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Performed Electronics: Compositional Paradigms for Reinforcing Human Agency in Electroacoustic Music

DISSERTATION

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by

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VITA

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ABSTRACT OF THE DISSERTATION

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by
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While musicians have been *performing* with electronics for nearly a century, there still exists very little *performable* repertoire for electronicists. In fact, the notion of the electronicist as a performative role in contemporary classical music is still not necessarily widely accepted. It is still the case that most contemporary electroacoustic repertoire calling for *live electronics* refers only to the real-time nature of the electronic processes and not human action as it is enacted and perceived in real time. I present a new term in response to this issue which I call *performed electronics.* This new category of work (for which there are historical examples I adopt into the new terminology) focuses on liveness, performativity, and temporally immersive human agency given to the electronicist. I discuss what these terms mean in the context of performing with electronics, present three compositional paradigms for composing works for performed electronics, and analyze existing works that exemplify these concepts. I argue that these compositional approaches yield more engaging and compelling performances—for both performers and audience members—and that this practice is necessary in trying to promote the electronicist as a legitimate role in contemporary electroacoustic music.

Introduction

There is no doubt that the use of electronics has become omnipresent in nearly all forms of contemporary music making. The use of laptops as instruments is seen in a wide variety of genres today. In popular and commercial genres such as electronic dance music (EDM) and hip-hop, laptops are always seen on stage, frequently accompanied by hardware controllers. In academic music communities there are radical new developments in experimental controllers and instruments each year. Additionally, there has been a significant resurgence of interest in modular and analog electronic synthesizers, particularly in online music communities. In fact, market trends reveal that the electric guitar is rapidly declining in popularity, swiftly being replaced by electronic music instruments.[1] Performing with electronics is arguably going to be one of the most common forms of live music making in the very near future.

Performing with electronics is by no means a new phenomenon. In fact, the earliest experiments with electronic instruments in the 20th century were all necessarily live and required a human performer (Wolff et. al. 1998). Throughout the 20th century there have always been prominent figures developing new ways to perform with electronics, exploring how the human body can interact and participate with live electronic systems, and developing creative practices

[1] The following articles outline this general trend:

https://www.marketwatch.com/story/we-asked-guitarists-why-guitar-companies-like-gibson-are-struggling-and-how-to-revive-them-2018-05-04

https://www.washingtonpost.com/graphics/2017/lifestyle/the-slow-secret-death-of-the-electric-guitar/?utm_term=.730c7803fef9

https://blog.reverbnation.com/2018/02/06/electric-guitars-decline-in-popularity/

that could be described as "virtuosic". Just as one who plays the piano is a pianist, or the violin a violinist, I refer to people who perform with electronics as *electronicists*.

Perhaps the earliest example of an electronicist as self-contained performer identity is Clara Rockmore's virtuosic work with the Theremin. Her approach was to take a new electronic musical instrument—the first to afford control without direct physical contact—and perform existing classical repertoire. Rockmore undeniably mastered the instrument, demonstrating extreme precision with no direct tactile reference, she had a truly expressive ability on the instrument. It is unfortunate that ultimately the trajectory of the Theremin descended more into novelty than innovation and eventually becoming a cliché.

Artists like Suzanne Ciani and Morton Subotnick developed unique improvisatory performance practices on Buchla modular systems. These electronic systems allowed performers to *interact* with their instrument, engaging in dialogue, rather than exerting total control over it. Interest in modular synthesizers has seen a resurgence in recent years, appearing in all kinds of musical communities, from academic and experimental music to popular music and film scoring. However, there exists virtually no "repertoire" for modular synthesizer performance. The fundamental appeal of these systems is their nearly infinite combinatorial possibilities, both in terms of sonic output and interface design. The process of working with these kinds of systems tends to be intensely personal and highly improvisational: specific sonic results are hard to replicate or deliver on demand in performance.

Perhaps the most mainstream and commercially successful modes of performative electronics was born out of turntablism. Artists like Christian Marclay and Otomo Yoshihide experimented with adventurous techniques, pushing the turntable to its physical and sonic limits. Other artists like Africa Bambaataa, Grandmaster Flash, and Rob Swift developed a unique virtuosic style of manipulating and juxtaposing samples as well as performing with turntable platters and crossfaders in order to create melodic and rhythmic shapes with found sound. Many of these techniques eventually became codified and developed into a lexicon of sophisticated scratching techniques. In fact, Berklee College of Music now offers a degree in Electronic Digital Instrument performance, with courses such as "Turntable Technique".[2]

I would be remiss in not mentioning the work of artists like Laetitia Sonami and Pamela Z, pioneers in DIY and experimental controller performance. They, and others like them, have cultivated an intensely virtuosic and original creative practice. While composers have written works for electronicists like Laetitia Sonami[3] and Ikue Mori[4], these works are not widely accessible, and in some cases are entirely personalized to that particular performer. To elaborate, it is incredibly difficult to find scores for these works (if they even exist) and it is overwhelmingly the case that the work itself was never conceived to be realized by any other performer(s).

While there clearly exists a rich tradition of performing with electronics, there still remains very little work for electronicists to perform. That is to say, the creative practices of most artists who work with electronics is self-contained and not designed to be realized by other performers (i.e. electronicists). The problem, in short, is that on one end of the spectrum there exist "fully composed works" which give little to no room for performativity or interpretation with electronic devices and on the other end are works that are intensely personal and highly improvisatory in nature. There exists virtually no middle ground for electronicists who are looking to perform composers' works.

[2] https://www.berklee.edu/electronic-digital-instrument-principal
[3] Eliane Radigue composed *Occam IX* (2013) for Laetitia Sonami's "Spring Spyre" instrument
[4] John Zorn wrote for Ikue Mori in his large ensemble work *Orphee* (2005)

This dissertation limits its scope to focus on works that exist within the tradition of what we might now call "contemporary classical music" which utilizes the tradition of the composer-and-performer paradigm. Specifically, I will focus on works that are created with the possibility of realizations and performances by people other than the composer. I will argue that the existing taxonomic distinction of "live electronics" is no longer sufficient in describing works that require a human performer on electronics. Instead, I propose that a new term—*performed electronics*—is necessary to describe works in which temporally immersive human agency is given to the electronics performer, whom I refer to as an *electronicist*. Though the term *real-time* is commonplace in computer music parlance, I use the term *temporally immersive* as a replacement in order to reinforce a human-centric approach so as to distinguish between how humans act and perceive in "real time" versus "real-time" processing in a coding context.

Additionally, this dissertation intentionally does not address the growing phenomenon of laptop orchestras. While laptop ensembles/orchestras address and share many of my concerns in this dissertation, I am more interested in the specific role of individual performers as part of a mixed ensemble. Dan Trueman expressed this sentiment quite nicely:

> I think a bigger question is whether laptop orchestra should be really all about laptops/computation, or whether they should be part of a larger musical structure. Maybe it really should be a laptop section within an orchestra or ensemble? I don't think there is a yes/no answer to this — I still find some laptop-only pieces quite interesting, but I'm finding that the majority of pieces that I'm interested in use laptops within mixed ensembles. Put another way: is a laptop orchestra sort of like a bell choir? Some of the early laptop orchestra pieces felt that way to me, and while bell choirs are fine, I think there are reasons they are, um, niche.

(Interview, “Laptop Orchestra Panel Discussion”, https://seamusonline.org/laptop-orch/)

I am proposing a new term—performed electronics—as encompassing a new taxonomy to be used in the electroacoustic community for pieces that specifically employ an electronicist as a clearly defined performer. Specifically, this term directly responds to the ubiquity of the term *live electronics*, which does not accurately describe the performative capabilities or requirements of a work. When searching for repertoire as a performer, the term *live electronics* only refers to real-time processing (i.e. a computer program that executes code within a near-immediate temporal frame) and it frequently refers to pieces that are mostly automated or simply require advancing automation cues.

While it is possible to argue that any performative action on stage is a performance, no matter how minimal (e.g. John Cage’s *4’33”*), this paradigm of electronicist as mere technician is the most common one in the repertoire and is the least interesting thing a human can do with electronics in a live setting (i.e. a “performance”). It leaves virtually no room for interpretation, expression, or performativity by the human performer. Pressing binary keys (i.e. advancing cues in an automated electronic system) is so limited as to be trivial in performance. I will elaborate on this argument further in the next chapter.

The impetus for this research stems from my disappointment with the current performance practice and paradigms that have been established for electroacoustic music. The role of the electronicist is reduced to a sentient footswitch for the vast majority of the repertoire written for instruments and live electronics. “Live” in most cases simply refers to the real-time processing of an acoustic instrument or the synchronization of pre-recorded material.

In 2017 I formed the piano and electronics duo Teeth and Metals with pianist Mark Micchelli. In searching for repertoire for piano and electronics I came across the work of Xenia Pestova, who had compiled an impressively comprehensive list of works for "piano and live electronics."[5] Her website was arguably the most complete compendium for this specific body of repertoire, yet virtually no work from that list exceeded the traditional paradigm of advancing cues in a Max patch. In nearly every score, I—as an electronicist—had no opportunity to *do* much of anything: no freedom to express, interpret, or "be musical." I was frustrated and dismayed by the painfully limited scope my role had been reduced to—I hardly felt like I was even considered a "performer" in any of these works. This led me to the question then, why are there so few works with a performative aspect?

There are admittedly a number of hurdles when trying to develop performative works for electronicists and overcome these traditionally non-performative paradigms. It requires consideration of a type of performer for which there is no standardized or extensively theorized performance practice. Many times, it means implementing alternative custom notation. It usually requires the use of hardware that is also not standardized. It may very well also require intimate collaboration or consultation between the performer and composer throughout the compositional process, also not a standard practice. Finally, in order to take full advantage of the opportunity for interaction that electronic instruments afford, some degree of improvisation or indeterminacy comes into play, which can be at odds with the traditional concept of a fully determined "composition". However, rather than try to destabilize the traditional and rich history of the relationship between composer and performer, my research hopes to formalize a new approach that is more inclusive of electronicists while enriching these relationships.

[5] https://econtact.ca/13_2/pestova_repertoirelist.html

I do not wish to simply propose a dogmatic set of compositional guidelines for performed electronics. I have no desire to institutionalize an inherently experimental and developing tradition that is still in its early stage of development. I do wish to create dialogue around this idea though, so that a new set of paradigms may take shape and provide entry for composers to contribute to the repertoire of performed electronics.

For me, the most important aspect of performed electronics (as a new perspective rather than a new genre) is that it reinforces human relationships. It affords spectators the ability to make assumptions and connections between the human and the electronic system, keeping them more engaged with the work. It provides the electronicist with a more performative role, enhancing their engagement with the work. It likely requires active dialogue between composers and performers to successfully create and realize the work, enhancing their social ties and raising the performer's personal stake in the successful execution of the work.

Much has been written on the topic of liveness, performativity, and agency in electroacoustic music.[6] There are also continually developing research trends in new software and hardware for embodied performance practices in electronics. This dissertation aims to frame these theoretical concepts through practical examples and personal experience developing a professional creative practice as an electronicist. I will discuss my own interests in liveness, performativity, and agency from the perspective of the performer. Specifically, I frame this

[6] Croft, John. "Theses on Liveness." Organised Sound 12.01 (2007): 59. Web
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research around a central question: “What does it mean to *perform* with electronics?” I will argue that at its core, performed electronics is about facilitating temporally immersive human agency.

Additionally, I propose new compositional paradigms in which works for performed electronics can be framed and situated. These paradigms are useful in the analysis of performed electronics works and approaches to composing for electronicists. The paradigms can be thought of as building blocks for composers interested in writing works for performed electronics.

Lastly, I will discuss specific works that exist in both the historical and contemporary repertoire that manifest the conceptual paradigms of performed electronics. The scope is limited to works that have the potential to be performed by someone other than the composer and that have some kind of written documentation for purposes of detailed analysis.

Chapter 1: Liveness, Performativity, and Agency

Liveness

In the context of this dissertation, *liveness* is a perceptual quality of performance related to the presence and actions of human agents interacting with electronic media in a live concert setting. Liveness and its ontologies—related to sound—emerged in the 20th century when music had the potential to be realized without human agents. That is to say that electronic media presents the potential situation of music without performers and thus begs the question, is it being performed? The scope of my research is not concerned with asking questions related to training or teaching computers to perform, but rather focuses on humans performing with electronics and computers, where agency is primarily given to the human rather than the machine. Because physical action is not directly related to sonic output in electronic systems, the relationship of the performer to the system is suspect in terms of control and input. Liveness is an issue that needs to be considered from both the perspective of the viewer and the performer, as it poses a unique set of problems in both composition and performance.

The word "live" as an adjective has an interesting etymology. Its use emerged as early as the 1540s referring to being a-live or having life, but it has been used to personify machinery and technology since the 17th century. In the early 17th through the late 19th century it was used in conjunction with fire and coal, as in a lively furnace, then with live ammunition, and finally with electricity, as in a "live wire".[7] The first use of 'live' with respect to performance is in 1934, referring to being performed by a human rather than an electronic recording or reproduction.

[7] https://www.etymonline.com/word/live

Throughout the 1950s and early 1960s, "tape music"—also referred to as "fixed media" and encompassing the genres of Musique Concrete and Elektronische Musik—was the predominant compositional practice among composers interested in working with electronics. In this compositional paradigm the composer is afforded complete control over all aspects of the work. In that sense, there is fundamentally no room for interpretation as the work is entirely fixed.

In the mid 1960s, the term "live electronics" (e.g. "for instruments and live electronics") emerged as a reaction against the disembodied and non-performative nature of tape music (Sutherland 1994). Many composers at the time were interested in exploring more performative and embodied music practices with electronics.

It seems that as digital technologies began to overtake their analog predecessors, the term "live" was taken to mean "live processing" over "live human interactions." Computers allowed for a much greater degree of precision and automation over real-time generation of signals (in terms of the coding processes), but removed much of the performativity and agency inherent in some of these early experiments with electronics. So, while the process may be live, there was little to no necessity for living human agents.

In his *Thesis on Liveness* John Croft draws a useful distinction between *procedural* liveness and *aesthetic* liveness. Procedural liveness refers to "the material fact that live sound is being transformed in real time" while aesthetic liveness is "a situation in which...meaningful differences in the input sound are mapped to aesthetically meaningful differences in the output sound" (2007, p.61). Croft also argues that aesthetic liveness can only reliably be achieved "by means of procedural liveness" (2007, p.61). This condition ensures that the relationship is not "faked" or pantomimed, as could be the case with tight choreography synchronized with pre-recorded material.

While I generally agree with Croft, I think his proposition is a bit of an oversimplification. He fails to address some of the key emergent properties of liveness, particularly that the audience not only becomes aware of, but actively involved in the live decision-making process of the performer. This emergent property is sometimes colloquially called the "energy" of the space or the elusive "magic" of a performance. It is a shared experiential quality of a performance and is essential to the audience feeling that it is in fact *live*.

Bown, Bell, and Parkinson propose that "audiences call something 'live' when they feel aware of performer decisions, typically but not always manifest in explicit physical activity in the moment of the performance" (2014, p.18). This awareness of performer's decisions is the foundation to liveness in the context of performed electronics. Additionally, it is important to note that Bown, Bell, and Parkinson suggest that the performer's physical activity is *not always* explicit in the perception of liveness. That is to say that certain audiences can perceive a work to be "live" without the need for a performer to create noticeably perceivable effort.

My interest in liveness, then, is characterized by my desire to promote this concept of *performed electronics* as a separate taxonomy from *live electronics*. I argue that liveness should refer to a living performer, whose temporally immersive actions and decision-making processes are perceivable on stage and shared with the audience as an emergent process. I want to advocate for more repertoire that explores this narrow zone of liveness particularly by focusing on performativity and human agency.

Performativity

Perhaps obviously, the perception of liveness occurs in a live setting, in performance (e.g. on a stage in a concert setting). By their very nature, musical performances and concerts occur in a social setting with varying roles: performer, audience, technical crew, composer, organizers, etc. These roles are manifested through different kinds of enacted behaviors. Christopher Small has referred to all of these various roles and enacted behaviors as “musicking” (1998), while others use the term “performativity” (Kartomi 2014, Davidson 2014).

The term “performativity” is used widely in a number of academic disciplines, from linguistics to philosophy, science and technology studies, and of course in the performing arts. Though he did not actually use the term itself, John Austin pioneered the underlying concepts in his seminal work *How to Do Things with Words* (1955/1962). Expanding on his concepts and applying them to gender theory, Judith Butler defines performativity as the “reiterative power of discourse to produce the phenomena that it regulates and constrains” (1993). In a musical context, Jane Davidson says the following about performativity:

> In music study generally, the concept of performativity has been introduced slowly, even though musicians deal with the competencies of performers as articulated and consolidated in repertoires, events and practices; in other words, performativities. As a form of expression not found in material culture, performativity in music demands that we explore what is embodied, and also brings to the fore the socio-cultural environments in which performances exist. (2014, 179)

Also in a musical context, Margaret Kartomi defines performativity as not just “the condition and behaviour of musicians while performing,” but extends it to include “the whole musical and socio-cultural process of bringing performances to fruition" (2014, 192). She proposes a four-level model of analysis including: (1) the music itself and the rationale for selection, (2) the execution of the music including performance style, persona, interaction, etc., (3) the relationship between the performer(s) and audience in both directions, and (4) the contributions of everyone involved in bringing the performance to fruition (2014).

