ANACOUSTIC MODES OF SOUND CONSTRUCTION: ENCODED (IM)MATERIALITY IN SYNTHESIS

By

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To my parents

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The composition of music typically and traditionally presupposes its ultimate manifestation in sound, that is, in physical, acoustic vibrations that can be heard by humans. It follows that composers employ rationale based on sound ideas. There is a body of work, however, that challenges this seemingly fundamental notion. Its compositional strategies are enacted in the domain of digital sound synthesis in which abstract schemata (types of information) have the potential to become sonic phenomena, but not inevitably or predictably so. We witness these processes by hearing what they leave as a trace, which is perceptually distinct from acoustically recorded sound (i.e. sound captured with a microphone) or synthetic sound modeled after acoustic reality. This type of sound construction, divorced from representational intention, is suggestive of *anacoustic* as opposed to acoustic origins.

The common thread that links each example in this research is the conception of *data* as *sound*. Anacoustic modes represent an address of the computer at its most fundamental level: the syntactic level of information. This changes the nature of signification as sound is considered first as an informational construct rather than a

material circumstance, rupturing the front-loaded meaning that arises from our acoustic experience. Following certain concepts encompassed by N. Katherine Hayles's *posthumanism*, anacoustic modes are an expression of the materiality of information.

My analyses show that anacoustic modes of sound construction are fundamentally different from previous modes of sound making in music because of the unique ontology of digital information. Anacoustic modalities are fertile ground for artistic experimentation. More importantly, the discourse I have constructed around this practice informs an approach to sonic computing that is sensitive to the extrinsic significance of sound in the acousmatic scenario relative to its mode of production.

CHAPTER 1
INTRODUCTION

The composition of music typically and traditionally presupposes its ultimate manifestation in sound, that is, in physical, acoustic vibrations that can be heard by humans. Even in the musics that have challenged well-established notions of what music is or can be, such as the early tape music of *elektronische Musik* and *musique concrète* or the numerous other sound art practices that followed, there remains the natural tendency to employ compositional rationale based on a sound idea—some imagination of or desire for an aural result. And why would it be any other way? The art of music is predicated upon the human faculty of hearing.

There is, however, a body of work that challenges this seemingly fundamental notion: the presupposition of music's existence in sound. Its compositional strategies are enacted in the domain of digital sound synthesis in which abstract schemata (kinds of information) have the potential to become sonic phenomena, but not inevitably or predictably so. We witness these processes by hearing what they leave as a trace, which is perceptually distinct from acoustically recorded sound (i.e. sound captured with a microphone) or synthetic sound modeled after acoustic reality. This type of sound construction, divorced from representational intention, is suggestive of what I shall refer to as *anacoustic* as opposed to acoustic origins.[1]

In contrast to the use of acoustic or psychoacoustic models in the design of digital sound synthesis processes, applications designed by composers such as Gottfried Michael Koenig, Herbert Brün, and Iannis Xenakis instead use anacoustic models that are not predicated on sound as heard or electronically recorded. These

[1] An *anacoustic* zone, such as the upper region of the atmosphere or space, is unable to support the propagation of sound. The term, as it functions in this writing, is synonymous with "soundless."

composers, among others, have proposed or invented systems that allow the direct construction of waveforms via time-domain synthesis according to informational processes with unknown sonic properties.[2]

The common thread that links each example in this research is the conception of data as sound. Anacoustic modes represent an address of the computer at its most fundamental level: the syntactic level of information. This changes the nature of signification as sound is considered first as an informational construct rather than a material circumstance, rupturing the front-loaded meaning that arises from our acoustic experience. Following certain concepts encompassed by N. Katherine Hayles's *posthumanism*, anacoustic modes are an expression of the materiality of information. The scope of this research is limited to works composed exclusively for playback over loudspeakers, or *acousmatic* music.[3]

My analyses show that anacoustic modes of sound construction are fundamentally different from previous modes of sound making in music because of the unique ontology of digital information. Anacoustic modalities are fertile ground for artistic experimentation. More importantly, the discourse I have constructed around this practice informs an approach to sonic computing that is sensitive to the extrinsic significance of sound in the acousmatic scenario relative to its mode of production.

The next chapter places anacoustic modes of sound construction within a historical context of sound synthesis. Chapter 3 outlines a semiotic analytical

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[2] In digital audio, *time-domain* displays plot amplitude over time in discrete intervals, and are likely familiar to anyone who has viewed a waveform in sound editing or playback software. Time-domain synthesis involves the construction or manipulation of these discrete amplitude/time-point pairings.

[3] *Acousmatic* commonly refers to post-Schaefferian music that continued in the style of *musique concrete*. For the purposes of this writing, *acousmatic* refers to the condition of sound being heard without a visibile, causal origin.

foundation. Chapter 4 examines the concept of information and certain strands of thought born out of its different configurations. These first four chapters lay the conceptual foundation for the examination of works by Gottfried Michael Koenig, Herbert Brün, Iannis Xenakis, Yasunao Tone, and Ryoji Ikeda that comprise Chapter 5. Chapter 6 focuses on the listener perspective in relation to sound construction, culminating in a personal account of the influence of anacoustic modalities on my own work and the work of others in Chapter 7.

