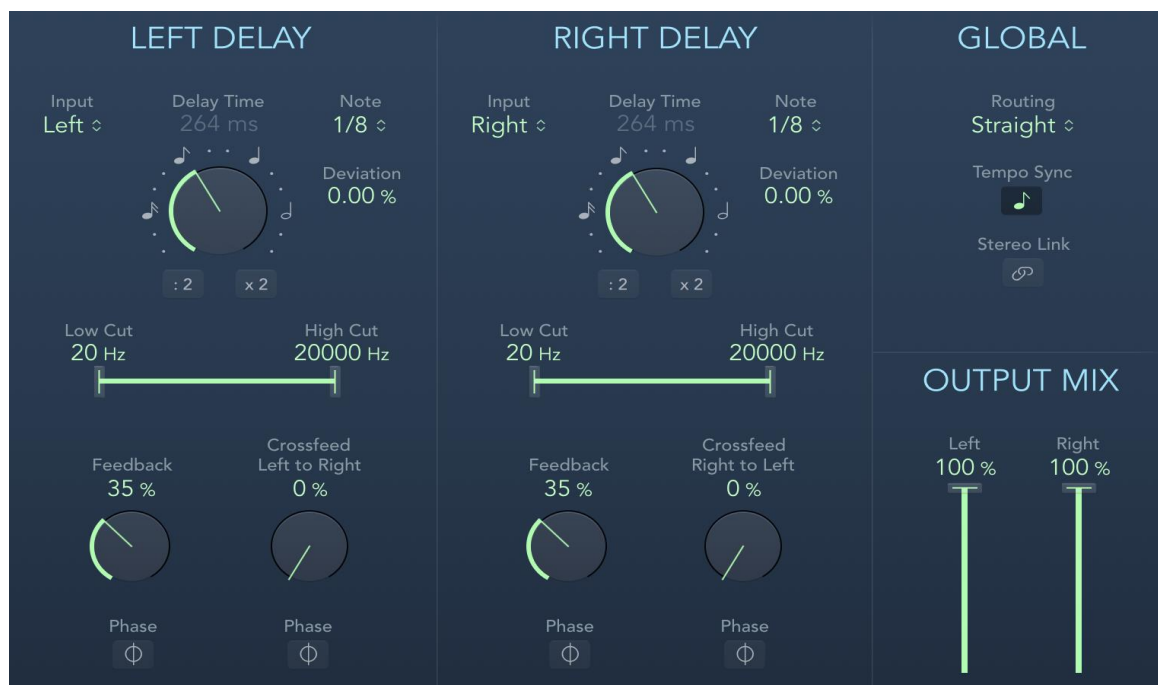
Figure 13 - Stereo Delay Settings in MainStage for *Echoes No. 1*

Selected Works with Electronic Effects

The majority of works written for percussion and electronic effects are written for digital delay, which is likely due to percussion colors generally being effective through delay effects due to the articulate and rhythmic nature of the instruments.[57] There are a number of other electroacoustic works that use effects, some of which are listed in Table 6.

The likely reason for the low number of works written for this category is that the technology required for digital delay or live looping (using a computer) is also capable of live interactive processing, so composers tend to utilize these electronic effects as just one component of their live interactive compositions.

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[57] Landry. "The Electric Marimba: A Study of Selected Works for Marimba with Electronic Effect." Page 29.

Table 6 - Selected Works with Electronic Effects

Composer	Work	Instrumentation
Mark Berry	Mare Tranquillitatis	Steelpan, Crotales, Digital Delay, and Pitch Shifter
Jim Casella	Prime Ordinals	Djembe, Digital Delay, and Fixed Media
Greg Harrison	Echoes No. 1	Marimba and Digital Delay (with additional warp pedal)
Grigory Smirnov	Mirrors of Emptiness	Marimba and Digital Delay
Nigel Westlake	Hinchinbrook Riffs	Marimba and Digital Delay
Nigel Westlake	Fabian Theory	Marimba, 3 Toms, and Digital Delay (with Loop Pedal)

CHAPTER 5

WORKS WITH LIVE ELECTRONICS

Overview

Live interactive electronics are a type of electroacoustic music where the performer and the computer may truly interact, as technology or devices are used to "generate, transform, modify, or trigger sounds produced by the performer."[58] The computer's behavior will change in response to musical or physical input and can therefore actually participate in the variability of live performance.[59] Works with interactive electronics typically involve a more complicated technical setup, as multiple footswitch cues (usually triggered by a MIDI sustain pedal or USB pedal) are often required to trigger audio or processing events.[60] Some works can have triggers cued by certain pitches or physical gestures detected by the computer.

Technical Setup

The technical setup for works with live interactive electronics can vary greatly based on the piece, so the suggested diagrams will be presented on a per-work basis. Live interactive electronics can include any technology that utilizes computer programming or electronic devices to react to a performer in any way. As an example, there are works written for tools such as the Microsoft Kinect, web cams, infrared sensors, Wii remotes, and many other devices not

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[58] Chen. "A Catalog of Solo Works for Marimba with Electronics and an Examination and Performance Guide of "Flux" for Marimba and Electronics by Mei-Fang Lin." Page 8.
[59] Kimura. "Performance Practice in Computer Music." Page 72.
[60] Keelaghan. "Performing Percussion in an Electronic World: An Exploration of Electroacoustic Music with a Focus on Stockhausen's "Mikrophonie I" and Saariaho's "Six Japanese Gardens"." Page 35.

originally intended to be used for music technology purposes.[61] As a result of the infinite musical

and technological variations possible, this document will only give a brief glance into the

possibilities of live interactive electronics.

Overview of Max/MSP and Pure Data

The two primary pieces of software available for performing with live interactive

electronic are Max/MSP and Pure Data, based on the patcher system developed in 1985 by

composer and engineer Miller Puckett at the Institute for Research and Coordination in

Acoustics/Music (IRCAM) in Paris. IRCAM is one of the primary research institutions in Europe

that deals with the technology of creating electroacoustic music.[62]

Both Max/MSP and Pure Data are object-based programming environments, meaning

rather than writing computer code line by line, the programming is done by connecting "blocks"

of signal processors together using virtual cables and commands. These pieces of software were

originally designed for use with Audio and MIDI but have been expanded to work with live and

pre-recorded video, servo motors, sensors, and many other technologies.[63]

The main difference between Max/MSP and Pure Data is that Max/MSP is a paid

application with a large library of pre-made patchers, while Pure Data is an open source version

with less fewer built-in resources. The company that makes Max/MSP was purchased by Ableton

in 2017, which has resulted in a version of Max/MSP being included in Ableton Live, called

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[61] Scott Deal. "Percussion Instruments of the Mind." *Percussive Notes.* (2017). Page 68.
[62] Keelaghan. "Performing Percussion in an Electronic World: An Exploration of Electroacoustic
     Music with a Focus on Stockhausen's "Mikrophonie I" and Saariaho's "Six Japanese
     Gardens"." Page 35.
[63] JB Smith. "Performance Patches for Percussionists." Web.

Max for Live.[64] Max/MSP being integrated with Ableton greatly expands the reach of object-based programming environments into performance environments.

Common Practices

It is important to know that the performer is accountable for all of the sounds the audience hears, just as they would be in an acoustic percussion performance.[65] Unfortunately, most works for live interactive electronics are impossible for the performer to hear from the audience's perspective. Having a trusted colleague who can learn the intricacies of the piece and give honest feedback is crucial to optimizing the realization of the work.

Understanding how each different patch or cue reacts to your performance is crucial to comprehending the intended effects and processing. Timing is crucial for these cues, so understanding how the pedal or trigger reacts will also allow you to align better with elements within the electronics.

***After Long Drought* by Elainie Lillios**

After Long Drought was composed in 2016 for percussionist Scott Deal, Professor of Music Technology at IUPUI, and the Director of the Tavel Arts and Technology Research Center.[66] This work for Max/MSP and amplified vibraphone utilizes a variety of techniques, including fixed media triggered by foot pedal cues, filter effects, delays, pitch changes, stutter effects, harmonizers, and auto pan effects. Lillios has programed all of these effects to occur

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[64] Peter Kirn. *A Conversation with David Zicarelli and Gerhard Behles*., (2017). Web.
[65] Kimura. "Performance Practice in Computer Music." Page 65.
[66] Deal. "Percussion Instruments of the Mind." Page 69.

through the performance of the work with foot pedal cues notated in the sheet music. There are also two moments with visual countdowns prior to events in the accompaniment (notated in the score). An example of these type of cues may be seen in Figure 14.

Figure 14 - Notation of Foot Pedal Cues and Event Countdowns in *After Long Drought*

Technical Setup for *After Long Drought*. The technical setup involves a relatively standard set of audio equipment including a computer running the Max/MSP patch provided by the composer, an audio interface with at least two microphone preamps and two audio outputs, two microphones, a foot controller (the author is using a standard MIDI sustain pedal), and PA speakers.