My concern with performativity has to do with the role of the electronicist in performance and the establishment of a clear performative identity. From my own perspective as a performer, the electronicist is frequently left out of the musical conversation on stage. In order to create a greater sense of performativity, it is necessary that the role of the electronicist is clearly established as an active participant in bringing the performance to fruition.

Many contemporary works involving computers lack a sense of performativity because the way the performer is operating the laptop is visually no different than any other non-musical daily usage. The ubiquity of the modern laptop renders it inherently uncompelling in a performative context, there is simply nothing innately special about watching a person operate a computer. This is exacerbated by the fact that the traditional laptop has very little "sensing" capability to respond to nuanced human gestures.

A primary method for creating works with a high degree of performativity is to incorporate hardware peripherals and gestural controllers/sensors. These tools can facilitate moving performers away from the laptop and attempting to incorporate more embodied music making practices. By this I mean making more clear mapping considerations between physical input and sonic output (à la Croft).

Additionally, another major issue contributing to a lack of performativity (from a perceptual standpoint) is that the electronicist is often disembodied from their sound source. This is not a problem for acoustic instruments, as their sound always emanates immediately from their source. However, for the electronicist the traditional stereo PA system significantly displaces the sound from the performer. One potential solution many have experimented with is localized amplification.[8] By having the sound emanate more locally to the performer, the audience is given the opportunity to more closely associate the performative actions of the electronicist and situate their role in the ensemble.

One issue that resides out of the hands of composers is the lack of established pedagogy and training for electronicists. While there are a number of academic programs for studying electronic music composition, there are very few that allow a performer to focus on electronics as their main instrument. For acoustic musicians, performativity is learned via private lessons, playing solo repertoire for their instrument, playing in ensembles, etc. Electronicists on the other hand tend to self-navigate and discover or build their own systems and thus develop an intensely unique sense of performativity. I think that as the number of these programs grow and the introduction of more electronic music courses make their way into the music curriculum, the knowledge of what is possible and what is expected of an electronicist in performance will take shape. It is my hope though that we will see more traditions that resemble private lessons and transmission of performance practices as prominent electronicists develop them. Rather than try to propose an institutionalized norm for the role of the electronicist, I instead propose a welcome acceptance of this individuality. Percussionists are frequently asked to construct or assemble DIY instruments or found objects, composers can request electronicists do the same.

[8] Many laptop ensembles, such as PLOrk and SLOrk, build hemispherical speakers that are situated next to performers to mimic the acoustic diffusion of sound from the performer

https://ccrma.stanford.edu/~njb/research/slorkSpeaker/

I am particularly interested in performativity as it is experienced from the audience's perspective. While there exists little to no empirical research to validate these claims—in my own anecdotal experience as a member of the larger electroacoustic community—I feel justified in saying that there is a general consensus that a lot of this music is tragically uninteresting to watch.

In my own creative practice, I have noticed two general comments from audience members after my performances (including both practitioners of electroacoustic music and those entirely outside the community and non-musicians). The first is audience members say they "could tell I was actually doing something" on stage. I take this to mean that in their general experience, they cannot tell what many electronicists are "actually doing" while performing; the audience is not making any meaningful connections between the physical presence of the performer and the sound they hear. The second is that I usually hear "that was fun/compelling/exciting to watch" after a performance. I find it particularly interesting that many of these comments focus on the visual and corporeal nature of my performance rather than on the sound.

Agency

As with performativity, the usage of the term *agency* varies quite a bit among—and even within—various disciplines. My use and understanding of the term draws upon Andrew Pickering's simple definition: "doing things that are consequential in the world" (2013, 78). I use the term *agency* to describe a performer's (i.e. electronicist's) actions and the musical/sonic consequences in a live performance context.

Additionally, Pickering considers the action relationships between "humans" and "things" as symmetrical, in what he calls a "dance of agency" (78). It is important to note that Pickering rejects "human exceptionalism" when observing these aforementioned relationships (2008). I realize the predicament here, in that I am indeed arguing for a special role in reinforcing human agency in electroacoustic performance, however these concepts can be reconciled. My contention regarding the predominant compositional practices in electroacoustic music is that the role of the human is in fact not on equal footing with the electronic processes, that the relationship is actually tipped in favor of fixed media or automated code—it is asymmetrical. My argument coincides with Pickering's, simply from a different perspective.

Additionally, I agree with Pickering in that agency is an emergent process (2013). In my own creative practice, I frequently employ the use of systems that require attunement and tending to as well as navigating and balancing as the system responds and evolves throughout the performance (more on this concept in my Situational-reactive paradigm in the next chapter). Many times, the electronicist must discover what their instrument or tools will do by building them.

In order to afford more agency to a performer, the performer must be given the opportunity to interpret and interrogate the work in a live setting as a temporally immersive experience (i.e. as it happens). A degree of freedom must exist in determining how and why actions occur within a given performance. In this sense, agency could also be viewed from the perspective of interaction or interactivity.

In the context of electroacoustic music, the terms interaction and interactivity imply different relationships. *Interaction* can be understood as mutually interdependent actions among individuals while *interactivity* is the degree of influence a user has over a given medium (Borgo and Kaiser 2010, 1). Taken together, both these concepts are a measure of the electronicist's agency in a given piece. They may have to respond to or manipulate an acoustic musician's signal in the moment of the performance. Alternatively, they may have varying degrees of control over an electronic system, relying more on active and musically informed decisions than predetermined automations.

Even in works that are fully notated for acoustic instruments, the performer is given relative freedom in interpretation of non-notated musical elements. These include for example: timbral decisions, subtleties of vibrato, interpretation of dynamics, and micro-timings, for instance. The same level of interpretation is not usually afforded to the electronicist. Most frequently, the electronicist only triggers cue points to execute automated lines of code. This relationship is entirely one dimensional—it is a single point on a line. Moreover, the binary nature of digital computers removes any nuance in these kinds of triggering events. It does not matter how hard, how fast, or with which finger a key is pressed, just that it is pressed at the right time.

Providing more agency to the electronicist is important because it allows the performer to have a more cognitively challenging engagement with the work. As a result, I find that the work becomes more interesting and rewarding to perform. Take for example the "spacebar pieces" that only require starting or advancing cues; these works could be "performed" (I argue this is hardly performing at all) by virtually any competent musician irrespective of their expertise or skill with electronics.

My main contention is that providing agency to the electronicist results in a more cognitively challenging and rewarding relationship with the work. Leaving room for interpretation raises the stakes so to speak. Automation removes the agency of the performer because it normally safeguards against mistakes and errors. However, this risk is precisely what makes live performances a compelling experience. John Croft elucidates on this concept which he refers to as “the grain”:

> The grain, the ‘imperfections’, the unrepeatable, constitute, I would argue, the reason for the continued importance of performance...The grain of performance is the outcome not just of the physical nature of the instrument, but of its physical limitations – the threat that the high notes might break, the unavoidable scraping and breath sounds, the slight roughness of a strong attack. The things which in learning an instrument we are taught to minimise, but which remain as an ever-present sense of fragility, the appearance of human fallibility and corporeality. (Croft 2007, p.65)

It is common to remove these imperfections and strictly regulate the potential outcomes of the code or hardware systems, but in doing so the performer’s agency is also dramatically reduced. In order to create more agentic relationships between the electronicist and their instrument, the composer must not too heavily constrain the potential for mistake and rely on the expertise and ability of the performer to master the control and expressivity of the system.

The kind and degree of agency I am calling for occupies a wide spectrum. Since there does not yet exist a shared language or even traditional lessons (as compared with the highly codified student-teacher relationships for most acoustic instruments) there is not necessarily a clear solution, nor am I calling for one. I can however point out a few clear approaches that would give more agency to the electronicist.

First, removing automation and allowing the performer to make decisions and gestures to change musical parameters. This could for example mean not writing audio fades into files, but rather relying on the performer to create a musical fade in/out, change panning/spatialization, or alter other aspects of the sound in a performative way. Second, composers can be more descriptive, rather than prescriptive, in their notation of digital signal processing techniques. A composer could provide a sound file and indicate that it should be "granulated, with sharp stochastic attacks" for example. It would then be left up to the electronicist to fulfill this request by implementing their own software or hardware capabilities. Similarly, the composer could indicate that the electronicist must capture a section of audio from an acoustic performer and manipulate it by adding intense amplitude and frequency modulation, the specifics of which are left up to the performer. There are obviously many more possibilities, but these examples should highlight the general idea.

In summary, I define the central tenet of performed electronics to be works in which temporally immersed embodied agency is given to the electronicist. While I am personally interested in works that also explore performativity through explicit mappings between physical input and sonic output (i.e. making "effort" perceivable), there are indeed cases in which works can be classified as performed electronics without this level of performativity. This can frequently be the case in works that are more liminal in nature, in which the performer is adjusting continuous controls rather than more discrete triggers. It could also be the case in works that explore monitoring of bodily functions (i.e. biofeedback). In any case, these works still fit within the proposed definition so long as (1) the performer can make decisions in real time, (2) these decisions are mediated and manifested through the body (whether explicit or implicit), and (3) they have some degree of freedom in choice, expressivity, or interpretation in the work.

Chapter 2: Paradigms of Performed Electronics

I propose three paradigms of performed electronics: curatorial-design, situational-reactive, and techno-bodily integration. Each paradigm contains an essential set of features that I believe are necessary in affording an electronicist temporally immersive embodied agency in the piece. Thus, a work of performed electronics will manifest at least one of these proposed paradigms.

These paradigms are *not* considered mutually exclusive; quite the contrary, in fact. Many example works for performed electronics will indeed utilize two, or even all three, of these proposed paradigms. Rather than take these as compartmentalized approaches, instead I view these paradigms as containing the essential features of works that clearly necessitate or facilitate liveness, performativity, or agency in the role of the electronicist. I offer these paradigms as a framework for understanding previous and current work in performed electronics as well as a system in which composers may approach various methods for creating new works for electronicists.

Curatorial-Design Paradigm

In the curatorial-design paradigm, the electronicist is given agency in realizing or creating their instrument, interface, or electronic system for the piece. The design of the system could be prescriptive or descriptive—fixed or indeterminate. A composer may explicitly request to the performer, "design a system that is capable of the following…" or alternatively, the score may implicitly provide this agency by describing an electronic system to be used (e.g. "create a feedback loop using a matrix of microphones and loudspeakers"). The unique process of creating or realizing the instrument/interface/system is central to this paradigm.

One of the primary issues in electronic music performance is the lack of a standardized instrumental practice. It is a bit of a misstatement to suggest that there is no standardized *hardware* in electronic music. These days, it is absolutely common for an electronicist to have access to a standardized laptop or computer that will—at the very least—contain an alphanumeric keyboard that can generate ASCII data and a mouse that affords interaction with the entire 2D visual screen space. As a result, composers have gravitated toward the model of creating software (typically a Max patch) that requires as little human control as possible (e.g. advancing automation cues with a keystroke). This practice is admittedly successful in yielding pieces with low threshold of difficulty and high degree of accessibility, in terms of realization.

However, relying solely on the capability of the QWERTY keyboard and mouse/trackpad has a number of drawbacks in live performance. First, all the actions of the electronicist are literally obscured by a screen—the audience frequently cannot see any of the performer's physical gestures. Second, even if the performer positions themself in such a way so as to make their gestures visible, the relationship between the physical input gesture and the resultant sonic output are completely decoupled. Specifically, the result of a physical keystroke can range from a tiny blip to triggering the sound of an entire symphony, thus even audience members who may be familiar with computer music techniques will have difficulty in determining *what* exactly the electronicist is doing or their relationship with the resultant sound. Third, the digital (i.e. binary) nature of the keyboard does not allow for continuous or nuanced control. Moreover, where the mouse/trackpad can make up for this continuous control, the limitations in mapping prevent nuanced simultaneous control over parameters. For example, one would only be able to interact with one graphical user interface (GUI) object at a time. Even if advanced parametric mapping is employed, the Cartesian nature of the trackpad/mouse input is drastically more limited than say the capability of accessing multiple physical faders or dials on a mixing console.

There are a number of reasonable assumptions composers can and should make about the hardware tools of the electronicist. Three basic assumptions are (1) they will have access to discrete buttons or triggers, (2) they will have access to continuous controls like faders or knobs, and (3) they will have the ability to map or assign these parameters with relative ease.

It is reasonable to assume that an electronicist will, at the least, have some kind of external hardware controller. There are a number of commercially available MIDI controllers that have similar, predictable features. One of the most widely used cheap MIDI controllers currently is the Korg nanoKONTROL. This device includes faders, knobs, and buttons and can be used in essentially any software to provide continuous control over 16 parameters and more than 24 discrete triggers.

It can also be the case that an electronicist has created their own fully formed instrument and is commissioning a composer to write for their instrument. For example, Eliane Radigue composed her 2013 work *Occam IX* for Laetitia Sonami's "Spring Spyre" instrument (see Figure 1).

Figure 1 Laetitia Sonami's *Spring Spyre* instrument

The curatorial-design paradigm addresses the issue of non-standardized instrumental practice by embracing the practice of allowing or requesting the electronicist to create their instrument or alter the mapping to suit the needs of the piece. There are obviously many possible approaches to composing in this paradigm; I will highlight a few.

One possible approach is to describe the required musical capabilities of the instrument for the piece. For example, one might request that the instrument must be able to produce sine tone clusters, of which the relative density, volume, and register must be controlled within a specified range. The electronicist is then charged with the task of deciding how to create those sounds, both by designing the instrument that may produce those sounds (e.g. a Max patch) in addition to curating the physical gestures required to produce and control the sounds (i.e. deciding on the controller/interface and the internal mapping structures).

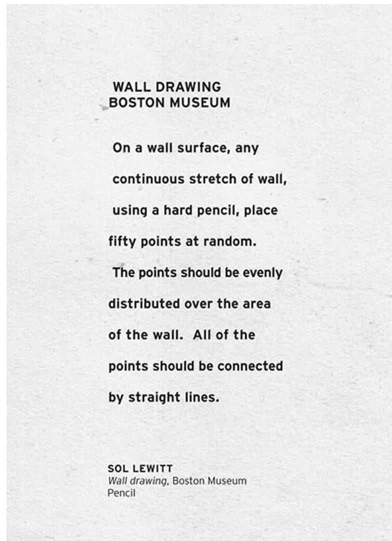
Another approach might include describing a desired sound and allowing the electronicist to creatively realize the approach method. In John Cage's *Inlets* (1977) for performers with conch shells, he indicates in the score that "a tape recording of burning pine cones fades in." Similarly, in Nicole Mitchell's *Inescapable Spiral* (2017) for mixed ensemble, she describes the sound of "fire cracking" in the text and graphic notation. Both cases allow the electronicist to creatively curate these sounds and also to freely decide by what means they physically introduce them (a fade-in could be achieved in many ways).

Lastly, the composer may describe the relationship the electronicist has with another acoustic performer, usually in terms of electronically processing their sound. Alvin Lucier employs this method in his work *The Duke of York* (1971):

> Two persons design a musical performance in which one of them, the synthesist, uses an electronic music synthesizer or equivalent configuration of electronic equipment to alter the vocal identity of the other, the vocalist, who selects and orders any number of songs, speeches, arias, passages from books, films, television, poems, or plays, or any other vocal utterances including those of non-human intelligences, in ways determined by his or her relationship to the synthesist and the particular purpose of the performance. (*Chambers*, 1980, 80)

Again, the electronicist (referred to as a "synthesist' by Lucier) is charged with curating their own technology for the piece. Lucier goes on to say that "the synthesist makes one or more alterations of any aspect of sound including pitch, timbre, range, envelope, vibrato, and amount of echo" and also indicates that once alterations to the sound are made, they cannot be undone (81). He provides enough detail so as to give the electronicist constrained freedom in their approach.

This kind of agency and freedom of interpretation is conceptually related to Sol LeWitt's *Wall Drawing* series. Rather than directly creating the artwork, LeWitt instead provides instructions about how to realize and install the work (see Figure 2).


WALL DRAWING
BOSTON MUSEUM

On a wall surface, any continuous stretch of wall, using a hard pencil, place fifty points at random. The points should be evenly distributed over the area of the wall. All of the points should be connected by straight lines.

SOL LEWITT
Wall drawing, Boston Museum
Pencil

Figure 2 ***Wall drawing*** **instructions**

In many ways the curatorial-design paradigm is closely related to percussion practices in contemporary classical music. "Percussion" is not an instrument in and of itself. It is a collection of musical skills that can be applied to working with materials. A percussionist may be tasked with obtaining and creating a specific setup unique to the requirements of the piece, as is the case with Morton Feldman's *The King of Denmark* (1965). I propose that this model also be applied to works for performed electronics, whereby the composer provides instructions for what is necessary to realize the work and leaves it open to the interpretation of the electronicist to decide how best to implement their own custom instrument or interface.