It is my hope that this writing is of interest to composers and listeners of electronic music as well as artists working in other mediums that critically engage with digital technology. I consider it an addition to the growing body of literature that examines the relationship of art and *informatics*—"the technologies of information as well as the biological, social, linguistic, and cultural changes that initiate, accompany, and complicate their development."[4] This dissertation is a reflection upon various strands of discourse (musical or otherwise) that are, in my view, of contemporary relevance.

[4] N. Katherine Hayles, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics* (Chicago: University of Chicago Press, 1999), 29.

CHAPTER 2
BACKGROUND

The following account is not a linear history, but presents a number of partly converging, partly diverging threads linked by the concept of anacoustic as it applies to sound construction via digital synthesis. For preliminary clarification, I use the term *sound construction* to describe the production of "new" sounds via synthesis, which is distinct from *sound reproduction*: the re-presentation of an acoustical event via recording or the use of pre-existing, sampled materials.

Digital Sound Synthesis

The first developments in digital sound synthesis occurred in the mid 1950s, when Max Mathews "began exploring the use of the computer as a means of synthesizing sound from first principles, using mathematical principles of waveform calculation."[1] Working at Bell Labs, Mathews wrote MUSIC I in 1957, the first widely used program for digital sound synthesis. He recalls in a 1997 lecture at Indiana University:

> Computer performance of music was born in 1957 when an IBM 704 in NYC played a 17 second composition on the MUSIC I program which I wrote. The timbres and notes were not inspiring, but the technical breakthrough is still reverberating. MUSIC I led me through MUSIC II through V. A host of others wrote MUSIC 10, Music 360, Music 15, Csound, Cmix, and SuperCollider.[2]

MUSIC-N applications and their progeny have retained the technique of wavetable synthesis, whereby a waveform is constructed based on an acoustic description of partials and corresponding amplitudes. The waveform is then stored in

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[1] Peter Manning, *Electronic and Computer Music* (New York: Oxford University Press, 2004), 187.

[2] Max Mathews, Lecture at "Horizons in Computer Music," Indiana University, 2007, csounds, Max Mathews, http://www.csounds.com/mathews/max_ideas.html (accessed January 7, 2018).

memory as a wavetable function. Curtis Roads refers to the wavetable synthesis implemented in MUSIC V (perhaps the epitome of MUSIC-N iterations) as *fixed-waveform table-lookup synthesis*. "The process of repeatedly scanning a wavetable in memory is called *table-lookup synthesis*." Furthermore, "table-lookup synthesis is the core operation of a *digital oscillator*—a fundamental sound generator in synthesizers."[3] The waveform is fixed because it does not change over the course of a sound event.

Underlying the construction of digital oscillators is a conceptualization of sound in which the sine wave functions as a fundamental element in the makeup of timbre. Wavetable synthesis and *additive synthesis* (the summation of simple waveforms such as sine waves) are fundamentally tied to the *Fourier series.* Named after Jean-Baptiste Fourier (1768-1830), the Fourier series is a mathematical process by which any complex periodic function can be deconstructed into a sum of simple sinusoidal components. Take as an example the tones generated by acoustic instruments: following Fourier, they are composed of series of overtones or *partials*—each at an individual frequency with a dynamic energy profile. Fourier methods play a role in many avenues of digital audio and are commonly utilized for access to the frequency domain, in which sound is visualized or processed as an aggregate of individual sine and cosine components. Naturally, the power and appeal of Fourier methods stem from the window they provide into the intrinsic makeup of sound.

Fourier-derived sound constructions can be easily realized by adding groups of digital oscillators or by calculating a wavetable from partial data. This clarifies the primacy of sine waves and other fixed-waveform constructions as the basic building blocks of sound synthesis in Matthews' MUSIC-N languages. However, the Fourier

[3] Curtis Roads, *The Computer Music Tutorial* (Cambridge: MIT Press, 1996), 90.

view has some limitations that catalyzed alternative synthesis practices in the late twentieth century. Specifically, the representation of sound as a sum of infinitely long sinusoids can compromise the fine detail of complex transient phenomena that characterize acoustic vibration. Transients are typically defined as the high energy, short duration onset or attack portions of sounds. Because of their ephemerality, they are easily misrepresented in Fourier analysis, which seeks to isolate periodic spectral components. The *FFT* or Fast Fourier transform compromises resolution in the time-domain for resolution in the frequency domain. Anacoustic modes were conscious moves toward a more noise-based paradigm, where transient microsonic fluctuations were measured as alternating values in the time-pressure curve.