With the method of cues chosen by the composer, there is no need to monitor the audio with headphones. The performer can route the audio into their headphones using the Max/MSP Audio routing settings, but this is unnecessary in most cases. The technical setup for *After Long Drought* may be seen in Figure 15.
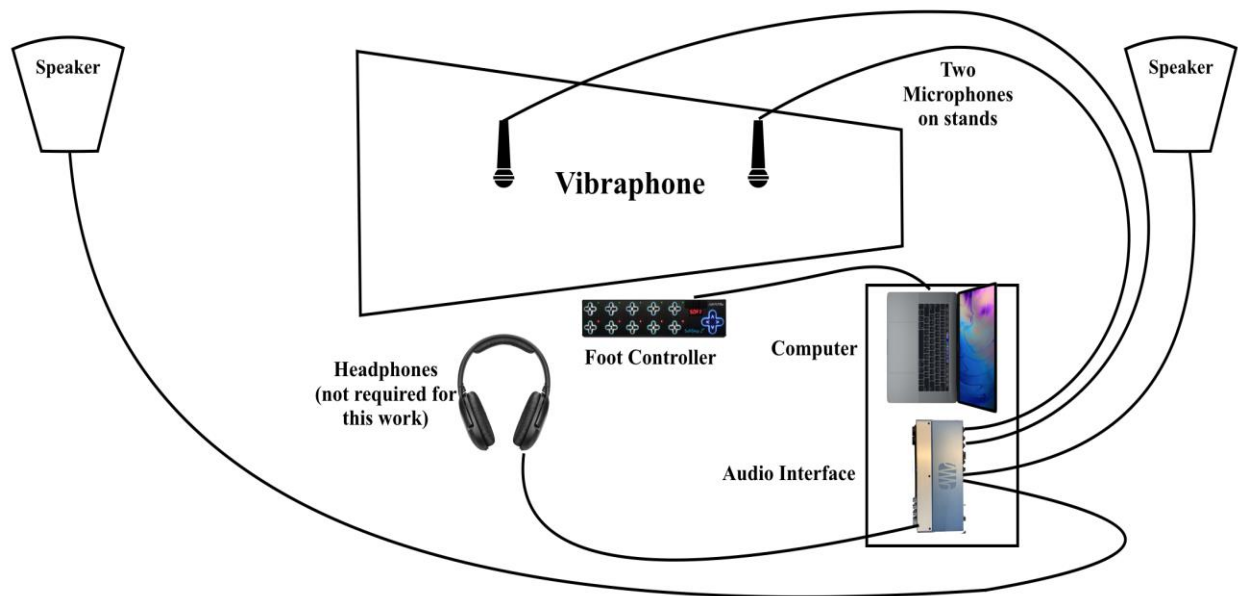
Figure 15 - Technical Setup for *After Long Drought*

Max/MSP Performance Patch for *After Long Drought.* There are displays for current cue number, event count downs, current lapsed time, as well as main output level, vibraphone amplification level, and vibe effects send level. The composer also includes a thorough quick start guide, plus a rehearsal guide to walk the performer through the steps necessary to play the piece effectively.[67]

Dropdown menus to choose the audio driver, input, and output are crucial because in different performance situations, the microphones for the vibraphone might need to be plugged into different inputs. The audio routing allows the performer to change the input and output to different channels on your audio interface. The Max/MSP performance patch for *After Long Drought* is shown in Figure 16.

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[67] Elainie Lillios. *After Long Drought*. (2016). Rehearsal Guide.

Figure 16 - Max/MSP Performance Patch for *After Long Drought*

If the performance mode of Max/MSP is exited, the edit mode appears which reveals the full extent of the patching and object-based programming contained in *After Long Drought.* There are multiple Max patches operating inside the main performance patch, which all have different roles in the piece.[68] It is not recommended that the performer make any adjustments in edit mode unless absolutely necessary.
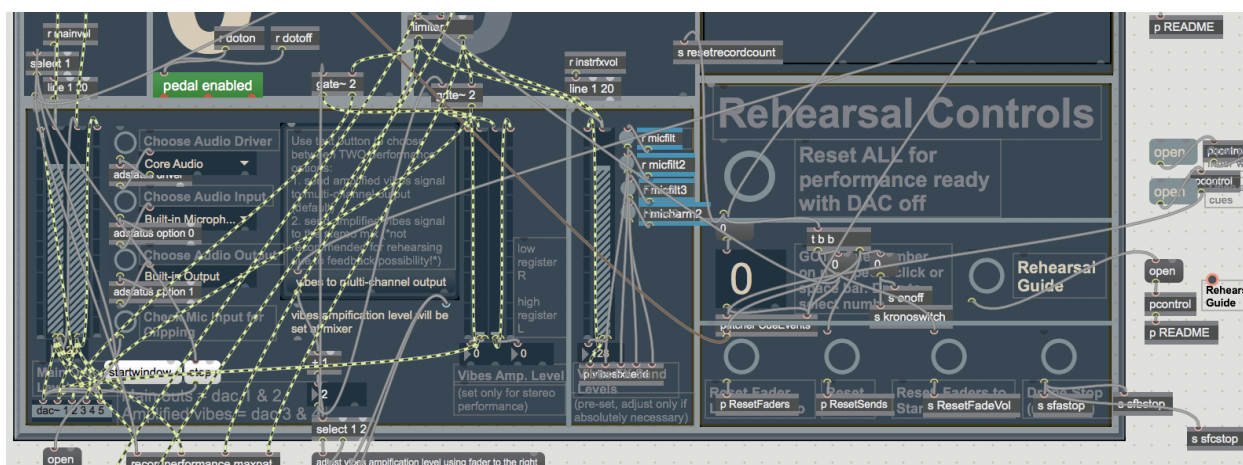
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[68] Ibid. Rehearsal Guide.

Figure 17 - Edit Mode of Max/MSP in *After Long Drought*

Open End **by Ben Hackbarth**

The next work for live interactive electronics to be examined is *Open End* for Multi-Channel Audio and Vibraphone by Ben Hackbarth. *Open End* was written in 2007 and utilizes the software Pure Data. The work does not use microphones—it instead relies on pre-recorded fixed media files that are fed into live processors. The electronic events are coordinated through a series of cues taken from a foot pedal in live performance. The use of foot pedal cues provides a flexible framework in which the performer can take liberties while electronics adapt in real time. Hackbarth uses this system for two reasons: (1) to make coordination with the electronics easier so that the performers can focus on other musical tasks and (2) to permit variation in successive performances.[69]

Each electronic cue is shown in the score as a number inside of a circle. A vertical arrow extends from the circle to show which acoustic event triggers the next electronic segment. An example of these cues can be seen in Figure 18.

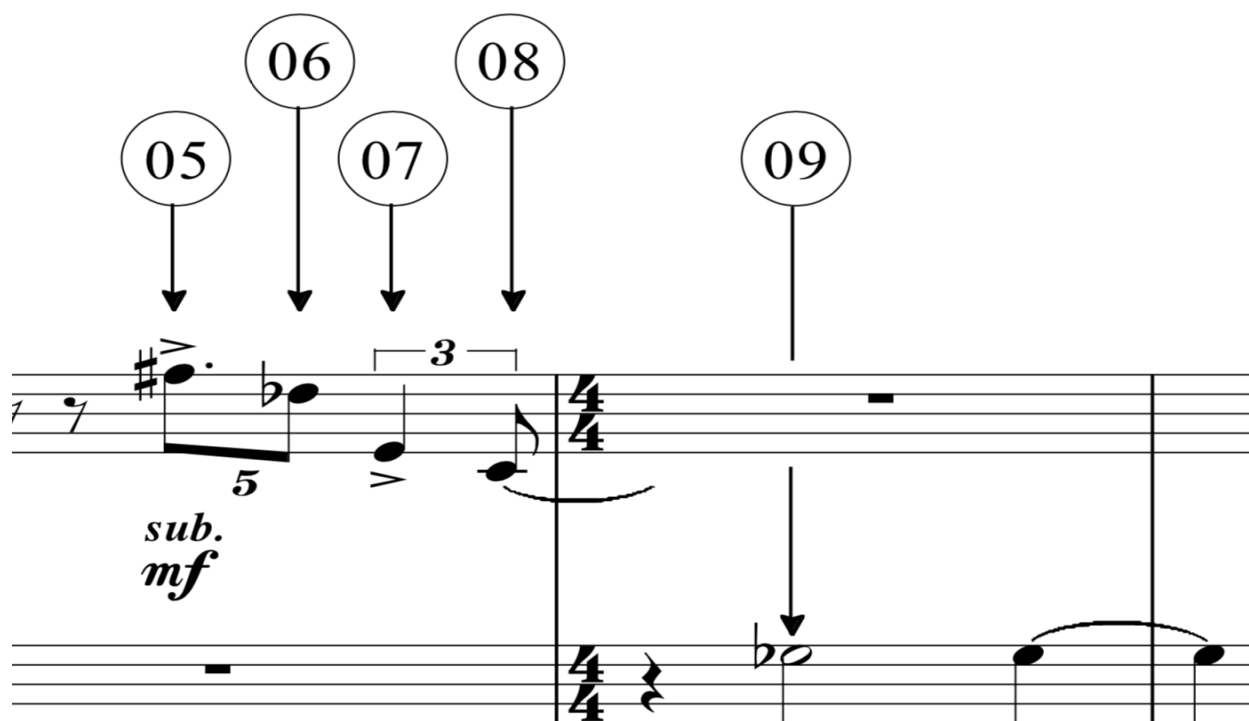[69] Ben Hackbarth. *Open End*. (2007). Technical Notes.