Situational-Reactive Paradigm

The situational-reactive paradigm is perhaps the most broadly inclusive. The fundamental aspect of this paradigm is that the composer creates or defines a situation, system, or environment in which the performer must react, negotiate, balance, or maintain active responses. The governing rules can be made explicit by the composer or can be implicitly defined by the system. The former may manifest itself as a set of prescribed improvisational relationships (e.g. "sample and process a live input signal") while the latter may mean navigating a self-generating system (as is the case with most feedback systems).

This paradigm is perhaps most unique to electronics, in that the work can be focused on the concept of interactivity within a given system. Interactivity in this case can be understood as "mutual influence between agents that are also in some way autonomous decision makers" (Dobrian 2004, 1). Another way to think about this is that the performer can be forced to interact *with* their instrument, rather than exerting direct control over it. A piano or violin never has any agency in a piece; acoustic instruments do not have autopoietic capability. In this sense, the electronics may have an inherent behavior or unpredictability and the performer must participate in the process of temporally immersed music making that exceeds what can be traditionally notated.

Improvisation is central to the situational-reactive paradigm. "Authentic interactivity" would suggest that the relationship between the performer and the electronics is not entirely predetermined (Dobrian 2004). In the case of a computer, the code may exhibit its own autonomous or non-deterministic behavior. In analog situations, circuits may have chaotic or self-regulating behavior that the performer may have no direct control over.

Moreover, I argue that direct control—with respect to the production of specific pitch and rhythm—is perhaps the least interesting compositional approach to writing for electronics. There are two glaring issues with the "play this note at this time" approach to composing for electronics. The first is that it is likely best realized on a keyboard or percussion interface (such as MIDI instruments), in which case the piece really is not written for an electronicist at all and would almost certainly be better realized by keyboard player or percussionist. The second is that computers are far superior to any human in terms of pitch and rhythmic precision; so, if the tightest possible precision is the goal, then there really is no need for the electronicist.

Admittedly, there are clever solutions to these problems mentioned above, but generally speaking these compositional approaches garner the least interesting performative results. By maintaining such tight control, one squeezes the life out of the performative possibilities. I refer to William S. Burroughs for the basis of this value judgement:

> A basic impasse of all control machines is this: Control needs time in which to exercise control. Because control also needs opposition or acquiescence; otherwise it ceases to be control….All control systems try to make control as tight as possible, but at the same time, if they succeeded completely, there would be nothing left to control.
>
> (1985, 116)

The improvisational aspect of the situational-reactive paradigm can perhaps challenge the composer's sense of authorship. There has been much debate about what exactly constitutes a *composition*, especially when improvisation plays an important role in the work (Lewis 1996). A more detailed discussion on that topic exceeds the scope of this dissertation, but I will make the point that I think it is mostly an issue of composers' general unwillingness to relinquish power and control over performers. Personally, when I am in the role of a performer who is tasked with improvising in a composition (i.e. a piece composed by someone else), I take no issue with giving full credit to the composer for "creating" the music. If the composer has devised the situation, scenario, or environment in which I realize the music, they are entitled to claim authorship and it is, in my opinion, a composition.

Thus, the situation-reactive paradigm highlights some of the underlying issues and difficulties in composing for performed electronics. It is in many ways at odds with the traditional notion of "Composition" in a Western art music context and demands that the composer relinquish some degree of control over the work. This paradigm is similar to other kinds of improvisational music, particularly in the jazz idiom, in which the composer may only provide a limited musical framework (such as lead sheets or chord charts) for the performer to realize or interpret. While many realizations are possible, there is still is clear sense of authorship and credit is given to the composer who originally devised the idea.

Techno-Bodily Integration Paradigm

The techno-bodily integration paradigm refers to pieces in which technology is mounted on, integrated with, or monitoring the body. Techno-bodily integration can also include pieces in which the interaction between the performer and the technology (i.e. the gesture or movement) is explicitly notated or choreographed. I use the term choreography here because the mapping of physical input to sonic output may be divorced, altered, or fluctuating. Thus, the relationship between the performer and the sound may not be entirely instrumental, that is to say that the movement itself may be more important than trying to “play” the instrument. In short, this paradigm includes works in which the body, gesture, or movement are the primary focus.

Sensors are frequently used in these kinds of pieces, whether they be gyroscopes, accelerometers, camera or motion tracking hardware, or biofeedback sensors. Implementing these types of hardware peripherals affords the performer greater control and more fine-grained precision in performance. Moreover, these types of physical input devices may allow a performer independent control over many parameters simultaneously. Additionally, composers have experimented with different kinds of graphic and tablature notational systems to direct physical actions with controllers and hardware.

Today, there is a large array of commercially available hardware sensors, many of which are relatively cheap or easy to build. I will discuss a few of these devices in some detail, focusing on three that I have seen used in a number of works and that have examples of experimental notation as well.

The GameTrak controller has seen a surge in popularity after it was used as the main performance instruments for the Stanford Laptop Orchestra (SLOrk). Originally designed as a physical game controller for a golfing video game, it is easily repurposed as a two-channel XYZ joystick controller. A retractable string is connected to a joystick which allows a performer to explore three-dimensional space with one or both hands (see figure 3).

Figure 3 GameTrak Controller

Ge Wang composed his work *Twilight* (2012) for an ensemble of performers on GameTrak devices. Each performer has custom software instruments designed in ChucK that are controlled by the various parameters coming from the GameTrak. Wang's score for *Twilight* functions as choreography. Rather than notating resultant sonic outputs, Wang primarily notates only the physical gesture to be performed (see figure 4). Indications for which instruments to use are given, but the performers are not explicitly instructed to react or adjust their motions to the sound.

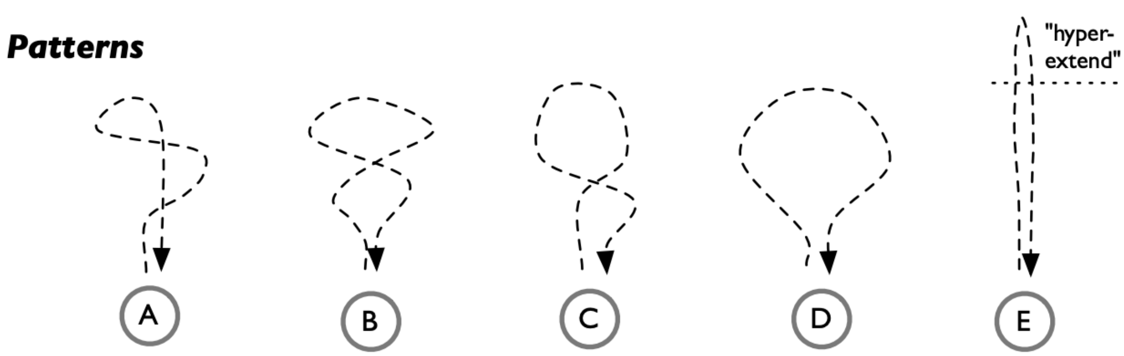


Figure 4 Ge Wang *Twilight* (score excerpt)

The next common group of controllers seen widely used today are tablets. I use the more general term "tablet" to include any surface controller capable of sending complex input data like multitouch or MIDI polyphonic expression (MPE). Examples include: iPads running software like Mira, Lemur, or TouchOSC; Wacom tablets; and more recently the Sensel Morph. These types of controllers offer direct, tactile input that can far exceed simple XY trackpad data.

Composer Craig Smith has written etudes for the iPad by implementing the Decibel Score Player app[9]. His work *Formal Domestic I* (2015) is scored by displaying finger locations on the iPad through time (see figure 5)[10]. Two performers each use a different app to generate sound.

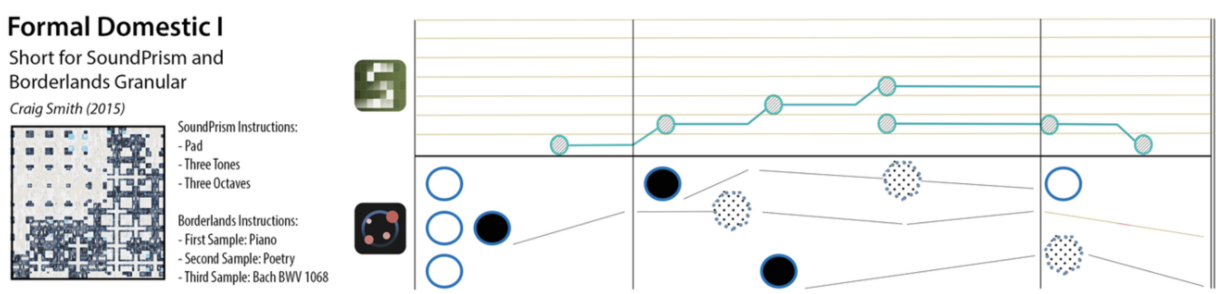


Figure 5 Craig Smith's *Formal Domestic* (score)

[9] https://www.decibelnewmusic.com/decibel-scoreplayer.html
[10] http://www.autismpedagogy.com/blog/2015/4/11/ipad-music-and-graphic-notation

Similarly, Rama Gottfried has experimented with iPad notation to display finger location as well as more complex gestures like pinching and spreading. His work *prototype I* (2011/2015) uses Lemur to track finger locations and control synthesizer parameters in Max (see figure 6).

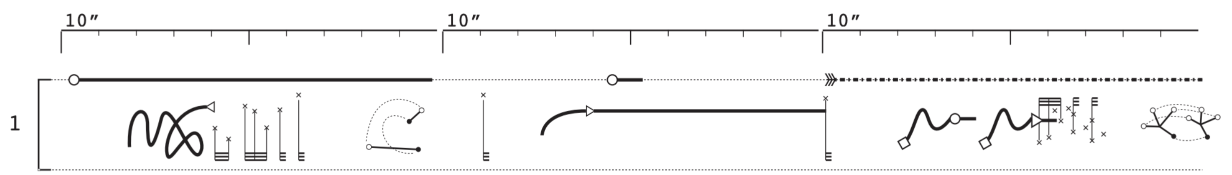


Figure 6 Rama Gottfried's *prototype I* (score excerpt)

While not explicitly a *controller* per se, the no-input mixer has become a relatively well known and commonly implemented performance system. A no-input mixer (also referred to as a feedback mixer/matrix) uses any commercially available audio mixer as an instrument by rerouting output signals into input signals to create controllable feedback oscillations. While the exact output is not always stable or precisely controllable, general influence can be exerted over the system in intuitive and semi-repeatable ways.

Some composers have begun exploring various ways to notate performative actions on no-input mixers. For example, Kelly Sheehan's work *Talk Circus* (2018) for two percussionists and one musician on no-input mixer implements a tablature system to indicate channel levels and muting (see figure 7).

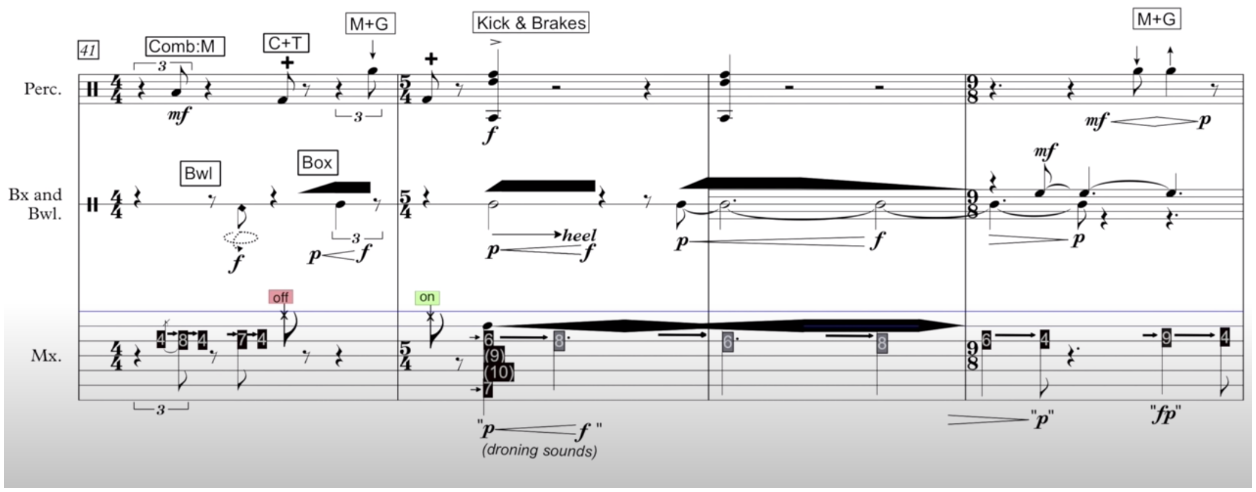


Figure 7 Kelly Sheehan's *Talk Circus* (score excerpt)

In her tablature, channels are indicated on the staff line, small numbers indicate knob positions, and lines indicate continuous movement of knobs. She also calls for rhythmic muting/unmuting of the overall signal.

In all these examples, the gesture is clearly evident to the audience and there is arguably a clear cause-and-effect relationship between the physical input and sonic output. By notating clear gestural information, the composer reinforces liveness and performativity, displaying the temporally immersive human control over the system. The availability of the equipment means that these approaches are no longer entirely novel or esoteric but should be considered as standard resources for composers interested in writing works for performed electronics.

Chapter 3: Paradigmatic Works

The scope of this dissertation is primarily situated within the context of what may be called contemporary classical music, with a specific focus on works that can be performed by someone other than the composer. I am interested in developing repertoire and knowledge of performed electronics in order to cultivate a performance practice for electronicists and curate a body of works representative of this practice.

In choosing which works to discuss in this chapter, I decided to focus on the following two criteria: 1) the work must have some kind of written documentation (i.e. a 'score' of any kind) and 2) the work must have the capacity to be performed by someone other than the composer. Additionally, I have personal experience performing many of these works, and this intimate knowledge is useful as an analytical tool and in discussing why these works are particularly interesting or compelling for an electronicist.

The above selection criteria do not imply that works without a formal written score are fundamentally excluded from the performed electronics taxonomy. On the contrary, there are a number of compelling works without scores in the contemporary repertoire that I think perfectly exemplify the paradigms discussed in Chapter 2 and that function as excellent examples of works that clearly reinforce liveness and agency in performance. Their exclusion here is more a pragmatic decision due to the difficulty of analysis and documentation of such works.

I selected works that distinctively fit into each of the proposed paradigms of performed electronics and exemplify the unique nature of each paradigm. This is by no means a comprehensive analysis of all works in the field, but rather a personally curated list of historical and contemporary works that have either inspired much of this research or were grown directly out of this practice. This chapter focuses on other composers' works and my perspective as a performer. In the next chapter I will discuss my own creative work and practice as a composer.

Curatorial-Design Paradigm

John Cage's *Song Books* (1970) contains solos for voice that also feature the use of electronics and occasionally theater. The pieces with electronics are presented and notated in such a way as to give enough constraint that the piece has a clear sonic identity but allow for a wide range of interpretation and performative possibilities. In most of the works with electronics, Cage only notates parameter numbers, positions of a 'dial' for each parameter (superscripts), and relative temporal location for each parameter change (see Figure 8).

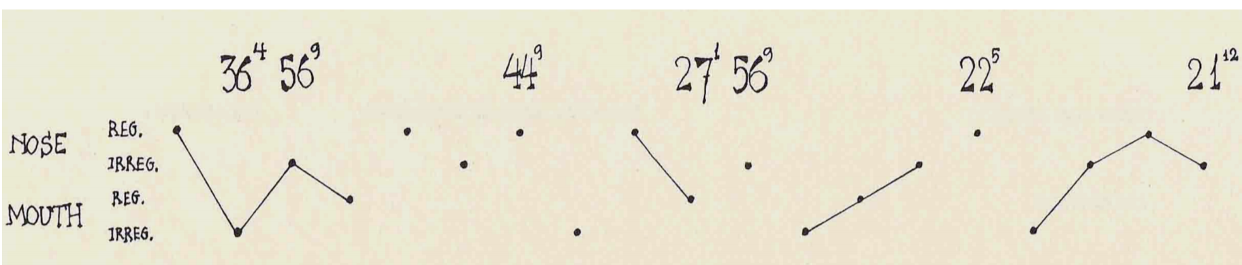


Figure 8 "Solo for Voice 22" from *Song Books* (1970) [score excerpt]

Cage makes no specific indication for *what* the electronic processes should be, but instead provides a translational chart to accommodate for any specific number of processes the electronicist has available for the performance (from one to sixty-four unique possibilities).

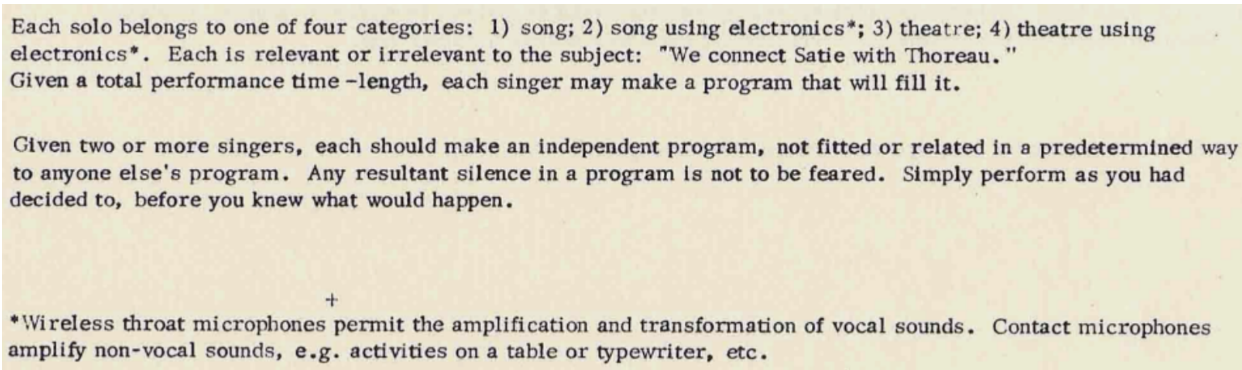
In this way, the electronicist can freely select and map whatever potential processes—and their potential parametric changes—that are available to them, given their specific hardware/software performance environment/interface. The electronicist must make such changes adhering to the temporal location and "dial position" provided in the score but given that "no duration is notated" they must follow and respond accordingly to the vocalist's pace.

Additionally, Cage provides an extensive appendix for translating or re-mapping any of the sixty-four notated parameters (the larger subscripts) onto any fewer parameter possibilities. In other words, if the electronicist only has 8 dials/parameters, Cage provides a kind of "lookup table" for how to map the 64 notated numbers onto those 8 parameters.

The score provides enough information so as to be specific—this piece is not improvised—but it affords creative freedom in designing or implementing any personal or custom electronic system the electronicist may use. The electronicist is responsible for curating their own system and mapping the necessary changes to the available control interfaces. It is also important to point out that the process cannot be simply automated. Since the exact temporal duration and occurrence is not strictly indicated, but rather exists in relation to where the vocalist is in the score, the electronicist must listen to the vocalist and adjust their timing accordingly.

The score functions like indeterminate tablature for the electronicist. The ingenuity of this approach is that the work is just as relevant and interesting to perform today, as it can easily be realized with more complex computer processing mapped to any conceivable hardware controller; it overcomes the looming issue of hardware/software specificity in many contemporary works using computers.

In approaching a contemporary performance of this work, an electronicist could easily use either a computer with hardware dials (e.g. a commercial MIDI controller) that interact with software or use a collection of analog electronics or effects pedals. Cage does not state in the score that the electronics *must* be processing the voice, but it is implied under the "General Directions" at the start of the books (see Figure 9).


Each solo belongs to one of four categories: 1) song; 2) song using electronics*; 3) theatre; 4) theatre using electronics*. Each is relevant or irrelevant to the subject: "We connect Satie with Thoreau."
Given a total performance time-length, each singer may make a program that will fill it.

Given two or more singers, each should make an independent program, not fitted or related in a predetermined way to anyone else's program. Any resultant silence in a program is not to be feared. Simply perform as you had decided to, before you knew what would happen.

+

*Wireless throat microphones permit the amplification and transformation of vocal sounds. Contact microphones amplify non-vocal sounds, e.g. activities on a table or typewriter, etc.

Figure 9 "General Directions" from *Song Books* (1970)

Notice that the first mention of electronics in the score refers to a footnote that only describes microphone techniques. At many other points in the score Cage will explicitly refer to microphone levels and techniques (e.g., "highest volume without feedback" p. 56) and occasionally call for pre-recorded materials (e.g. birds or telegraph wire sounds). In *Solo for Voice 17,* Cage gives the following direction: "Use electronics to so transform the voice that it resembles singing wires, not strident, but whirring (aeolian harp, musical saw)" (see figure 10).

SOLO FOR VOICE 17 SONG WITH ELECTRONICS (RELEVANT)

DIRECTIONS

The text is a mix of remarks about the "telegraph harp" from Volumes II-IV of the Journal by Henry David Thoreau. Use electronics to so transform the voice that it ressembles singing wires, not strident, but whirring (aeolian harp, musical saw). The notation relates horizontal space to time. Beams are slurs. Commas above the notes, periods following words, are phrase endings. High, middle and low are differentiated; size of note may be related to changes of amplitude, dynamics.

This solo may be accompanied by a tape recording of telegraph wire sounds or by improvisation on a musical saw equipped with mike.

Figure 10 *Solo for Voice 17* from *Song Books* (1970)

It seems clear then that Cage envisions the electronics to be fundamentally intertwined with the voice and that their main function is to process and transform the vocalist's signal. The electronicist is tasked with making the determination for what processing is appropriate for the performance. This brings up the possible argument to be made for "historically informed" electronics performance practice. Does the electronicist stay faithful to the technological limitations of the time? I think Cage would be open to all means of electronic manipulations.

The freedom that Cage affords the electronicist is what gives the work a vast array of possibilities for creative realization. The electronicist can use virtually any existing performance interface or system; 64 maximum parameters is extensive even for complex software and hardware systems, and exceeds what the majority of performers could even mentally keep track of in live performance. The work is not beholden to any specific software or hardware; thus, it has a low threshold of difficulty for future realizations, allowing the electronicist to make creative decisions in using any conceivable electronic system.

In my own realization of the work I decided to use an analog configuration of effects, mapping the dials to the amplitude of effects sends (reverb, delay, pitch shifting, ring modulation, equalization, and panning) and parameters of those effects (delay time, pitch, ring mod rate/depth, etc.). My system allowed for 24 potential "dials", but the remapping matrix only called for the use of about a dozen of the variables.

David Tudor's *Rainforest IV* (1973) is perhaps the most elegant example of the curatorial-design paradigm in its simplicity. The score is simply a high-level circuit diagram that describes an electronic system with indeterminate inputs and outputs (see Figure 11). This piece is generally realized as a "performance-installation" meant to be experienced as an immersive environmental work. However, I include it in this discussion primarily because of the way Tudor managed to represent the score in such a reduced format. Furthermore, there is no explicit indication as to how this work should be presented. The work is open to being realized in a great number of ways, reinforcing a central aspect of the curatorial-design paradigm. Agency in this case can be reinforced through the design of the performance environment. Electronicists are free to create and implement their own systems and exemplify whatever degree of performativity and liveness they choose.

Typically, complex electronic systems used in performance or installation require a few pages of technical notes, going into great detail about the routing and configuration parameters. But here, Tudor has managed to encapsulate the entire possibility of realization with a simple signal-flow diagram (see Figure 11).

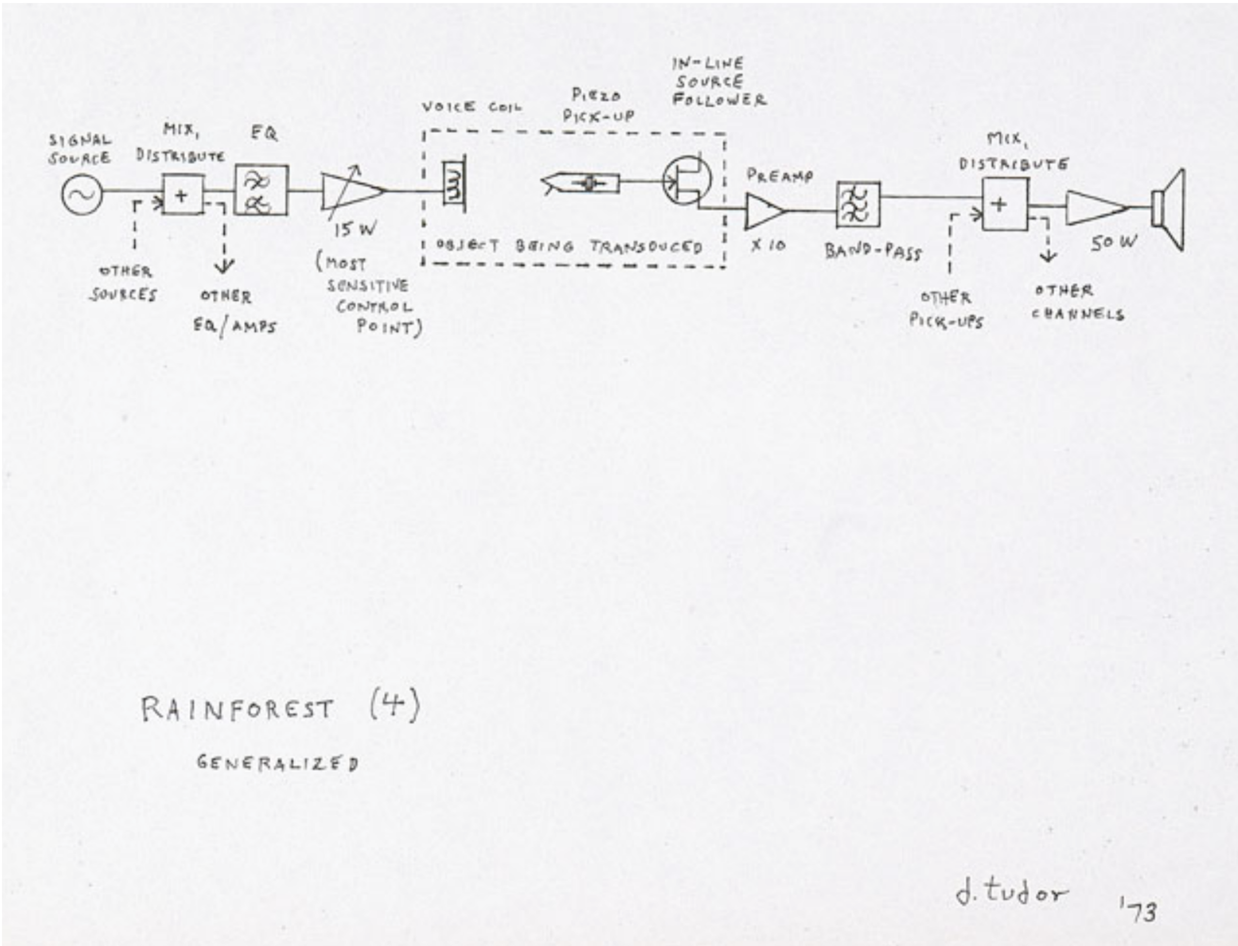


Figure 11 Generalized score of Tudor's *Rainforest IV* (1973)

Tudor calls for an indeterminate "signal source" to be routed through a matrix of amplifiers and equalizers and transduced through a physical object. That signal is in turn re-amplified with a contact microphone and spatially distributed with a loudspeaker array. The score provides clear and detailed information for realization but is left entirely indeterminate in terms of *what* is being played and *which* objects to transduce.

The work comes to life through the process of creatively deciding how to design the electronic configuration. In the same way that the standardized circuit diagram functions, the specific realization (particularly with regard to design, spatial layouts, size, parts, etc.) is open and many variable realizations are possible. The electronicist is left with a number of curatorial decisions to make. How many source signals are there? What are they? How many objects are being transduced? What objects are being transduced? Where are the objects in the performance space? How are the contact microphones routed to loudspeakers? Where are the loudspeakers in the space? And so on.

Rainforest IV necessitates and essentializes the consideration of presentation through curation. Tudor himself has said the following about the curatorial nature of the work:

> It's important that each person makes their own sculpture, decides how to program it. [*sic*] and performs it themselves. Very little instruction is necessary for the piece. I've found it to be almost self-teaching because you discover how to program the devices by seeing what they like to accept. Its [sic] been a very rewarding type of activity for me. (David Tudor, from An Interview with David Tudor by Teddy Hultberg in Dusseldorf, May 17-18, 1988.)

It is also clear that Tudor explicitly considers this a performative piece. He considers the system not just a means of amplification as "reproduction", but "but as an instrument unto itself" (1988). Tudor had given much thought to the "dilemma" of the uniqueness and complexity of individually designed custom electronic instruments.

> When I work with other people we try to make do with very simple resources. I can give you an example of what Composers inside Electronics did. We were asked to give a series of programs and we decided that each one of us would take one evening and we would all perform the same work. Now that created a dilemma because the equipment for each piece is unique and only one person has it, so we were not able to duplicate the

equipment. The problem became 'can you realize the same electronic principles, the same composition, with other equipment?' And it turned out to be very possible and surprisingly easy. It was a joyous experience to find out that you were actually doing somebody else's music with things that you had on the shelf.

(David Tudor, from An Interview with David Tudor by Teddy Hultberg in Dusseldorf, May 17-18, 1988.)

Tudor's thoughts on this matter are a central concept in the curatorial-design paradigm. His question, "can you realize...the same composition, with other equipment?" has been a growing conflict in the creation of performative electronic works since the ubiquity of the computer took off. Relying on specific hardware/software for the realization of a work drastically limits its potential to be performed by people other than the composer (or without the composer present).

Tudor was successful with *Rainforest IV* by creating a work that has a clearly defined 'personality' but is open in its potential for realization. The process of designing the system is a part of the score and thus informs the performance practice of the piece. It requires that the electronicist develop an intimate relationship with the abstract system that Tudor created, but allows them to implement their own electronic instruments in the realization of the work.

Nicole Mitchell's *Inescapable Spiral* (2017) explores a different approach to the curatorial-design paradigm in which she uses text and graphics to describe the sonic output but leaves the design and realization of the electronics indeterminate. This work was originally conceived with me as the electronicist, thus the following thoughts and discussion stem from the personal process of creatively realizing the work.

Inescapable Spiral is a large-ensemble work that features various overlapping solos, duos, and trios. Mitchell describes the work as a " 'variable process' piece for five or more instruments of any kind for musicians with a wide range of playing abilities" (Mitchell 2017). Shorter works indeterminately overlap and collide to form the larger structure of the piece. I will specifically address the shorter works that call for electronics.

The score(s) with electronics employ a hybrid text-graphic notation system that describes the resultant (i.e., "desired") sound. Pieces with electronics are usually paired with voice or flute. Thus, the temporal aspect of the notation is usually a vertical relationship between the two performers, rather than aligning with a global beat or pulse. The notation focuses on the following: time expressed as a vertical relationship between two performers, relative pitch height, small rhythmic fragments that can be loosely interpreted, dynamics, textual descriptions of desired sounds, and graphical representation of sound transformation or sound objects.

While the work was originally developed through direct communication between Mitchell and me, using my particular configuration of electronic instruments, the score is presented in such a way that virtually any electronicist could realize the piece. *Silver* is a duo for flute and electronics that focuses on two basic electronic sounds—drum beats and various noise sources (see Figure 12).

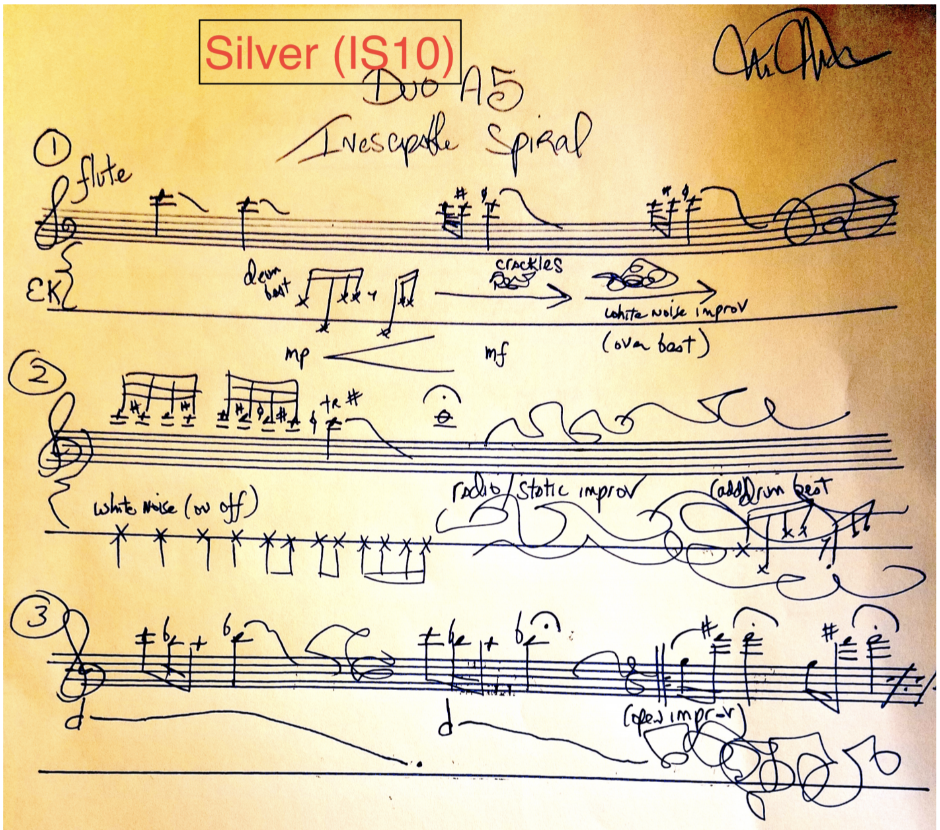


Figure 12 ***Silver*** **from** ***Inescapable Spiral*** **score (2017)**

The notational system here is different from the previous examples discussed in this chapter. The notation is quite direct and results in a clear (and repeatable) sonic identity. The curatorial design of the electronic system is embedded within the sonic requests made by Mitchell. First, the electronicist must be able to generate a "drum beat", "crackles", "white noise", "radio static", and some kind of sustained pitch. Second, the electronicist must be able to control the dynamics and relative density of the sound. Third, they must be able to 'rhythmically gate' (i.e. "turn on/off") the white noise (furthermore, at a fast enough rate to accommodate 1/4 to 1/16th note divisions). Fourth, they must be able to simultaneously layer each sound and independently control the dynamics of each layer. Fifth, they must be able to dynamically control the sustained pitch and radio static.