Figure 18 – Notation of Foot Pedal Cues in *Open End*

Technical Setup for *Open End*. The technical setup for *Open End* requires a large performance space, as well as a larger than average number of speakers. The following equipment is recommended for *Open End: a* computer running the Pure Data patch provided by the composer, an audio interface with at least 6 discrete audio outputs, 4 regular PA speakers, 1 small personal monitor speaker (for mounting under the vibraphone), a foot controller (such as a MIDI sustain pedal), and headphones. The headphones are not required if the performer utilizes the visual click option in the software rather than the audible click. The technical setup for *Open End* is shown in Figure 19. As is the case with most multi-channel electroacoustic works, the composer also includes a version of the work that is playable with regular stereo speakers.[70]

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[70] Keelaghan. "Performing Percussion in an Electronic World: An Exploration of Electroacoustic Music with a Focus on Stockhausen's "Mikrophonie I" and Saariaho's "Six Japanese Gardens"." Page 46.
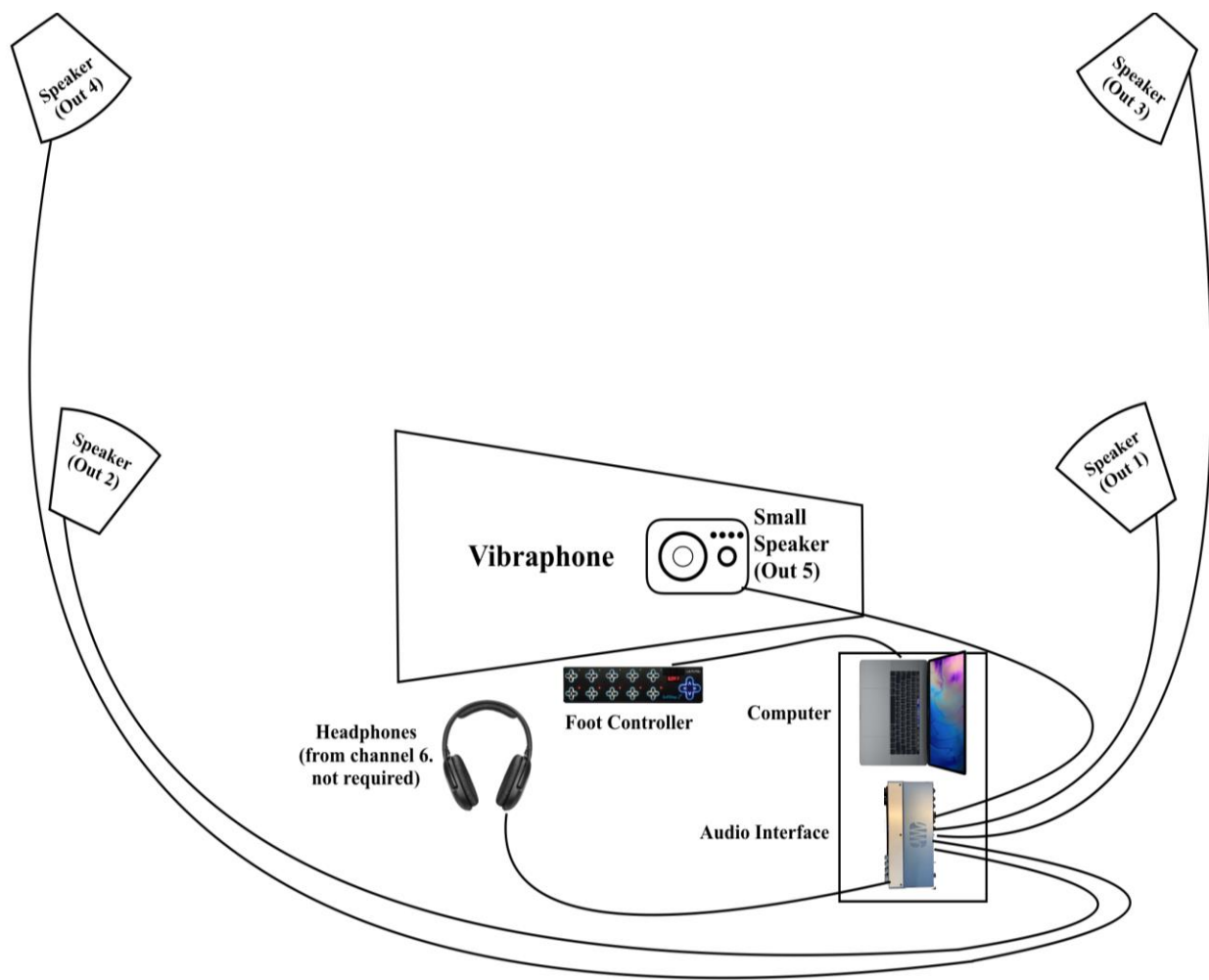
Figure 19 - Technical Setup for *Open End*

Pure Data Performance Patch for *Open End*. The Pure Data patch for *Open End* is laid

out by the composer in a way that makes each control or function clear. There are displays for

current and next cue, meters for audio levels, output volume selectors for the surround speakers,

vibe speaker, and click track, plus a reference file for setting the speed on the vibraphone

motor.[71] The Pure Data patch is shown in Figure 20.

[71] Hackbarth. *Open End.* Technical Notes.

open end   by ben hackbarth

control

next cue   tempo
                          60
    02   goto cue
stop   back1   >1   ○

meter
surround
L R RW LW   vibes   click

1 2 3 4   5   ○ test 6

output
surround   vibe   click
>100   >86   >71
stereo version? □   mute ○

nav
○ 1 begin
○ 5 single notes
○ 10 alter-pulse
○ 13 space opens
○ 14 rotations
○ 17 even pulse
○ 28 foil end
○ 29
○ 30

settings   □ <- for setting vibe motors
■ audio click
□ visual click

■ laptop trigger (keys: space=play, delete=stop)
□ pedal trigger

pd control_stuff
declare -path ./out5/   <- set spatialization
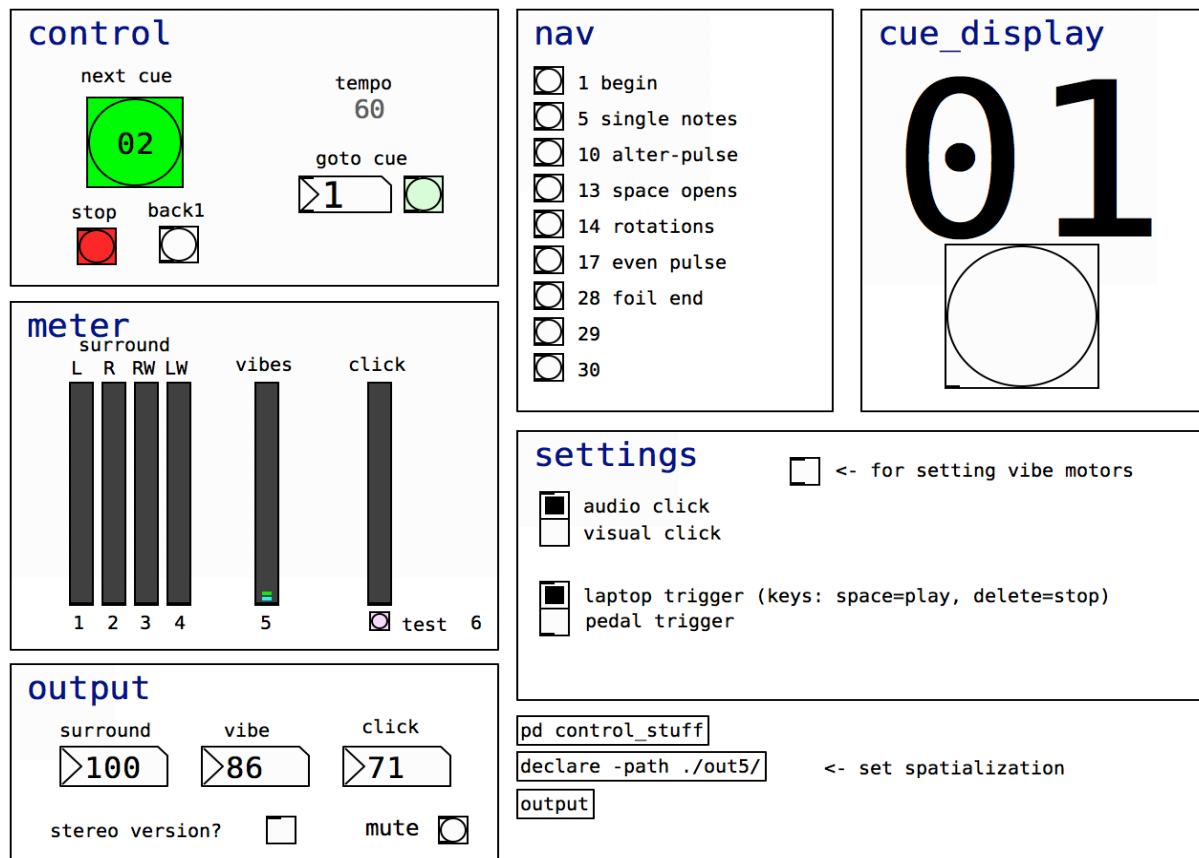output

cue_display

01
○

Figure 20 - Pure Data Performance Patch for *Open End*

There are a few options that Hackbarth offers the performer. They have the ability to choose between an audio click (coming through headphones on channel five), or a visual click. The option of an audio or visual click is helpful if a performer does not want to wear the headphones in a performance environment. Both the audio and visual click do not last the full duration of the composition—they are only present when needed to cue the performer to move on to a new section. Hackbarth also lets the performer choose between using a MIDI pedal trigger or a laptop trigger to move between the cues in the patch. If the performer is

uncomfortable playing the vibraphone and cueing triggers at the same time, an assistant may be used that would press the space bar on the laptop to move to the next cue.