Though the score is short and appears simple, it is rich with complex curatorial possibilities. Any of the aforementioned sound sources could be generated in a number of ways, from pre-recorded material to synthesis. The control parameters will necessarily involve both discrete (e.g. buttons) and continuous (e.g. knobs) physical controls. It could be realized with a computer or through entirely analog solutions. Lastly, the vertical relationship between the instruments, in addition to the specific call for “improv” in two sections, implies that the realization cannot simply be automated, but must in fact be performed.

Similarly, in *Charcoal* Mitchell provides clear and simple requests for sound objects. Terms like “fire crackling”, “birds (3 kinds)”, and “bells+sand paper” can be realized through a number of creative approaches, ranging from field recordings to synthesis techniques, or a combination of the two (see Figure 13).

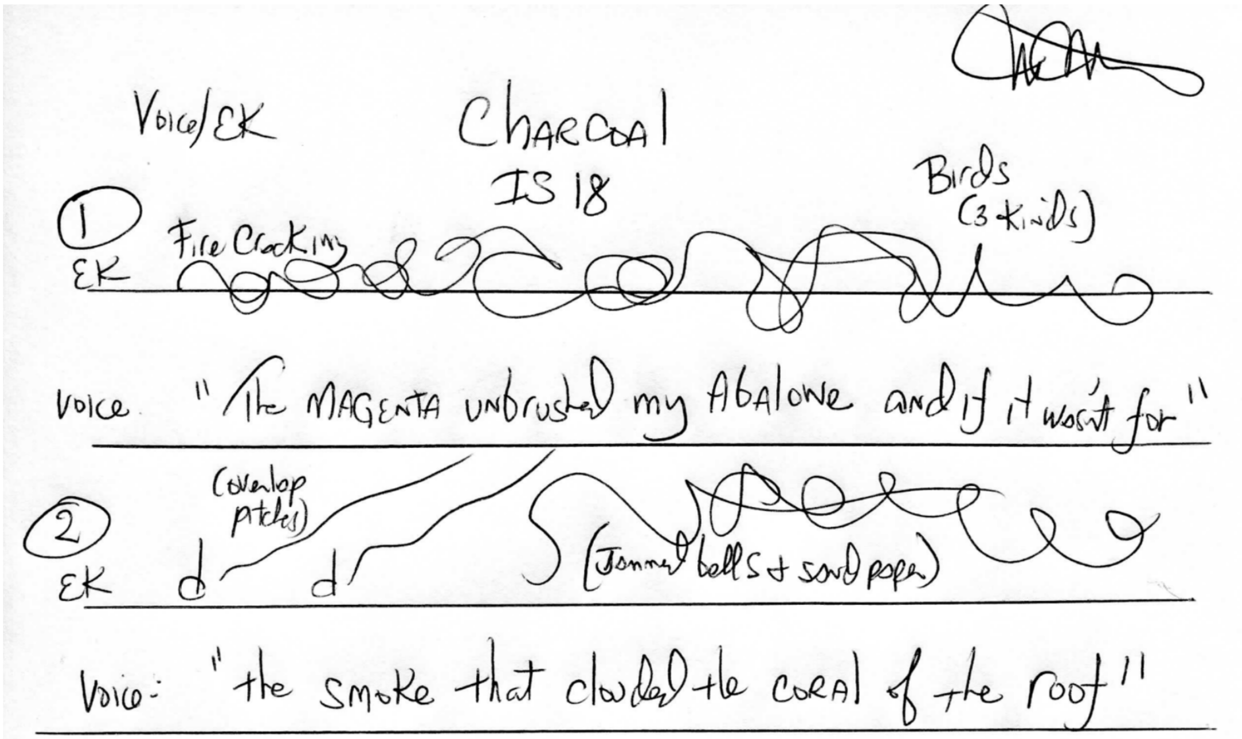


Figure 13 ***Charcoal*** **from** ***Inescapable Spiral*** **(2017)**

It is left up to the electronicist to decide how best to achieve these sonic results through their own electronic system/instrument. Again, this approach reinforces the potential of the work to be realized by any electronicist, thus lowering the threshold of difficulty for future realizations. I argue that this approach, as opposed to providing fixed sound files or an automated patch with cues, is substantially more engaging and rewarding for the electronicist and benefits the overall realization of the work. I do not see this as offloading compositional duties onto a performer, but rather allowing the freedom to best realize the desired outcome.

Situational-Reactive Paradigm

David Behrman's *Wave Train* (1966) is a work for piano and live electronics featuring the use of magnetic guitar pickups to generate feedback and cause the strings of the piano to sympathetically vibrate. The score is presented as mostly text descriptions providing improvisational guidelines and structures as well as visual diagrams of hardware routing and phrase contours (see Figure 14). The performers have flexibility in the realization of the piece and must practice getting controllable feedback oscillations based on the various hardware routings and placement of the pickups on the strings.

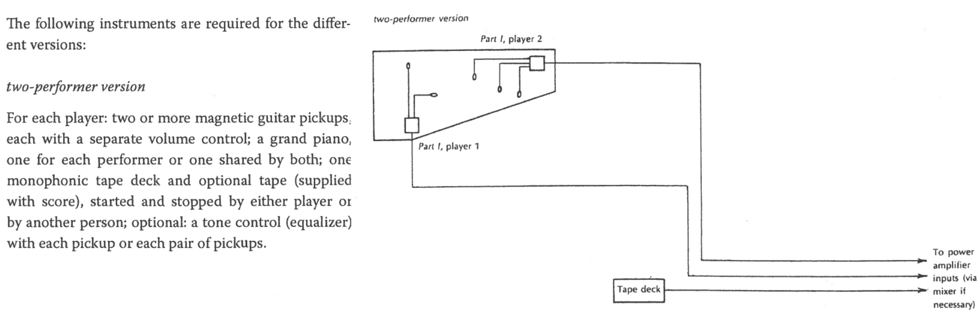


Figure 14 Routing diagram from David Behrman's *Wave Train*

In this situation (see figure 14), the electronics (i.e. hardware) is strictly specified, and elaborate text descriptions help narrow the performance possibilities as a kind of structured improvisation but remain open. The performers must interact with a relatively chaotic system and learn how to control or tame it according to a set of instructions and the inherent ecology of the electronic system. A traditional score laid out with linear time is not useful here because of the unpredictability of the electronic system. Instead, Behrman explains a number of situations that may arise and potential solutions or strategies for sustaining these modes or transitioning to new modes with relative timescales (see Figure 15). The performance requires careful aural attention and reaction to the delicate balance of what is coming out of the system and how minor changes can influence those results. The point is to participate and guide a system rather than exert direct control over it.

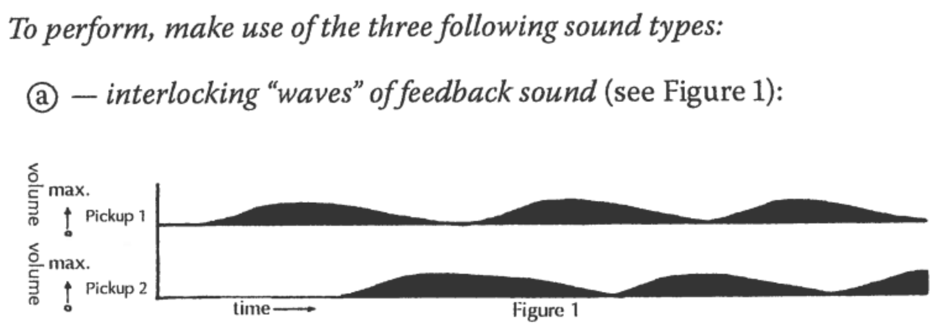


Figure 15 ***Wave Train*** **(score excerpt)**

Like all works that implement feedback as the primary sound source, there is no question as to the liveness in the work. The feedback is always in flux, influenced by subtle environmental changes (e.g. humidity and air pressure) and instabilities in the electronic circuitry. While performers can "practice" to familiarize themselves with a number of different outcomes, they must always negotiate and navigate the feedback as it happens.

In my opinion, a strong or compelling realization of the work will demonstrate the performers' expertise in being able to quickly react and manage the sometimes-unwieldy sonic results while also instilling a sense that things could "explode" into uncontrolled feedback at any moment. Riding this line (or "wave" as Tudor says) creates the tension and relaxation in the performance.

With regard to performativity, each performer must engage in constant, direct physical tuning of the system in order to achieve the desired interlocking rhythms Tudor calls for in the score. While some may argue that it is equally uncompelling to watch a performer attend to a mixer as it is to watch a performer at a laptop, the former is undeniably more engaging from the performer's perspective. Rather than simply cue automations or advance cues, the performer is always actively trying to balance stability and movement in the system. In this kind of a system, the human agent is fundamental. It requires the ability to finely tune and adjust the system beyond what could be automated. In other words, it requires a performer to make a value judgement about the results of the system and determine, in real time, what is the most musical result and what actions they can take to achieve that desired intention.

...wash yourself of yourself for piano and performed live electronics was composed by Jacob Sudol in 2009 and it was premiered by Xenia Pestova and Sudol himself at the University of California, San Diego. The score for is presented as a mostly text-based description detailing the technical aspects of the piece, some performance notes, and a graphic score outlining the formal structure of the piece (see Figure 16). It is worth noting that the majority of my knowledge about the work comes from direct conversations with the composer himself. The work requires more intimate care beyond what directly reading the score can provide. What emerges is dialogue between the composer and performers, allowing each performance of the piece to be specially and carefully crafted.

Sudol provides what I call a "form score" to guide a structured improvisation. Rather than precisely notating each moment in the work, he indicates macro sections subdivided by markers of change in probabilistic materials. Ultimately, the piece evolves as an improvisation that occurs in two larger sections with time ratios given to indicate smaller subsections in the latter half. He provides a graphic notation that indicates time ratios relating the total time of the piece, which is left up to the performers. The work can be realized as a single piece on a program, which will last about 18-20 minutes, or can be realized as a concert work of 45-60 minutes in duration. This decision emphasizes the liminal nature of the work by only providing the edges and boundaries for which change is supposed to occur, leaving the performers with the decision and task of filling in the process.

Section 1 is primarily a timbral exploration of the piano. In this section the piano repeats a multiphonic on the lowest Eb string that is sampled and processed in real-time by the computer. This sample is used to create a rich and dense texture that serves as an undulating drone for the entire first section (~1/4 – 1/3 the total duration of the piece).

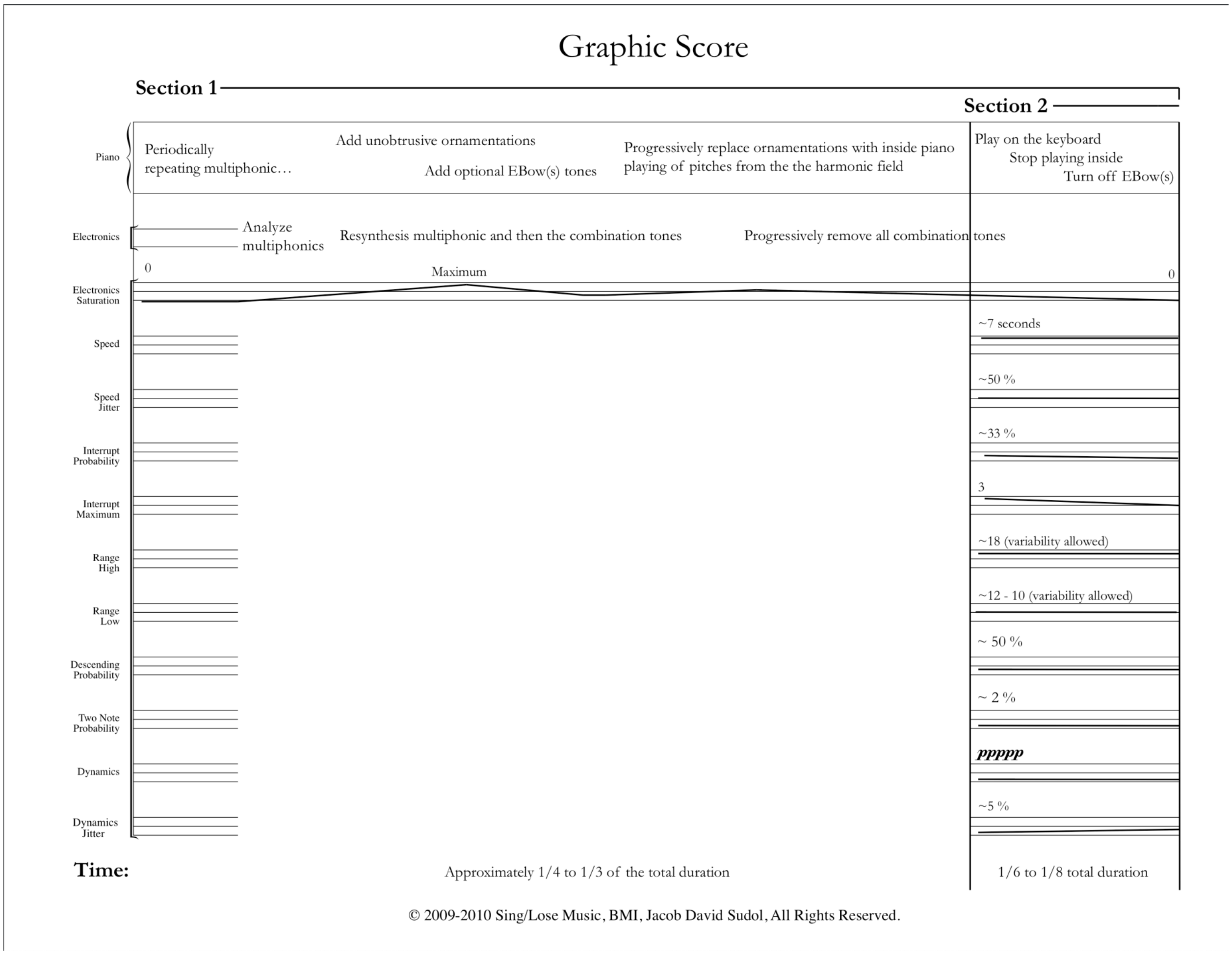


Figure 16 ...*wash yourself of yourself* (score excerpt)

Density increases as the computer musician adds more synthetic sounds one at a time. The piano continues to explore non-keyboard timbres including: string scrapes, glissandi, pizzicato clusters, and knocking on the soundboard. These two processes unfold together in a large swell that gradually morphs into the second section.

Section 2 switches to a different mode of improvisation that follows a set of probabilistic and statistical variables presented at different time points in the score. Both musicians are given a set of variables and instructions to shift extremely slowly within smaller subsections. These variables include indications about pitch, speed, and dynamics as well as jitter and a set of ranges within each of these categories. Below is a table describing each statistical variable (see figure 17).

Variable Name:	Variable Definition:
Electronics Saturation	Relatively defines the number of simultaneous synthetic sounds in the electronics – e.g. the highest value implies a maximum number of simultaneous synthetic sounds, the lowest value implies the presence of only one, and 0 implies the presense no synthetic sounds.
Speed	Rate in notes per second or millisecond. Applies to both the electronics and piano in the second section.
Speed Jitter	Jitter (i.e. random variation) of the speed variable. Applies to both the electronics and piano in the second section.
Interrupt Probability	Probability that a note's instantiation will be replace with a rest. Applies to both the piano and electronics in the second section.
Interrupt Maximum	The maximum number of possible consecutive instantiations of a note being replaced with a rest. Applies to both the piano and electronics in the second section.
Range High	A number corresponding to the highest partial from the harmonic field. Applies to both the piano and electronics in the second section.
Range Low	A number corresponding to the lowest partial from the harmonic field. Applies to both the piano and electronics in the second section.
Descending Probability	Probability that the samples or piano notes will descend the range specified above. Note choice is random otherwise. Applies to both piano and electronics for the second section.
Two Note Probability	Probability that two notes will sound simultaneously. Otherwise only one sample or note will sound. Applies to the piano and electronics in the second section.
Dynamics	The specific dynamic that notes have. Applies to both the piano and electronics in the second section.
Dynamics Jitter	Jitter of the dynamics. Applies to both the piano and electronics in the second section.

Figure 17 Statistical variables table from *…wash yourself of yourself*

Perhaps the most intriguing aspect of this section is the specificity with which the improvisational decisions are indicated. For example, in the third subsection of Section 2 the following parameters are indicated: notes are played every 800ms with a 10% speed jitter (+ or – 80ms) and an interrupt probability (replace a note with a rest) of 33% while improvising on pitches 4-20 (from the harmonic field) with a 60% chance of descending probability (descending motion vs. random motion), a 3% chance of two notes occurring simultaneously, and dynamics at mf with a 25% jitter. Both the computer musician and the pianist are expected to follow these parameters. While this is an easy task for the electronicist (the user interface provides the exact values), this becomes an extremely difficult improvisation for the pianist.