One particularly useful setting is that the performer can choose the number of speakers being used for the work directly in the patch. In many electroacoustic performance spaces, there are a variable number of speakers. This allows the performer to quickly change to a new configuration without needing to do complex programming changes.

Figure 21 shows the programming for the control section of *Open End*. Works that use object-based programming languages such as Max/MSP or Pure Data often have complicated sets of patches, therefore the author recommends performers do not edit these patches unless absolutely necessary as the composers/programmers of these patches often have set complex audio/MIDI paths and routing.
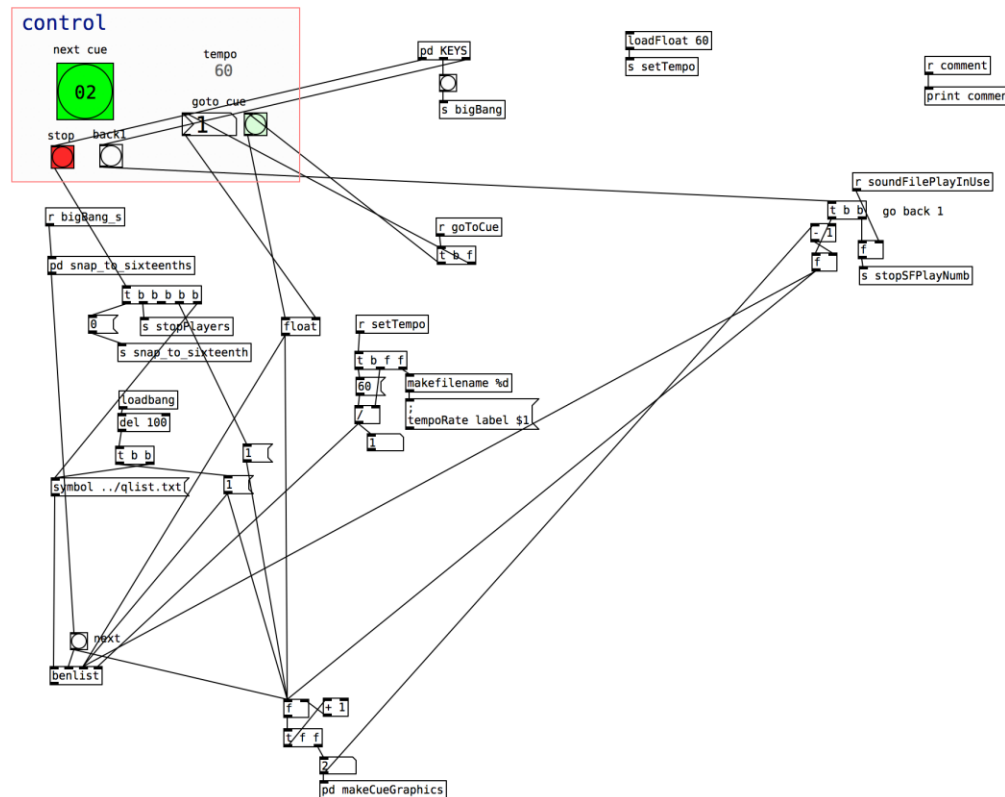

Figure 21 - Pure Data Edit Mode for the Control Section of *Open End*

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Selected Works for Percussion and Live Interactive Electronics

There are a number of published works available for percussion with live interactive electronics.[72] Many of these works are self-published by the composers or published in a collection of solos by multiple electroacoustic composers. Works for live electronics vary greatly in their technical demands, so it is recommended that the reader perform additional research to determine the exact setup required for each work.

Most universities offering instruction in electroacoustic composition also have classes in Max/MSP or Pure Data, therefore many composers are now comfortable with these programming language-based music applications. Due to the complexity of the software for most basic tasks, the author does not recommend using these applications for other electroacoustic music forms unless the performer is already comfortable with the software. It is recommended that applications such as Ableton Live, Logic Pro X, and MainStage are given priority for students as they have much greater application outside the electroacoustic performance field.

Table 7 - Selected Works for Live Interactive Electronics

Composer	Work	Instrumentation
Ben Hackbarth	Open End	Vibraphone and Five-channel Pure Data patch (with Pedal)
Cort Lippe	Music for Snare Drum and Computer	Snare Drum and Max/MSP Patch (with Pedal)
Elainie Lillios	After Long Drought	Processed Vibraphone and Max/MSP Patch (with Pedal)
John Mallia	Husk, with Aura	Multi Percussion and Max/MSP Patch (with Pedal)
Kaija Saariaho	Six Japanese Gardens	Multi Percussion and Max/MSP Patch (with Pedal)

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[72] Brad Meyer. "Solo Electroacoustic Percussion Repertoire." (2012). Web.

CHAPTER 6

WORKS WITH MIDI INSTRUMENTS

Overview

In the 1970s, electronic percussion developed from sequencer-type instruments into instruments playable with percussion implements. In 1981, Simmons released their SDS-5 electronic drum set, which was the first commercially viable instrument. Since the release of the SDS-5, popular music has strongly embraced the sound of electronic percussion. Rock bands such as Rush, Genesis, and Prince used a Simmons SDS-5 electronic drum set on their albums throughout the 1980s.[73] Due to the technological developments and new instruments from a range of manufacturers, electronic drum sets were used on significant numbers of records by many different artists in the 1980s and 1990s. Additionally, hip-hop producers such as Dr. Dre, J Dilla, and A Tribe Called Quest began using Akai MPC drum pad controllers to make beats for the purposes of rap accompaniment.[74] The MPC controllers included audio sampling features that allowed the performer to split up an audio file to be triggered as slices within a 4x4 grid of finger-activated pads.

During the early years of electronic percussion development, the focus was on the development of the drum and percussion sounds. In 1985, Alternate Mode released the malletKAT mallet percussion MIDI controller, which was created to allow classically trained percussionists to play electronic sounds.[75] A number of other mallet controllers have been developed since the 1980s, including Simmons Silicon Mallet, Marimba Lumina, Wernick

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[73] Thomas Brett. *Virtual Drumming: A History of Electronic Percussion*. (2016). Page 89.
[74] Ibid. Page 88.
[75] DeCiutiis, Mario. "malletKAT 8 - What Are You Waiting For?" *Alternate Mode*. (2018). Web.

Xylosynth, ZenDrum MalletPro, and the Pearl malletSTATION (which the author helped design in collaboration with Keith McMillen Instruments). The remainder of this chapter will focus on electroacoustic works for these mallet percussion MIDI controllers.

As electronic percussion instruments were being developed, the classical percussion community was unsure of the potential application and future of these electronic percussion instruments. James Blades mentions this specifically in his book, *Percussion Instruments and Their History,* by stating the following-

> In latter years, as well as their prominence in the repertoire of the orchestra, percussion has been used importantly in such experiments as machine-music, musique concrète, and is today a feature of the highly scientific electronic music. Opinions are divided concerning the values and the future of Electronic Percussion and whether such remarkable 'machinery' as the Midi synthesizer will be further developed as a part of contemporary percussion, and ultimately present a serious challenge to 'live' music. [76]

In retrospect, it is obvious that Blades was incorrect in his assumption that electronic percussion did not have a future. Electronic percussion may be found on practically every popular music track produced today, often replacing the acoustic percussion elements completely. Many touring drummers with high-budget large productions are using acoustic drum triggers to either replace or double their acoustic drums in the mix. Additionally, many Broadway performers and jazz musicians have switched from using acoustic keyboard instruments to using MIDI mallet controllers and sampling drum pads in order to save space and eliminate bleed from the microphones needed for these instruments.

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[76] James Blades. "Percussion Instruments and Their History". (1970). Page 440.