Though the pianist will not be able to exactly replicate these values in their playing, the composer does explicitly state that "the pianist must strictly adhere to playing the statistical variables and never let external musical mannerisms or figures enter" (Sudol 5). This type of playing is achieved through an intense aural dialogue with the electronicist. The piece demands that both musicians listen intensely to one another to remain as closely as possible within the indicated statistical variables.

Sudol has said that one of the main reasons this piece has not yet been attempted by any other duo is the complexity in which the performers must interact both individually with their instruments and with each other. Moreover, he adds that this piece almost certainly requires that the pianist have perfect pitch to adequately play with and respond to the computer musician. Not to mention that interacting with the Max/MSP patch itself requires a rather high level of programming knowledge in order to diagnose and troubleshoot technical errors (of which many occur in this kind of high level DSP).

Techno-Bodily Integration Paradigm

Alvin Lucier is a composer who has a long history of using the performer's body as well as physiological and psychological responses in his work. He has explored echolocation, the use of alpha brain waves, and emotional states to control various sonic parameters in simple yet revolutionary systems. Though many of his works implement novel psychoacoustic phenomena or technology, most of the time he is primarily concerned with the exploration of a single relationship in a work. In his piece *Clocker*, Lucier considers our relationship with the perception of time by designing a system in which a performer can control the expansion and contraction of time through their emotional state.

The system is relatively simple: the ticking of a clock is amplified and sent to a multitap delay line, controlled by the performer's skin resistance, and then amplified with a series of loudspeakers. Lucier uses a Westclox Silver Bell Monogram clock, an AKG contact microphone, galvanic skin response sensors, and a digital delay system. Though the piece was first conceived and performed in 1978, Lucier was disappointed by the delay systems he had available at the time and gave up on the work after only a few performances.[11] Nearly ten years later, DigiTech released a digital delay rack that would help revive the project.

Nicolas Collins, who engineered the recording of *Clocker,* introduced Lucier to DigiTech's new delay effect rack, the RDS 7.6 Time Machine. As opposed to the earlier system, the DigiTech RDS retained a truer sonic quality of the clock and created the desired illusion of distorting time that Lucier originally hoped to achieve. The RDS boasted a 7.6 second time delay that could be controlled via an external voltage control oscillator (VCO) along with the "infinite repeat" feature and "sound on sound" sampling, making it one of the more powerful digital delay units for live performance at the time. The most interesting technological aspect of *Clocker* however, is the use of the galvanic skin response (GSR) sensors to control the delay time.

GSR sensors essentially measure changes in psychological and physiological states of arousal by monitoring changes in skin conductivity over time. Early machines measuring skin conductance have been in use, particularly in the field of psychology, since the start of the 20th century. The theory behind how these machines work is that our emotional states are correlated

[11] http://www.lovely.com/albumnotes/notes1019.html

with autonomic physiological responses. The body's sympathetic nervous system controls the sweat glands, thus increases in activity in the nervous system means an increase in the activity of the sweat glands. In turn, there is a linear correlation between the number of active sweat glands and skin conductance (Thomas and Korr 1957), which means we can associate changes in skin conductivity to quantify changes in activity in our sympathetic nervous system (i.e., changes in "emotional states").[12]

In Lucier's system, when the performer is in a low state of psychological arousal, the delay line will decrease in time, subsequently increasing in pitch. Conversely, high states of psychological arousal will increase the delay time resulting in a decrease in pitch. At a few moments in the piece the performer is able to give the appearance of stopping time when he is in extremely low states of psychological arousal and can remain there for a period of time. The effect is the sound of the ticks speeding up, increasing in pitch, and then completely dropping out for a moment.

What is perhaps most interesting about *Clocker* is that it inverts this relationship by evaluating the effect emotional states have on music. However, because the performer can hear the sonic response (delay time and pitch) to the shift in mood, this is likely to elicit a psychological response, resulting in a feedback system that ultimately drives the piece.

There are several interesting aesthetic themes at play in *Clocker*. The most obvious is Lucier's distortion of time. Realistically, the clock itself remains unchanged; only the delay times and speaker matrix are altered. Conceptually, this perhaps suggests that our linear understanding of time constantly progressing remains unchangeable, but our relation to it is in constant flux depending on our emotional state. One hour spent at a concert feels different than an hour spent in

[12] Though there is still much debate over *how* to quantify this data and the accuracy of the measurements, it is generally accepted that GSR is a clear indicator of fluctuations in physiological and physiological arousal.

class, than an hour spent at the DMV, than an hour spent at a wedding, etc. In a way, this piece calls attention to our ability to take control of these relationships with time and emotion, while simultaneously recognizing autonomic psychological shifts that occur and create these feedback systems that we can easily lose control over.

In addition to exploring expanding and contracting perception time, there is a similar expansion and contraction of the perception of space. Though this effect does not come through as drastically as it could on the recording, the use of six loudspeakers placed at various locations and heights in the Wesleyan North Gallery creates an additional layer of acoustic delay and reverberation that constantly changes throughout the piece.

Lucier's use of the device was truly innovative and simply stated. What makes *Clocker* such a successful experiment is that there is no attempt to qualify the emotional states by having them affect the music in a clichéd or overreaching manner (i.e. high stress sounds dissonant, low stress creates major triads, etc.). Rather, he designed a system that demonstrated the unique implementation of technology mediated through the body that provided the framework for critical discussion of the relationship between emotional states, time, space, and sound.

Another work that exemplifies the techno-bodily integration paradigm—and one that I am intimately familiar with—is Mark Micchelli's *Solitude* (2018) for prepared piano, Tibetan singing bowls, and electronics. The work implements two of Mari Kimura's MUGIC™ sensors to trigger pre-recorded vocal phonemes that are rhythmically triggered by the electronicist's hand movements. Micchelli composed *Solitude* for our piano and electronics duo Teeth and Metals and as such I have an intimate knowledge of the compositional process and technological development of the work.

The score is quite straightforward; the electronicist's part is simply notated the same way the original vocal line would be for a singer (see Figure 18). Each syllable is stored in parallel buffers and are "played" after a particular gesture is performed. This gesture is theatrically representative of reaching into a bowl and extracting or pulling each sound out. The electronicist must perform the gestures in metered time as notated, but also has the freedom to expressively manipulate and process each sound through additional sustained hand movements. These movements include shaking (like vibrato), twisting, and orienting the hand in space.

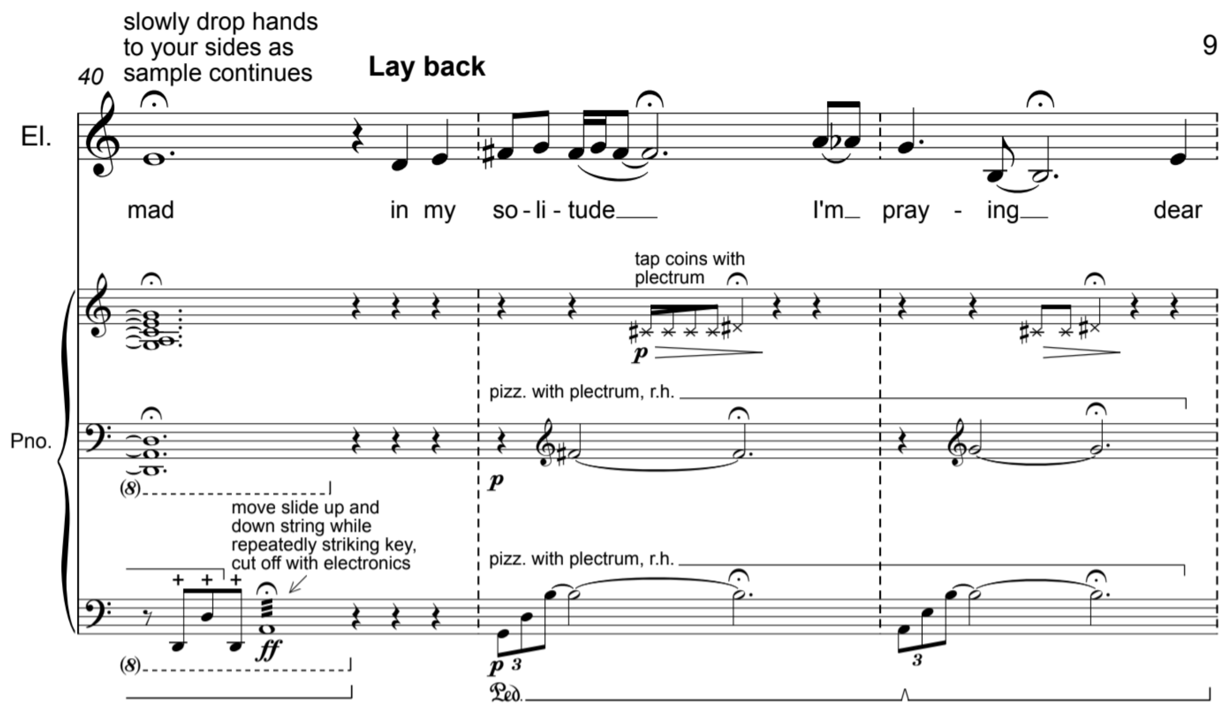


Figure 18 Mark Micchelli's *Solitude* (score excerpt)

I find this piece particularly interesting because it somewhat ironically follows a rather traditional model of having the electronicist cue pre-recorded samples at specific points in time. However, for precisely that reason the work is an excellent example of how performed electronics can invigorate more traditional technological approaches.

Micchelli's *Solitude* essentializes the performative role of the electronicist in that it would be an entirely different (and frankly uninteresting) piece if the samples were just cued using a key press. An audio recording alone of the work is not sufficient in conveying the complete goal of the work, the audience must actually see how the samples are triggered and manipulated to fully experience it. The symbolic gesture of pulling the disembodied voice out of a bowl reinforces the ghostly quality of the lyrics (Micchelli 2018, 2). The way in which Micchelli choreographs the gestures are not "extra-musical" at all, to the contrary, they are fundamentally intertwined with the resulting sound.

The same kind of agency is granted to the electronicist in *Solitude* as would be the case for a vocalist. While the work is "fully notated" there is still room for interpretation and personal expression. For example, ends of phrases can be subtly extended in time and long sustained notes can be shaped timbrally. The performer is free to make these decisions throughout the performance and experiment with different approaches between each performance, contributing to a very clear sense of liveness in the work.

Chapter 4: Selected Creative Works

In my own creative work I have explored the various paradigmatic approaches discussed in Chapter 2. In this chapter I will discuss four selected works, presenting them chronologically. This sample of works was selected to show a breadth of notational approaches, stylistic concerns, and varying degrees of improvisation. Relating back to the selection criteria from Chapter 3, each of these works also has some kind of written 'score' as well as the potential to be performed by someone other than the composer.

The lily I gave you in April

The first piece for solo performed electronics I wrote was *The lily I gave you in April* (2017) for tuning forks and the Mugic™ gestural controller. The piece was composed specifically to highlight the capabilities of Mari Kimura's Mugic™ sensor, a device that wirelessly transmits inertial movement data to a computer. The goal of the piece was to play with the perceptual boundaries between functional (i.e. "sound making") and symbolic (i.e. "expressive") musical gestures. The performer uses the Mugic™ sensor, attached to the hand, to detect and track hand motion while they sonically activate tuning forks in various ways. The data collected from the sensor both triggers and controls live electronic processing in Max.

I decided to use tuning forks as the main sonic material because of their inherent simplicity; they are about as close to sine waves as is possible by purely acoustic means. This allowed me to focus on the various ways I could activate the forks and categorize all the possible gestures with them. From there, I could begin making decisions about mapping the gestural data from the controller to the various processing and control parameters in Max.

In working with the tuning forks, there was an immediately clear realization that only one ‘macro gesture’ existed, which was to strike the fork to make it sound and then move it in relationship to a microphone to alter the sound. Each ‘macro gesture’ contained the same discrete events, which when taken together could be viewed as a kind of “gestural envelope” (Lough et al. 2018). This gestural envelope contains both discrete and continuous events, which can be applied to mapping considerations. Striking the forks—discrete events—could be detected by the sensor as spikes in acceleration and could be used for triggering events. Moving the forks in relation to a microphone—continuous events—were easily mapped to continuous control parameters like panning, volume, frequency of effects, etc. based on the orientation of the sensor. Each of the parameter mappings is automated on a set clock, bringing in different combinations of processes that are controlled by the Mugic™ (see Figure 19).

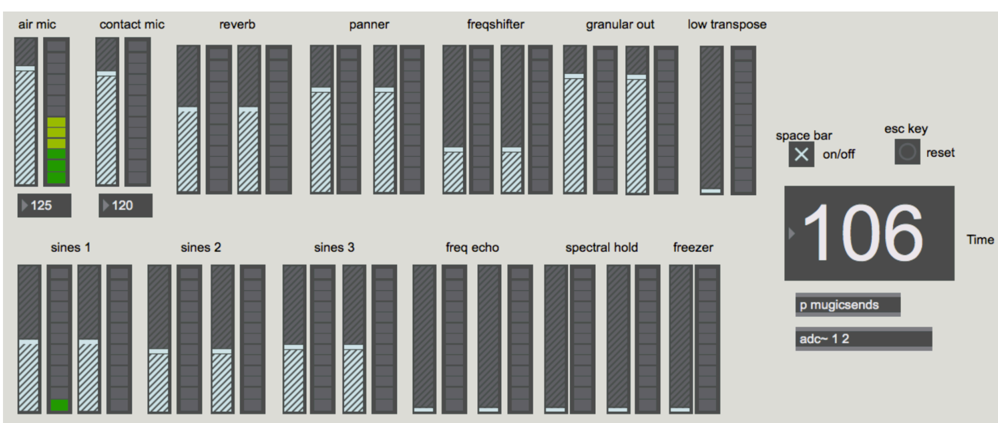


Figure 19 Max Patch from *The lily I gave you in April*

In terms of form, the piece resembles the general structure of a magic trick. First, the performer presents a relatively mundane or simple object, in this case the tuning forks. Then, the simple object is transformed or transported in some ‘magical’ kind of way, by means of electronic processing here. Finally, the object is returned or brought back to its original state, again returning back to the original sound of the forks.

The piece begins with the performer silently striking the tuning forks and bringing them up close to a microphone, amplifying their resonance. Simple panning is the first parameter controlled by the Mugic™. While rotating the fork in front of the microphone causes a very subtle phase shift and change in amplitude, it does not have a drastic effect on the resulting sound. By subtly changing the panning based on the orientation of the hand, this effect is further enhanced.

After this process is repeated several times, sine tones tuned just above and below the frequency of the forks begin to fade in. The frequency of the sine tones is changed again by the orientation of the hand, resulting in more intense beating patterns based on various rotational positions in relation to the microphone. This process again enhances the original subtle amplitude fluctuations normally present and begins to intensify the effect.

The tuning forks are then struck together for the first time, breaking the established drone. At this point, the other 6 forks are picked up and struck together in turn, beginning to form a semblance of melody and overlapping 2-note chords. When the forks are struck together, the Mugic™ detects a spike in acceleration and triggers a short recording of the resultant sound which is stored in a buffer. Short grains are triggered from this buffer, their rate and pitch transposition now controlled by orientation.

In the second section of the piece, the performer shifts to a wooden box with a contact microphone instead of using the original air mic. The forks are first struck and then placed on the box, amplifying their resonance. The processing in this section includes delay, comb filtering (i.e. short delay with high feedback), frequency shifting, and extreme pitch transposition (4 octaves down). Here, the gestures change slightly, as the forks can now be dragged along the surface of the box—exciting the comb filters—and quick scrape-releases cause a pseudo noise-burst. These scrapping and flicking gestures result in more rapid changing of hand position and orientation, which is mapped to delay time, feedback, and frequency shifting.

The most interesting gesture in the piece occurs in this section, where the performer can control a rapid increase in feedback, resulting in a slow attack that ramps into a new strike/scrape gesture. This is where the most 'magical' moment is in my opinion. The performer is now able to introduce an entirely different spectral morphology and envelope. Rather than having a sharp attack, quick decay, and long release—as would be expected from a tuning fork—the performer can ramp into attacks similar to the capability of a string or wind instrument.

The piece returns again to the original method of striking the forks and placing them in front of the air microphone. In the final section, granular freezing is applied when an acceleration spike is detected and results in the noisy attack, with some pitch content, being suspended unnaturally.

In terms of notation, I decided to experiment with a combination of traditional notes-on-a-staff with both graphics and text to describe the underlying electronic processing and physical gestures, respectively (Figure 20).

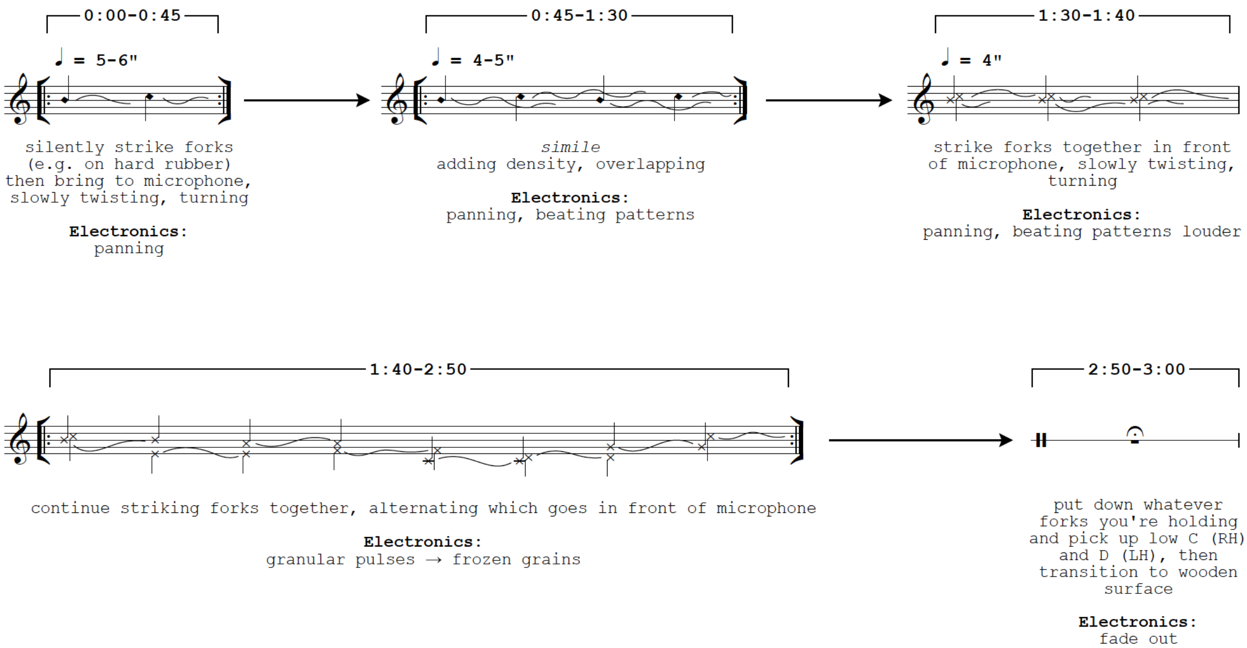


Figure 20 ***The lily I gave you in April*** **(score excerpt)**

The performer uses 8 "scientific tuning forks" which are tuned in just intonation starting at 256 Hz. For ease of reading, the score indicates that C4 is equal to this 256 Hz fork and simply uses a C major scale referring to each subsequent fork. Timing cells are given for each sub-section, with the intention of repeating the cell for as long as necessary to fill the indicated time. The performer refers to a stopwatch embedded in the Max patch for pacing. Curved lines represent physical movement with the forks. These are meant to be interpreted loosely and it is ultimately the responsibility of the performer to listen carefully and make judgement calls throughout the performance about hand orientation to achieve the desired effect.

The second section provides a bit more freedom in interpretation. Similar gestural cells with timings are provided, but the performer can freely choose among them. The reason this section is less specific is because of the nature of the frequency modulated delay with feedback. The patterns of the delay and the emergence of the feedback is somewhat unpredictable, but it is controllable as a response. In other words, the performer has to more acutely react to the responsiveness of the effects rather than trying to force certain things to happen. Thus, they are free to choose from a bank of gestures that will work well with the constraints of the effects given how the effects respond in turn (see figure 21).

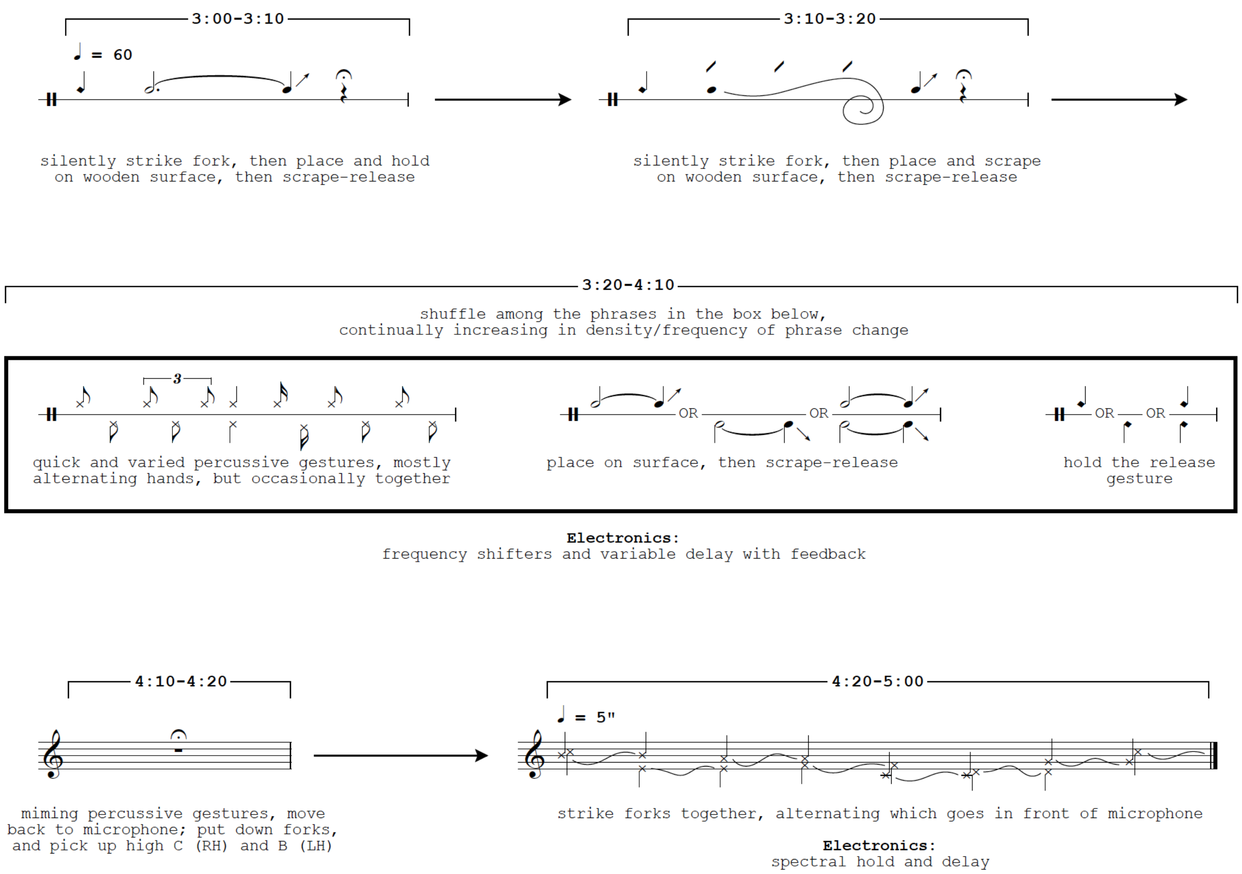


Figure 21 *The lily I gave you April* (score excerpt)

The lily I gave you in April primarily exemplifies the techno-bodily integration paradigm. Quite obviously, given that a sensor is mounted to the hand, the performer has control over the electronics which is directly mediated through the body. Miranda and Wanderley (2006) propose that there are two generalized groups of gestures "based upon whether or not they involve contact with a device" (2006, 5). Contact with a physical device is considered a "haptic gesture" while no contact with a device or instrument is a "naked gesture" (6). The use of the tuning forks acts as a way to create a haptic gesture for the electronicist while intentionally obscuring the naked gestures of the Mugic™.

Again, the theme of magic comes into play here. If the relationship between the gesture and the control over the electronic parameters is too obvious, it becomes uninteresting and uncompelling. It is functionally the same as turning a knob or adjusting a fader. On the other hand, if it is obfuscated to the point where no connections (real or imagined) can be drawn between what the performer is doing and the resultant sound, the result is equally uninteresting or uncompelling. Andrew Schloss notes, "Magic is great; too much magic is fatal" (2002, 2). This middle-ground is achieved in *The lily I gave you in April* by embedding the control gestures (with respect to the electronics) into the performative gestures with the tuning forks. It is important that there is some degree of transparency in order to convey the performer's expressivity (Fels et. al., 2002).

Crystal Cove

My first attempt to compose a work for performed electronics that was intended to be premiered by someone other than myself was *Crystal Cove*. The work was performed by Jacob Sudol and premiered at New Music Miami on February 7, 2018.

Crystal Cove is a generative piece for solo laptop performer coded in SuperCollider. The performer triggers events and samples that are algorithmically generated, making each performance of the piece unique. The sounds in the piece are a combination of samples created from natural found objects—sand, rocks, sticks, leaves—and field recordings collected at Crystal Cove state park in southern California as well as digital synthesis. During the sampling process, I explored different sound activation techniques with the natural found objects in combination with resonant bowls, focusing primarily on gravity and friction as performative forces. The field recordings are heavily filtered and act as different noise beds and textural layers as the piece evolves. The work is intended to be performed in order to inject a sense of liveness into what would otherwise be a static experience of pre-recorded material. In the revised version of the piece, the performer can collect their own samples and load them into the code, making the work site-specific and unique to a specific place depending on the location of the venue.

I had the goal of writing a work that could be performed by virtually any electronicist. Thus, the piece was written in SuperCollider and only made use of a Korg nanoKontrol. SuperCollider is a free cross-platform program and the code can be saved as a text file directly into the score, so it can be accessed by a performer at any time. The Korg nanoKontrol is a cheap USB-MIDI interface that arguably one of the most ubiquitous hardware controllers today. Even if a performer did not have access to this specific controller, the code contained comments on how to easily remap the MIDI values so that literally any MIDI controller with at least 8 buttons and a few knobs or sliders could be used in the performance. The piece also requires two resonant bowls (Tibetan bowls are recommended) as well as rice, beans, gravel, etc. that can be dropped into the bowls.

Additionally, I decided to create a score that would ensure the same global timing and form of the work from performance to performance. While the *exact* sonic output will always be slightly different with each realization, the piece retains a specific sonic identity. There is no improvisation in the work, in the sense that one must indeed follow the prescribed performance instructions through time, but there is a great deal of indeterminacy and freedom allocated to the performer. They have a responsibility of interpretation with each performance that necessarily requires engaging in aural feedback and dialogue which mediates their physical interaction with triggering the samples.

The score is graphically notated, providing timepoints for triggers and text instruction to supplement interaction modalities (Figure 22). “Events” are delineated by an ‘E’ and a number, these are meant to be triggered by a single button press and advance cue points within SuperCollider. “Oneshots" are delineated by an ‘O’ and a number, these trigger shorter oneshot samples that are meant to be triggered with varying density in different sections. Horizontal arrows extending from vertical points (which always contain performative ‘O’ material) show the duration of the section. The form and development of the piece is also outlined by the relative height of each direction (text boxes). Vertical space (y-axis) indicates a relative degree of importance or ‘drama’ in the piece.

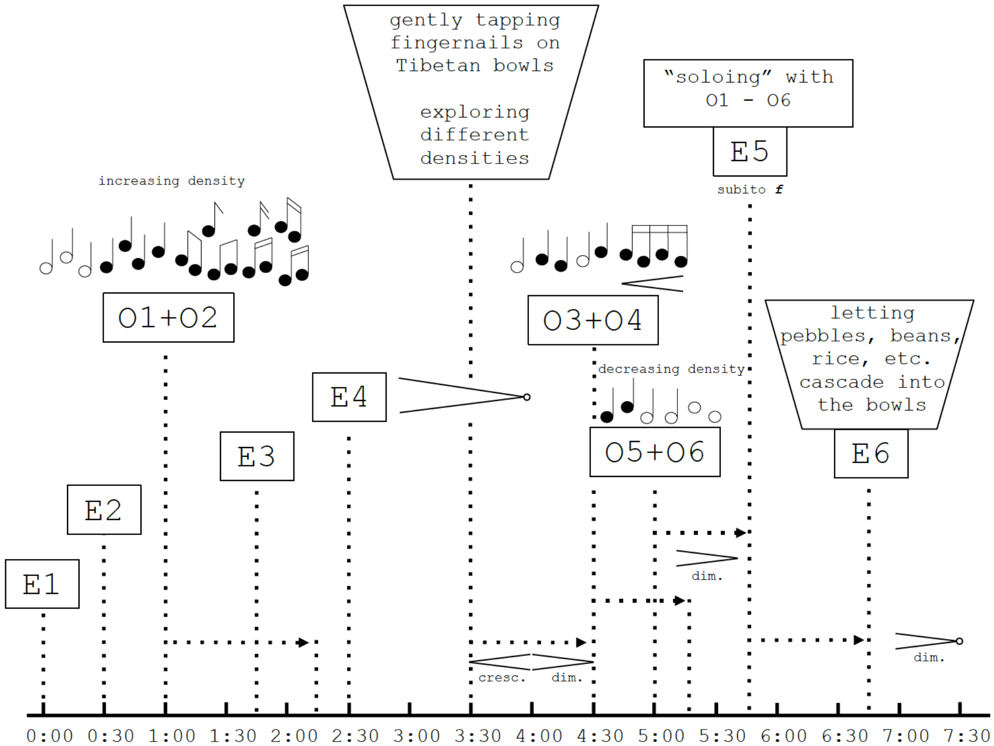


Figure 22 *Crystal Cove* (graphic score)

While the "events" do trigger automation, there is no global clock in the code. This means that the performer must faithfully trigger the events in order to keep the correct pacing of the piece. It also means that timings need not be incredibly precise and leaves some room for creative interpretation during a performance; moments of silence or climax can be extended or reduced based on the instinct of the performer in real time—the code will simply "wait" until the performer advances the next section.

Crystal Cove exemplifies both the situational-reactive and curatorial-design paradigms. While the piece is not "improvisational" in the sense that it is fact fully notated, the performer must listen, react, and respond to the outcomes of the indeterminately triggered samples. Both the "events" and "oneshots" have time variations (i.e the length of the sample) in addition to amplitude variations, thus choices in density and microtiming must always be made and adapted to in real time.

As mentioned earlier, the revised version of the piece allows a performer to load in their own locally-sourced samples. The performer is given the instruction to collect samples in three categories: *field recordings*, *gravity*, and *friction*.

'Field recordings' are to be taken from a single site, preferably near the performance venue, or in a location that audience members at the local venue would be familiar with (such as the case of Crystal Cove State Park in Orange County in my own original realization). These recordings should be "high in noise content" such as wind and water sounds.

'Gravity' samples should make use of natural materials being dropped into a resonant bowl (like a Tibetan bowl) and collected at the site where the field recordings were taken. The performer is encouraged to create these samples performatively and experiment with a number of different densities and heights.

Similarly, 'friction' samples should make use of natural materials collected at the site being rubbed, scraped, or brushed against one another in addition to a resonant bowl. The performer is also encouraged to be mindful of the collection process and not to damage or remove materials from the site, but instead perform and record the samples on location. Once the samples are collected they are to be trimmed and normalized in a DAW and exported as sound files in separate folders (one for each category) that is placed in the same folder as the SuperCollider code.

The last two works discussed in this chapter are both from my dissertation recital, *Current Flow: New works for electroacoustic duos.* The concert featured five different configurations of electroacoustic duos including dance, voice, percussion, flute, and piano. The concert was held in the Experimental Media Performance Laboratory (xMPL) at University of California, Irvine on May 4, 2019. The documentation from the entire concert can be found in Appendix A at the end of this document.

The works from *Current Flow* were all highly improvisational in nature and were developed intimately with each acoustic collaborator. I selected the following two works to focus on in this chapter because they have a concrete sonic identity (i.e. they sound essentially the same each time) and also highlight the compositional paradigms from Chapter 2. These works could also reasonably be performed by people other than the composer (or the original duo in this case).

we give name to those ideas which are

we give name to those ideas which are was composed for movement and performed electronics. Over the last several years I have been working with choreographer and dancer Koryn Wicks, developing a number of collaborative works for immersive dance and interactive sound. This work was created with the intention of using a dancer as acoustic source material for live-processing. The choreography was created in collaboration with Koryn Wicks who realized the finer points of the movement in the work.

we give name to those ideas which are exemplifies both the techno-bodily integration as well as the situational-reactive paradigms. Wearing the Mugic™ sensor and using the data in performance clearly places it in the techno-bodily integration paradigm. Moreover, I was interested in accessing the incidental sounds the body makes during dance as the primary sonic material. Her entanglement with the microphones can also be seen as mounting technology on the body. The movement and the sound are fundamentally intertwined. Additionally, the dancer's wiping movements in Section IV are mirrored by the electronicist. The choreography becomes a shared experience, that is to say that the audience should find the electronicist's movements equally compelling.

The electronicist must carefully follow the dancer and capture sound immediately after it happens. As she deals with the entanglement of the microphones, the dancer must react to her constraining situation, while the electronicist must also balance feedback that is continually evolving.

In terms of the technical setup, four microphones are placed around the dancer—who is wearing a Mugic™ sensor—and the signals are routed and processed through a laptop, which diffuses the signal through a 4-channel surround PA system (see Figure 23).