Technical Setup

The technical setup for a work with an electronic MIDI mallet controller can change

dramatically depending on the sound source. For the two works examined here, the technical

setup is minimal and requires the following—mallet percussion MIDI controller, computer with

sampling and sequenced looping software (this will be discussed later in the chapter), audio

interface, foot controller (can be a standard sustain pedal), headphones, and PA speakers. A

drawing of the technical setup can be seen in Figure 22.
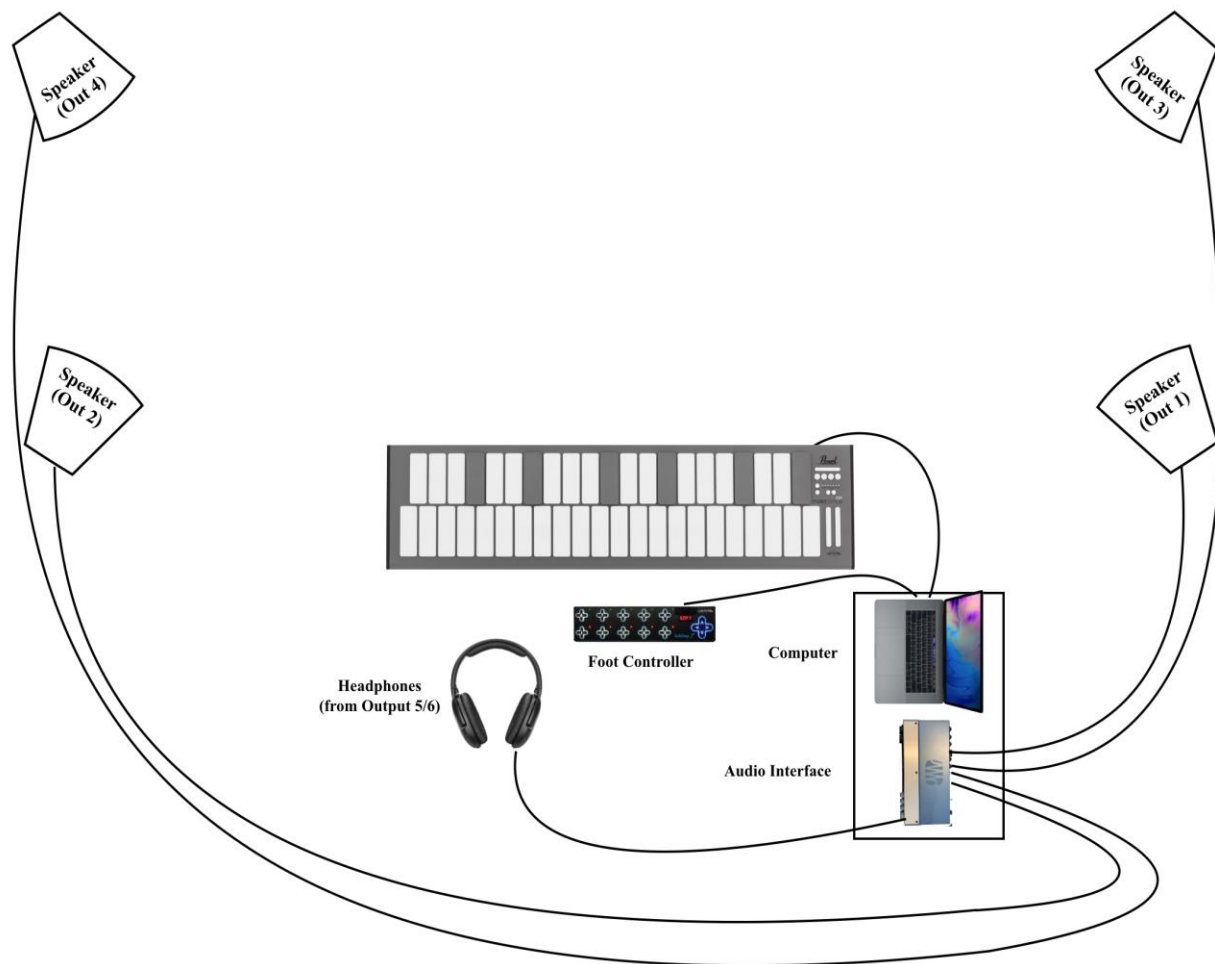

Figure 22 - Technical Layout for Works with MIDI Mallet Instruments

Both of the works examined in this document utilize a performer created cue track, therefore an audio interface with multi-outputs is recommended. Additionally, *Electric Counterpoint* by Steve Reich was realized in quadrophonic sound for the author's transcription of the work but is not required and could be done with only two speakers.

Common Practices

The most critical practice for this genre is determining the appropriate method for monitoring the signal. For many uses, a monitor speaker will give the most realistic feedback to the player as compared to playing an acoustic instrument. This is true within musical theater, jazz/fusion, and marching arts performances. Not using headphones allows the player to experience the music happening around them without feeling isolated in headphones. However, for the two works chosen by the author, headphones are the required method of performance due to additional cue tracks.

One other critical technique is adjusting the buffer size in your live performance software. The buffer size setting changes the latency of the keyboard from when you strike a bar until you hear a note come through the speakers. The buffer size should be set to where the round-trip latency is under 12ms, which is a delay imperceptible to most performers.[77] If this setting is too high, it can be very disorienting for the performer to hear the contact sound of the mallet into the bar and then hear the sampled sound delayed. Figure 23 shows the buffer size preferences in MainStage.

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[77] Martin Walker. "Optimising The Latency Of Your PC Audio Interface." *Sound on Sound.* (2005). Web.

Figure 23 - Buffer Size Setting in MainStage

It is often necessary to adjust the velocity scaling of the mallet controller being used to fit the performer's playing style and mallet selection. Because the range of MIDI velocities is limited to 127 values, the instrument should be set to use all of these values for each player. If the velocity range is higher or lower than the performer's playing style it can limit the range of musical expression that is possible.

For most Broadway/musical theater, jazz/fusion, and marching arts applications, as well as some solo applications, Apple MainStage is the most commonly used software. MainStage allows the performer to easily assign parameters to the instrument on a per-patch basis, allowing ultimate flexibility in performance.

Electric Counterpoint by Steve Reich

The first work for electronic percussion being examined is the third movement of *Electric Counterpoint* by Steve Reich. *Electric Counterpoint* was written for solo amplified electric guitar and a pre-recorded accompaniment track of seven more electric guitars and two bass guitars. The

work was composed in 1987 for guitarist Pat Metheny, who also recorded the accompaniment track that is available for rental from the publisher.[78]

Electric Counterpoint was transcribed for Xylosynth by British percussionist Joby Burgess in 2008. Burgess also recorded a completely new set of accompaniment tracks, with electronic sounds that are inspired by the analog synthesizers of the 1970s and 1980s.[79] Burgess's version was used as the inspiration for the author's transcription of the work.

Transcription Process of *Electric Counterpoint*. The accompaniment track for *Electric Counterpoint* used for this transcription was created by the author. The author used the following steps in the process of creating this accompaniment track-

1. The work was notated into Avid Sibelius from the original score.

2. The completed Sibelius file was exported as a MIDI file and imported into Logic.

3. Logic Pro X was used to choose the appropriate patches, set panning, add cue tracks for the performer, automate volume curves, and export the finished audio files.

4. The audio files were then imported into Apple MainStage for live performance and patch switching for the solo instrument.

The instruments chosen by the author for this transcription were intended to be as close as possible to Burgess's realization of the score on his album '*Electric Counterpoint'*. There are three separate types of timbres used by Reich in the original work—plucked staccato notes, resonant chords, and bass guitar parts, so three separate instruments were used to emulate these

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[78] Steve Reich. *Electric Counterpoint. (*1987). Performance Notes.
[79] Joby Burgess. "Powerplant: Electric Counterpoint." *Powerplant/Joby Burgess.* (2008). Web.

playing styles. The overview of the accompaniment track as composed in Logic Pro X is shown
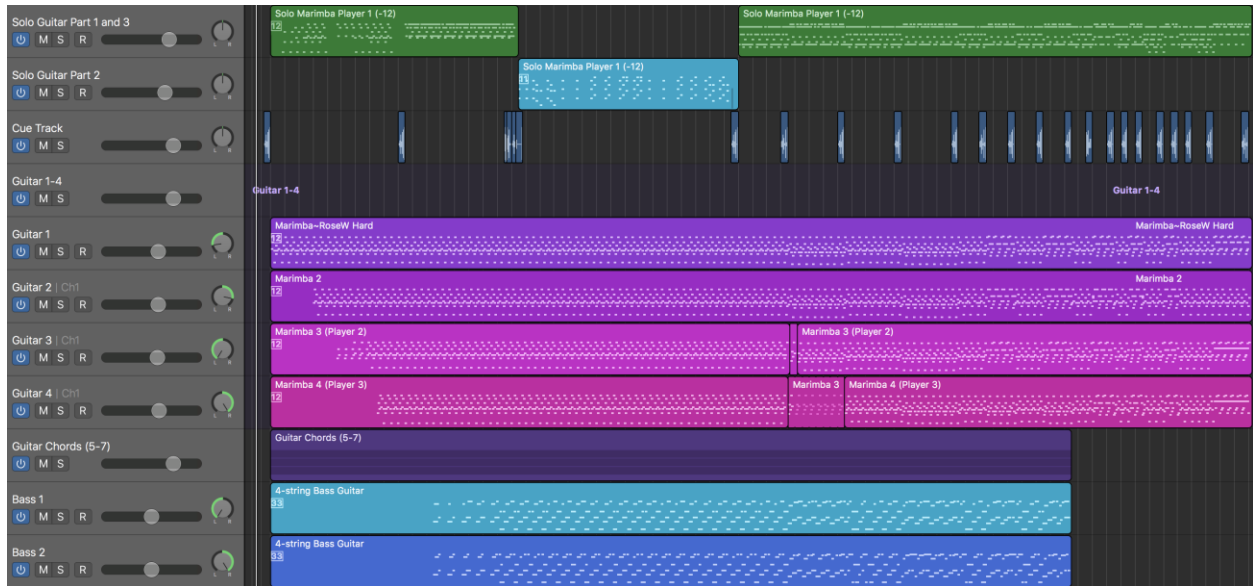in Figure 24.

Figure 24 - Overview of the Logic Pro X File of *Electric Counterpoint*

The instrument used in MainStage for the beginning and end of Movement Three was the
Retro Synthesizer instrument plug-in using a combination of a square wave and a sawtooth wave
in the two oscillators, with a short attack setting and a medium length release tail. The
combination of these settings allows the performer to not use a sustain pedal, making the
performance much easier. For the second patch, the Native Instruments Kontakt library Retro
Machines MKII instrument plug-in was used with a slightly longer attack time than the first
patch to create a more legato sound, and a much longer release tail to make the note last longer
than the staccato patch. For the bass guitar sound, a pre-existing patch in the ES2 synthesizer
instrument plug-in within MainStage was used to have a strong front-end attack characteristic.

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Use of Quadrophonic Surround Sound. For this realization of the third movement of *Electric Counterpoint*, I chose to utilize the same quadrophonic speaker setup as used in Ben Hackbarth's *Open End*. Reich's *Electric Counterpoint* was originally composed to be performed with two-channel audio. Movements One and Two of Reich's work are composed in a way that there are less defined voices—meaning there are more ebbs and flows rather than individually identifiable elements. Movement Three, however, is setup perfectly to allow for quadrophonic sound, as there are four primary contrapuntal voices in much of the work, so they can be panned to the appropriate speakers.

The quadrophonic realization of the pre-recorded fixed media accompaniment allows for more clear separation of the different voices, so the audience can clearly hear the additive process that Reich uses in the work. With a two-channel realization, these voices often do not have enough separation to hear them as separate contrapuntal voices.

Chain of Command by Graham Fitkin

Another work that utilizes a mallet percussion MIDI controller is *Chain of Command* by Graham Fitkin. *Chain of Command* was written for Burgess and his group Powerplant. The work utilizes a three-octave MIDI mallet keyboard controller with sampling capabilities, and live looping pedal that can handle three separate loops with overdubbing.[80]

Every audio sample used in the work is a short sample of a recorded quote from either George W. Bush or Donald Rumsfeld.[81] These audio files come in a folder as separate files—it is up to the performer to put them into a sampler in a usable format. Each audio file is labeled with

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[80] Graham Fitkin. *Chain of Command*. (2008). Performance Notes.
[81] Ibid. Performance Notes.

a note name and number for reference. Additionally, these samples are not melodic in nature, so when reading from the chromatic notes on the score, the performer will not hear any melodic content. The lack of an audible harmonic language makes the work much more difficult to learn as the melodic and harmonic content is not usable for memorization purposes.

Sampler Setup for *Chain of Command.* The Data CD that comes with *Chain of Command* simply contains a folder with the audio files that must be put into the performer's sampler instrument of choice. For this realization of the score, Native Instrument's Kontakt 5 was chosen, as it is an industry standard software sampler used for many different sampling applications.

Fitkin gives instructions for the performer to use two separate keyboard layouts—one for the beginning of the piece, and one for the ending. The majority of the samples remain the same between the two layouts, but four of the samples change in the new layout. Using Kontakt, each audio file is placed on a different note on the grid that relates to the piano keyboard as seen in Figure 25. In the score, Fitkin indicates that all of the sampled sounds are intended to be played back at full volume, with no dynamic contrast at all.[82] Removing the velocity sensitivity is achieved in Kontakt by changing the 'Volume via Velocity' setting at a global level, but other samplers will deal with this in different ways. The reader should consult the manual of the software sampling application being utilized to determine the appropriate method of adjusting this setting.
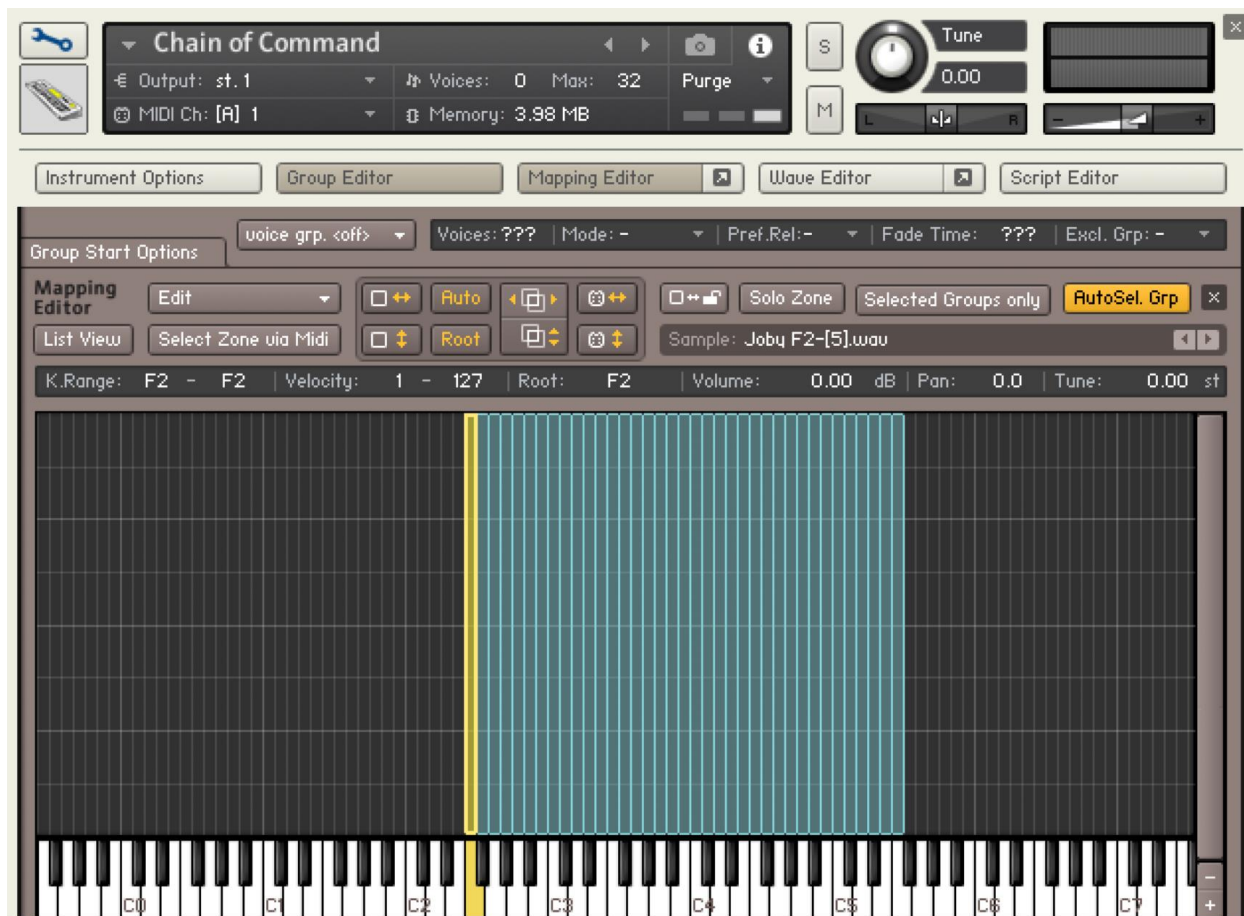
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[82] Ibid. Performance Notes.

Figure 25 - Kontakt 5 Sampler Loaded with Samples for *Chain of Command*

Live Looping Hardware/Software Options for *Chain of Command*. For Fitkin's *Chain*

of Command, the composer's intended method of using actual hardware looping pedals is not

possible logistically. There are many times where two loop-end triggers align with another loop

starting, meaning the performer would need to hit three pedals simultaneously. This is not

possible with the physical layout of the currently available hardware looping pedals. One option

would be to have a MIDI pedal with at least ten buttons, such as the Keith McMillen Instruments

SoftStep 2, that controls software such as Ableton Live or Apple Mainstage. With this

configuration, the performer can map multiple parameters to each pedal (this would make a

single trigger able to stop two loops and start a third loop, for example). This means there would

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be a dedicated pedal for each combination of loop stops and starts. While this is theoretically possible, there is now a much easier way to trigger these loops.

A particularly new and innovative concept in the audio software world is sequenced live looping. What this means is that unlike traditional looping that requires the performer build up a loop from scratch and then merely overdub, stop, or restart clips, sequenced live looping means loops can be built that reference clips from earlier in the piece, allowing the performer to program in the arrangements and transpositions. Performers such as Elise Trauw and Eldad Zitrin are using these techniques to create more pop music focused arrangements, but the technology is well suited for use in Fitkin's work.[83] Sequenced live looping software such ZenAud.io ALK 2, or Ableton Live with the audio record loops automated, allow the loop record, stop, and start to be controlled as they would be in a traditional sequencing application.

Live Looping with ALK 2 in *Chain of Command*. The application that was chosen for Fitkin's *Chain of Command* is ZenAud.io's ALK 2 Sequenced Looping Software. It is designed exclusively for sequenced live looping, as there are not audio or MIDI editing features in the software. It is assumed that the performer would edit any prerecorded audio or MIDI in a full featured digital audio workstation, then import that into ALK 2.[84] There are 5 main track types in ALK 2:

- Instrument Tracks, used for software or sampler instruments such as Kontakt 5.
- Audio Tracks, which handle all audio inputs and audio files.

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[83] Ziv. "3 Ways to Live Loop Hands Free Using Ableton and ZenAudio". (2018). Web.
[84] ZenAud.io. "ZenAud.io ALK 2". Accessed Oct 22, 2018. Web.