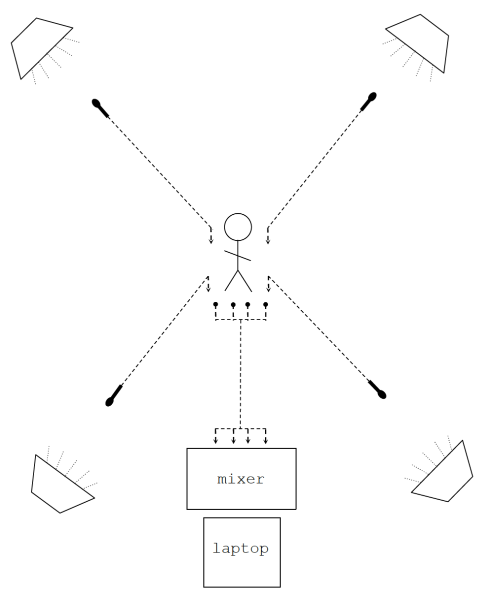


Figure 23 ***we give name to those ideas which are*** **(routing diagram, score excerpt)**

The dancer performs with the microphones and the incidental sounds are used as the primary sonic material. The Mugic™ is used to control and trigger buffers that store recordings of the incidental sounds picked up by the mics. This sound is further processed by a laptop running Max and Ableton Live and controlled with a Wacom tablet and a MIDI controller.

The score for the work exists as a routing diagram with text instructions and timings for each section. There are five distinct sections, each of which has a particular emotional resonance that guides the choreography. Obviously, the dancer cannot easily refer to a score or stopwatch throughout the performance, so each section is memorized and both performers must internally keep pace together.

Section I - “Desire” is about exploring the dynamic of reaching outward and pulling inward. The dancer begins lying on the floor in the center of the performance space, with the four microphones—attached to cables—jutting out in each direction. She starts by slowly pulling on each mic cable, dragging it gently toward her. This results in a gentle noise bed, akin to breath. She expands on this theme by also incorporating extension and contraction of her limbs, similar to waking in the morning. Slow, non-deliberate movements evolve into concentrated and intentional gestures. She begins pulling the cables closer to her by coiling them around her wrists and legs. The electronicist controls subtle amplitude modulation, low-pass filtering, and 4-channel panning to move the sound around the space.

Section II - “Entanglement” is a reaction to the previous section in terms of emotional content. She continues to intentionally tangle herself in the cables and begins to transition to floor movement and eventually standing. What began as a desire to immerse and wrap herself in the microphone cables turns into a realization of feeling trapped and ensnared. The cables that she wrapped around her arms and legs now make it difficult to move. The dancer searches for points of tension and explores tableaus. Concentrated and intentional energy transforms into more frantic and worried.

The mics now occasionally begin to fall on the floor and make contact with the dancer causing more sharp attacks in the sound. The electronicist must carefully watch for these moments and immediately respond by triggering short, granulated delays as well as "stuttering" the signal by recording into short buffers and playing them back at high speeds using the stutter~ object in Max (Figure 24).

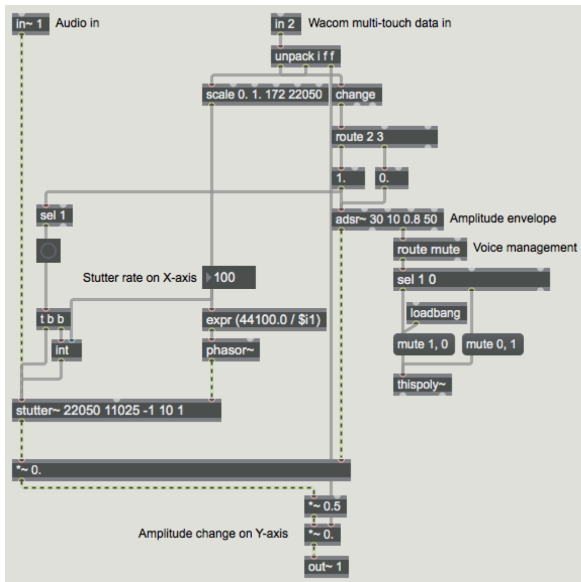


Figure 24 Max 'Stutter' abstraction inside of a poly~

Section III - "Shedding" begins with the dancer quickly shedding herself of the entanglement of cables, leaving them in a pile on the floor. Her aspirated breathing is amplified by the microphones, which are turned up to a very high gain level. She begins looking outward in the space and moving in areas not yet explored. The choreography here shifts to more expressive movements, stretching out and becoming more fluid as a response to what she was unable to achieve being previously entangled in the cables.

With the high gain level on the mics feedback between the 4-channels starts to produce feedback. The electronicist must carefully balance the levels to produce sustained, undulating drones. He also manipulates the sound of the dancer's breath and uses stark circular panning to move the signal around the space. The dancer interacts with the feedback tones by moving her head and searching for standing waves and nodes in the space. This process guides her choreography and movement as she continues to search for these points in space. Alvin Lucier's *Still and Moving Lines of Silence in Families of Hyperbolas* (1973 - 74) is the inspiration for this section. Lucier directs an electronicist to "Create standing waves in space caused by constructive and destructive interference patterns among sine waves from loudspeakers" while "Any number of dancers discover troughs of quiet sound along axes of pairs of loudspeakers which they may follow, changing directions, if they wish, at intersections. If bumps of sound occur due to reflections from walls or other surfaces, search for open paths or wait for troughs to shift" (from *Chambers* 1980, 128).

Section IV - "Blossoming" reflects on the concept of shedding and growth and uses movements akin to wiping and cleansing. The dancer uses these symbolic gestures as a means to "wipe off" the remnants of the constriction she experienced with the cables. The Mugic™ device becomes important in this section, sending triggers (sharp attacks in acceleration) and orientation data to the electronicist. Throughout Sections I and II the electronicist was recording all the incidental mic sounds into a large buffer. These triggers access small granulations of the buffer which are further manipulated and processed in real time. Again, the electronicist must give very careful attention to synchronizing with the dancer as she creates these impulses. This wiping movement is then mirrored as gestures on the Wacom tablet which further trigger these recordings and creates fast panning between channels. These large movements in the sound, paired with the addition of unnatural reverb, create a new sense of space, as if we have moved to an entirely different location.

Section V - “Return” is the final section and—perhaps obviously—is a return to the first section. The dancer notices the pile of cables left on the floor and returns to her original floor position, like getting back into bed with a forgotten partner. The cables, which were once stretched out across the space linearly and appeared as discrete objects, now the gestalt of a single object. The movement is meant to evoke a strange sense of comfort; symbolically she has matured and learned from the experience and is now ready to reconnect with this mass. Because she is now much closer to the mics, her intimate breathing and subtle vocalizations are amplified and can be heard throughout the space. The electronicist applies reverb and granulation of these sounds to atmospheric textures. Both fade out their sounds together. The complete journey—desire, entanglement, shedding, blossoming, returning—tries to present a relatable narrative through this abstract process.

between us the air encircles (once more)

between us the air encircles (once more) is the third installment in a series of pieces for percussion and transducers. I use the term “transducers” here to refer to tactile sound exciters, which are functionally the vibrating half of a speaker without a cone. When placed on a resonant object, the object functions like the speaker’s cone, imprinting it’s own unique sonic characteristics (something considered undesirable in optimal speaker design). This series of works—*between us the air encircles*—deals with various ways of performing with transducers on resonant objects (cymbals, sheet metal, and large drums). In each work, all for electroacoustic duos, at least one of the performers is moving the transducers along the surface of a resonant object, exploring its sonic architecture and resonant characteristics.

In this work, for percussion and performed electronics, a complex feedback network is created by mounting contact microphones on several large drums and routing them through a matrix mixer (see figure 25). All the sonic material is generated by the feedback induced on the surface of the drums and within the electronic mixer. No additional digital processing or synthesis is introduced; only analog compression, limiting, and filtering is used.

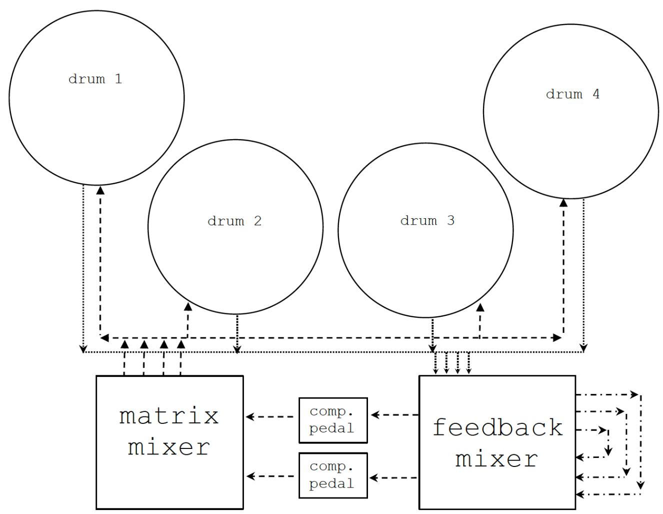


Figure 25 ***between us the air encircles (once more)*** **(score excerpt)**

The score for *between us the air encircles (once more)* is inspired by David Behrman's *Wave Train* and David Tudor's *Rainforest IV.* I draw upon the approaches both composers use to provide blueprints for realizing their work. The main signal flow diagram is at the heart of the piece (see Figure 25) which details the feedback network and thus the performance environment. This is coupled with text descriptions of how to approach the improvisatory nature of performing with feedback in three distinct sections.

In the beginning of the work, each performer makes distinct adjustments to their respective feedback matrices one at a time. Both listen to how the input alters the response of the system, then the other performer responds in turn with a distinct change of their own. This process is repeated back and forth, paying careful attention to how the system fluctuates and stabilizes. Increasing overlap between these distinct gestures begins to form a constantly shifting environment, sufficiently complex so as to react in unpredictable ways to subtle changes in the feedback matrices.

I specifically use the term "environment" here for a few reasons. First, it is a system that relies on a number of different inputs and control parameters as well as embedded, unpredictable behavior (particularly noise and crosstalk in the analog circuitry) that exceeds the traditional "playability" of an instrument. The system can infinitely sustain sounds, suddenly change sounds, or get into slowly undulating repetitive patterns, all from subtle changes to the routing matrix.

Second, much as in nature, ecologies and environments do not intelligently choose to do anything, this performance environment has innate behavior divorced from any choice, cultural practices, awareness, intelligence, or opinions about what is going on. It may shift its output in response to an input (either the piano signal or changes in potentiometers) but it does so without any knowledge or based upon any explicit rules. In that sense it relates to Marc Leman's paradigm of embodied cognition:

> The cognitive tradition was criticized for its neglect of the action component in the subject's involvement with the environment…. The main argument is that knowledge does not emerge from passive perception, but from the need to act in an environment. In that sense, ecology is not merely about the relationship between a subject and its

environment, but also about the knowledge which is needed to act in that environment. (2008, 43)

The knowledge and rules are constructed and mediated by the performer(s) who have the ability to input information into the system but have little direct control over what it will do coming out. They coexist in a performative ecology with shared (and shifting) roles and distributed agency with regard to input and output (both sonically and via physical control). It is precisely for this reason that I have been using this performance environment more frequently: it exists, and shifts its location, somewhere in the middle of the spectrum between direct control and unmediated chaos.[13]

On an acoustic instrument you cannot listen to it without playing it; the relationship is rather one-directional. The electronicist's relationship with the feedback mixer environment though, affords the experience of shifting between being a *user* and being a *spectator*. Simon Penny, referencing Augusto Boal, uses the term *spectactor*, defined as "simultaneously an actor and a spectator; this person not only attends to whatever events are unfolding as a result of their actions but also simultaneously and reflexively attends to their own kinesthetic, proprioceptive, and perceptual experience" (2017, 362). It is precisely this kind of relationship—one of mutual conversation or dialogue between the performer and their electronic system—that the situational-reactive paradigm embraces.

[13] As Simon Penny might say, it exists in a zone of *interaction poetics*.

Chapter 5: Conclusions

It is my hope that this research presents a convincing argument for the necessity of these new perspectives contained within the themes of performed electronics. While research on liveness, performativity, and agency is not novel in the field of electroacoustic music, I attempt to present them here as a reason for this new taxonomy. My three compositional paradigms should be helpful to composers, performers, musicologists as we develop and analyze new repertoire for electronicists. The historical and contemporary works I presented should provide a clear framework for composers interested in writing new works for performed electronics. I have presented my own perspectives as both a performer and composer to establish a holistic understanding of performed electronics as a new taxonomy.

Establishing a professional career as an electronicist requires a diverse set of skills. One must first obviously acquire the basic skills of musicianship. Given that working with electronics is rarely, if ever, taught as a first experience into music in primary education, electronicists must go through the entire process of learning an acoustic instrument, something that I think is actually necessary, and an essential aspect of learning music. However, this means that most people do not begin to 'dig in' to electronic music performance until well into adulthood. From there, they must first acquire the technological knowledge for working with electronics. Whether this is learning a programming environment like Max or SuperCollider, working in DAWs like Ableton Live, or working with hardware and analog/modular synthesizers, there is a necessary skill set that must be developed before any musical results come to fruition. Once all that knowledge is acquired, only then can someone begin to build their own electronic instruments/interfaces, essentially starting from scratch on an entirely new instrument.

I have been successful in convincing people in the electroacoustic community of the necessity of this research. My experimental piano-and-electronics duo Teeth and Metals now has several new works written for us that fall within the category of performed electronics. I am continuing to work with other composers who are interested in writing solo repertoire for me as well as inviting me to larger ensemble works that will include performed electronics.

It has been my experience in commissioning new works for performed electronics that an important cross pollination occurs between the composer and the electronicist. From one perspective, the composer usually must communicate with the electronicist directly and learn what their setup is capable of, both sonically and in terms of physical input. Mirroring this experience, the electronicist also must clearly learn to communicate how they perform with their setup. I think that it is incredibly important for more of this dialogue and experimentation to occur in order to build a larger repertoire and a clearer sense of performance practice with performed electronics.

I see the future of this research developing into a public resource for composers and performers interested in performed electronics. It is my hope to eventually create a comprehensive online resource of works for performed electronics. As mentioned in the beginning of this dissertation, it is difficult to search for new repertoire given the current taxonomic labeling of "live electronics" which includes works that have no performative element. By aggregating all known works for performed electronics, I would expect to see a rise in interest among others who wish to perform these works.

In short, my goal is to refocus the attention on the human in electronic music. For me, the most important aspect of performed electronics is that it reinforces human relationships. As an active composer and performer of electroacoustic music, it seems clear to me that there has been a significant erasure of the electronicist as a performative identity and my proposed taxonomy and compositional paradigms help to remedy this problem. As an emerging genre, performed electronics will challenge the traditional roles of the composer and performer, requiring new approaches to more clearly incorporate the human performer in the compositional process.

Works of performed electronics will allow for spectators to make assumptions and connections between the human and the electronic system, keeping them more engaged with the work. These paradigms provide the electronicist with a more performative role, enhancing their engagement with the work. This kind of work usually requires active dialogue between composers and performers to successfully create and realize the piece, enhancing their social ties and raising the performer's personal stake in the successful execution of the work, ultimately resulting in developing a stronger sense of a global community of people who share these interests.

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Appendix A: *Current Flow: New works for electroacoustic duos* (online documentation)

The following appendix serves as the documentation for the creative activity portion of this dissertation.

The concert was held on Saturday May 4, 2019 in the xMPL at UC Irvine. *Current Flow* presented a body of new works that manifest the research conducted throughout this dissertation, attempting to address the question, "What does it mean to *perform* with electronics?" My interest in the duo format stems from my desire to work in close collaboration with performers in order to write pieces that can reveal meaningful and intimate musical conversations. These dialogues are intended to communicate with others how the performers are interacting with one another—as well as the electronic systems—in each piece, showcasing various approaches to performing with electronics.

The pieces are presented in the order in which they appeared in concert.

we give name to those ideas which are

for movement and performed electronics

Koryn Wicks - movement

Alex Lough - electronics

Choreography by Alex Lough in collaboration with Koryn Wicks https://www.youtube.com/watch?v=XkrCOfDnrHA

of orange haze

for voice, wine glasses, resonant bowls, and performed electronics

Hanah Davenport - voice, glasses, bowls

Alex Lough - electronics

Lyrics by Hanah Davenport in collaboration with Alex Lough

https://www.youtube.com/watch?v=k03gZK6Vm50

between us the air encircles (once more)

for percussion, transducer-array, and feedback mixer

Chris Hadley - percussion and transducers

Alex Lough - feedback mixer

https://www.youtube.com/watch?v=Wsmi0jK3LOw

Files from Project Blue Book

for flute and portable electronic gadgetry

Nicole Mitchell - flute and electronics

Alex Lough - electronic gadgetry

https://www.youtube.com/watch?v=l-g8LCM_zOk

Cross Talk

for piano and performed electronics

Performed by Teeth & Metals

Mark Micchelli - piano

Alex Lough - electronics

https://www.youtube.com/watch?v=WZrw9GRtrVE