- MIDI Tracks, which may pass MIDI information to other tracks or external devices.

- Command Tracks, which pass MIDI commands such as On/Off/Trigger.

- Control Tracks, which pass MIDI continuous control commands (CC).

There are also two main types of loops:

- Record Loops, where the mic, instrument, or control message is actively being performed and creating the loop.

- Play Loops, where the mic, instrument, or control are not actively played, but are looped based on a previously-associated recording loop.

The setup in ALK 2 for *Chain of Command* is designed around a single instrument track for the live sampler instrument, and three additional instrument tracks for the three separate Loops. The malletSTATION is set as a MIDI input on all four tracks. Since ALK 2 will only pass audio when there is a record loop, the record loops are placed on each loop track only when "loop # start" is notated in the music, and last until "cycle loop #" is notated in the music. A play loop is then added that lasts until "stop loop #" is notated in the music. The live sampler instrument track has a record loop that lasts the entire duration of the piece, so it is always audible to the audience.

Additionally, the author set a control track to keep the volume of the loop track with an active Record Loop low, so the volume from the live instrument is not doubled, as the loop record track and live sampler track would both be active simultaneously. When the play loop on the loop track comes in (and the live instrument is performing a new musical sequence), the

volume is automated to raise to the appropriate and audible level. Each loop has also been set to a different level of panning, so the audience can audibly hear the layering as each loop is added.

Two performer created audio tracks are also used in the piece. One contains a click track to keep the performer in sync with the looper's timing, and another is a cue track to alert the performer of when a record loop is about to start to prevent any issues if the performer miscounts. The layout of the ALK file is shown in Figure 26.
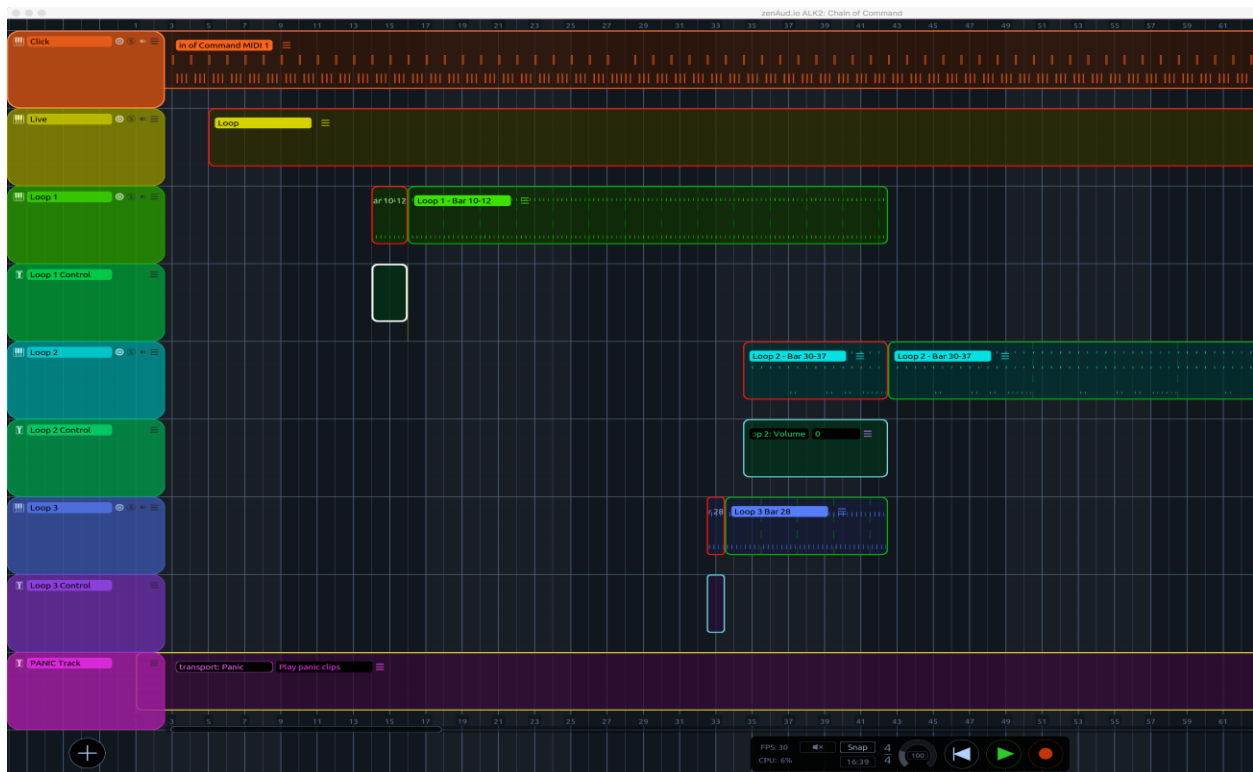

Figure 26 - Record and Play Loop Layout in ALK 2 for *Chain of Command*

Selected Works for Electronic Instruments

There are not yet many published works written for electronic percussion instruments. In fact, *Chain of Command* is the only published work for electronic controller (without an acoustic instrument) that the author has found. Multiple avenues of research have uncovered uses of these

controllers in large ensemble works, but published solo works are practically non-existent. A listing of the available works or recommended transcriptions are listed in Table 8.

The lack of published repertoire is due to the generally low adoption rate of electronic instruments among classical solo percussionists. As affordable instruments such as the Pearl malletSTATION and Keith McMillen Instruments BopPad become more accepted, there will likely be more demand for pieces written for these instruments specifically. Currently these types of electronic instruments are used much more frequently in musical theater, the marching arts, and the jazz/pop scene due to the flexibility of these types of instruments.

Table 8 - Selected Works with Electronic Instruments

Composer	Work	Instrumentation
Graham Fitkin	Chain of Command	Sampling Mallet Controller with Live Loop Pedals
Philip Glass	Glassworks - Opening (Transcription)	Mallet Controller
Vic Hoyland	Work-out for Marimba and KAT	Marimba and Mallet Keyboard Controller
Daniel Lentz	The Apparitions of JB	Mallet Controller and Electronics
Steve Reich	Electric Counterpoint (Transcription)	Mallet Controller with Fixed Media Accompaniment (Performer Created)

CHAPTER 7

CONCLUSION

The increasing number of electroacoustic percussion works written in the past three decades demonstrate computer and electronic music will occupy an even greater role in the musical development of percussionists.[85] Readily-accessible technologies now allow high school and college students to compose electroacoustic works at home—expensive hardware and software are not needed as they once were during the development of the genre.

Works for percussion and electronics do require a set of skills, technology, and equipment that until recently were not a part of the standard university percussion curriculum. Students inherently have had less options in the type of works they can perform, due to the lack of the music technology equipment or knowledge required. As music technology and electroacoustic compositions are integrated more thoroughly into the percussion curriculum, more works will be within reach for many performers.[86]

Electroacoustic music has developed rapidly in tandem with the development of music technology and is likely to continue to do so into the future. One may expect performance practice and technical issues within electroacoustic music to continue developing as the technology continues to advance. As a result of this continuing evolution, components of the technology that we currently take for granted might be unavailable in the future and could cause certain works to be unplayable in their current form. This could happen through a critical piece of software or hardware being discontinued, compatibility issues arising from different file types,

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[85] Chen. "A Catalog of Solo Works for Marimba with Electronics and an Examination and Performance Guide of "Flux" for Marimba and Electronics by Mei-Fang Lin." Page 16.
[86] Ibid. Chen. Page 20.

or any other unforeseen technical issues that could render a work unplayable in its current form. This is already an issue with music by John Cage that was written for record players and analog radios, as some of the technologies required by those pieces are becoming difficult, if not impossible, to find. Additionally, works composed for Max/MSP, Pure Data, and other programming languages are similar to computer applications in that they must be constantly updated to work with new operating systems. If a composer has a work's file locked out from being edited, only the composer has the ability to keep that work compatible with current operating systems. As a percussion community, staying current with these technological advances will allow us to maintain as much of this repertoire as possible so that future generations of performers have access to the same works.

APPENDIX A

SETUP DIAGRAMS AND MAINSTAGE OVERVIEW
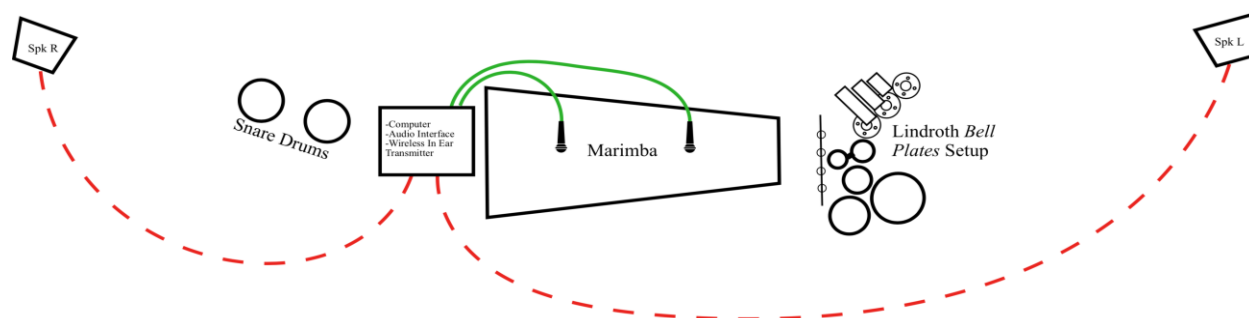## FOR LECTURE RECITALS

Figure 27 - Setup Diagram for Lecture Recital 1 (*Bell Plates, Electric Thoughts, Bounce!, The Alabados Song, and New-Thaan*)
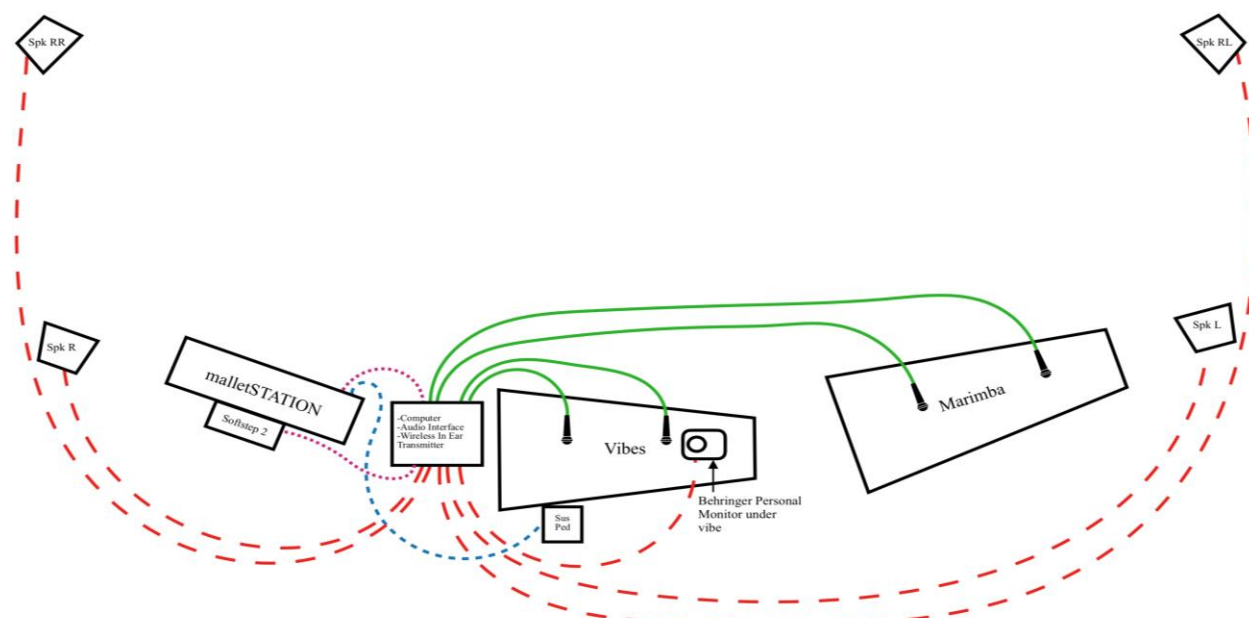

Figure 28 - Setup Diagram for Lecture Recital 2 (*The Hinchinbrook Riffs, Echoes No. 1, After Long Drought, Open End, Electric Counterpoint Mvt. 3, and Chain of Command*)

XLR Mic Cable (input)	————
XLR Mic Cable (output)	– – –
1/4" TS Cable	‑ ‑ ‑
USB Cable	·········

Figure 29 - Cable Legend for Lecture Recital Setup Diagrams
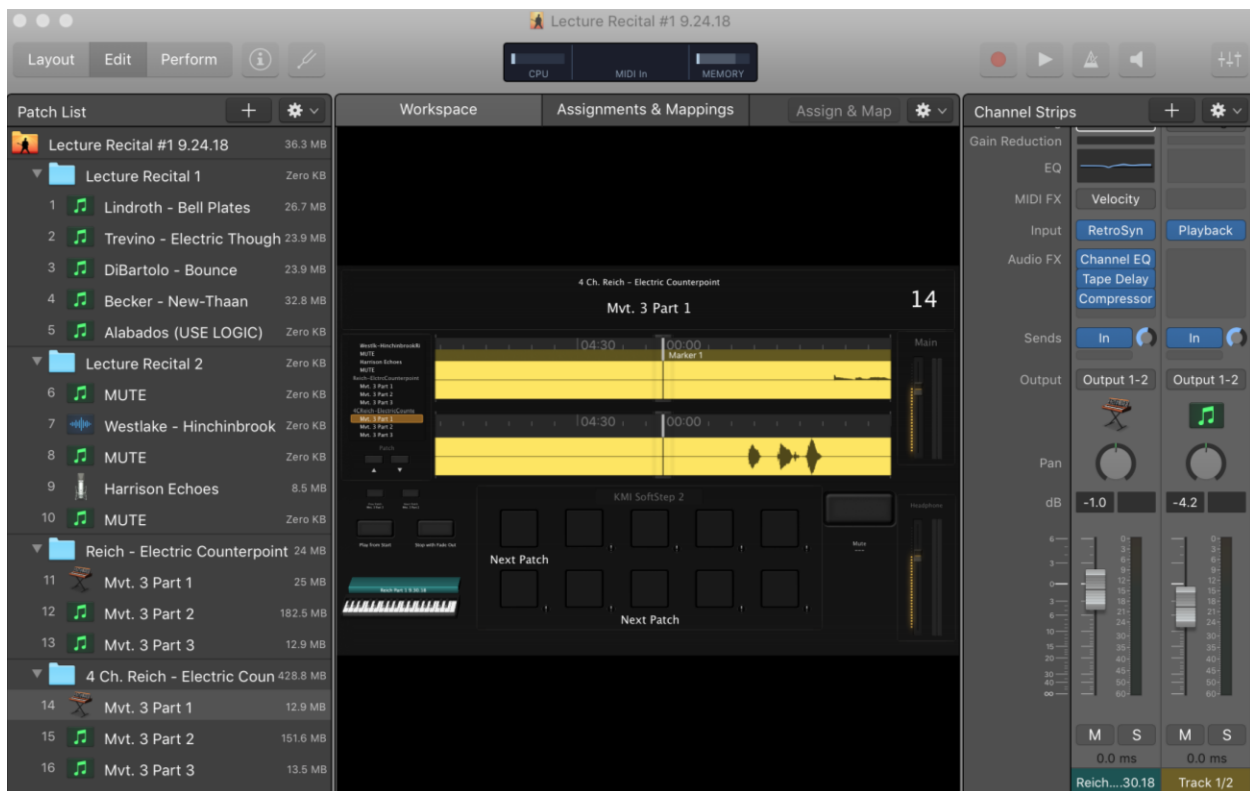
Figure 30 - MainStage File for Lecture Recitals 1 and 2 (Used for All Works Except *The Alabados Song, After Long Drought, Open End, and Chain of Command*)

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BIOGRAPHICAL SKETCH

Matt is currently the Concert Percussion Marketing Manager for Pearl Corporation/Adams Musical Instruments, and Adjunct Professor of Percussion at Middle Tennessee State University. He has earned the Doctor of Music degree from the Florida State University, a Master's degree from the University of North Texas, and a Bachelor's degree from Middle Tennessee State University. Matt is also currently the front ensemble arranger for Music City Mystique, and the Music Coordinator and Electronics Designer for the Bluecoats Drum and Bugle Corps.

Matt has worked as a percussion arranger with a number of DCI and WGI groups, including the Phantom Regiment (2011-2014), Carolina Crown (2015), and Spirit of Atlanta (2007-2010, 2018). He is also very involved at the scholastic level as an arranger for indoor drumlines and marching bands, having written for groups such as Max Percussion (Bangkok, Thailand), Bangkok Society Drumline, Franklin High School, Science Hill High School, McGavock High School, Dobyns-Bennett High School, and Father Ryan High School.

As a performer, Matt plays regularly with the Nashville Symphony Orchestra, and has also performed with Intersection Contemporary Music Ensemble, Tallahassee Symphony Orchestra, San Angelo Symphony, Eastern Philharmonic Orchestra, and the Tennessee Philharmonic. While at North Texas, Matt performed with the world-renowned UNT Wind Symphony, as well as the One o'Clock and Two o'Clock Lab Bands. Matt was the timpanist of The Cavaliers (2003-04) and Music City Mystique (2000-05) and in 2004, he received 1st place in both the DCI and PAS Timpani Individuals competitions.

Matt also travels abroad frequently, having performed in Mexico, China, South Korea, Hong Kong, Macau, and Japan. In the summer of 2010 he traveled to Ghana in West Africa to

study Ewe drumming. Matt's major influences include Dr. John W. Parks IV, Dr. Robert

Schietroma, Christopher Deane, Mark Ford, Lalo Davila, Erik Johnson, Leigh Howard Stevens,

Christopher Norton, John Feddersen, and Bill Wiggins.

As an employee at Pearl/Adams, Matt has helped design a number of percussion

products. He was especially instrumental in the development of two landmark products, the Pearl

Multi-Fit Bass Drum Legs, and the Pearl EM1 malletSTATION electronic mallet percussion

MIDI controller.

Matt is a proud artist and clinician for Pearl/Adams instruments, Innovative Percussion

sticks and mallets, and Evans Drumheads.