Standard Synthesis

Max Mathews's acoustic orientation in the design of MUSIC-N languages, following Fourier, gave rise to what Holtzman describes as *standard* synthesis:

> Standard or synthesis-by-rule systems such as Mathews' (1969) MUSIC V provide facilities for working "top-down" to specify sounds in terms of high-level acoustic models. After complex calculations, a massive list of samples is stored and synthesis subsequently consists of the transferal of the stored samples to digital-to-analog converters (DACs). [4]

The activity of composers expanding upon Mathews's research in the 1960s, such as James Tenney and Jean-Claude Risset, is a testament to the acoustic and psychoacoustic focus at Bell Labs. Tenney's article "The Physical Correlates of Timbre," for example, or Risset's investigation into timbral characteristics of brass

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[4] S.R. Holtzman, "An Automated Digital Sound Synthesis Instrument," *Computer Music Journal* 3, no. 2 (1979): 53.

instruments set a strong precedent for computer music research as a harbinger of psychoacoustic insight.[5]

My implementation of the concept of standard synthesis focuses on its orientation toward acoustic or psychoacoustic models, and by extension the Fourier series. Consequently, it encompasses numerous techniques as standard models inform the majority of activities in digital sound construction today. In fact, the foundations of synthesis as laid out by Matthews and his associates haven't really changed. Standard processes such as additive synthesis are common tools in virtually every digital audio workstation, and digital oscillators are at the core of most synthesis engines.[6] In order to delimit the territory of anacoustic modes, I will briefly discuss common standard synthesis techniques in terms of how they fit within an acoustically oriented framework. First, a note on acoustics.

Acoustic resonance

A special property of acoustic bodies that is the foundation of traditional instrumental performance is *resonance.* Resonance is the tendency of acoustic systems to exhibit certain modes of vibration called resonant frequencies. When subject to an external force, resonant acoustic systems such as a guitar string or flute create tones (harmonic partials) as a result of their natural vibrational modes, which effectively amplify certain frequencies and suppress others. The resonant frequencies of a string are directly related to the length, mass, and tension of the string. In an air column, the resonance is determined by the length of the column, its shape, and

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[5] Jean-Claude Risset, "Sculpting Sounds with Computers: Music, Science, Technology," *Leonardo* 27, no. 3 (1994): 259.

[6] A digital audio interface (DAW) is a software application that combines various functions and processes for music production such as recording, sequencing, effects processing, and instrument design.

whether the ends are open or closed. Waves reflect back and forth at the ends of the medium, creating standing waves at integer multiples of the fundamental frequency. Closed ends, as in a string, create nodes—stationary points (or zero crossings) in the wave amplitude, whereas antinodes, areas of peak amplitude, occur at the open ends of an air column. Frequencies that exhibit the correct nodal pattern will be supported by the medium and thus constitute its resonant modes.[7] The relative strength and morphology of each resonance determines the timbre of the sound. Vibrational modes are clearly tied to the Fourier series, which is a kind of informational abstraction of this physical phenomenon.

Additive synthesis

As defined previously, additive synthesis is the construction of complex waveforms from the summation of simple waves. This activity simulates resonance by using sine waves to represent vibrational modes as static, isolated units.

Subtractive synthesis

Whereas additive synthesis builds a sound complex from simple elements, *subtractive synthesis* begins with a sound complex and takes away from it. Spectra are sculpted with filters that allow the user to boost or attenuate specific frequency regions. Filters present tangible correlations between input parameters and their effect on timbre. Subtractive synthesis has a variety of applications, from the extraction of noise to the modeling of resonant bodies.

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[7] Perry R. Cook, “Voice Physics and Neurology,” in *Music, Cognition, and Computerized Sound*, ed. Perry R. Cook (Cambridge: MIT Press, 1999), 109.

Modulation synthesis

Modulation synthesis is the process of mathematically modulating (or controlling) characteristics of one waveform with another. Common applications include amplitude and frequency modulation (AM and FM, respectively), which are extensions of fixed-waveform techniques. AM and FM exhibit easily calculable behavior in their morphological and spectral effects.

Physical modeling

Physical modeling is a type of synthesis that formulates digital processes to simulate the behavior of sounding objects. Physical models are unique in that they emulate physical systems directly in order to elicit their acoustical attributes as a consequence, rather than patterning their analyzed acoustical attributes directly, with the hope of secondarily inferring the presence of the physical system assumed to have produced them.

Related to physical modeling is formant synthesis, which simulates the resonant properties of the vocal tract using both time-domain filters and simple waveforms.

Granular synthesis

Lastly, an extension of standard synthesis that has become increasingly common is *granular synthesis*, which approaches sound not as a continuous wave-phenomenon, but as a collection of discrete particles or grains. Roads asserts that granular synthesis (a type of time-domain *microsound*) "[stands] in opposition to representations at the sample level that do not capture frequency-domain information, and abstract Fourier methods that presume that sounds are summations of infinitely long sinusoids." [8] Despite their alternative status, granular techniques enable a firm connection to

[8] Roads, *The Computer Music Tutorial*, 168.

acoustic parameters in their high level address of collections of sound grains. Controls for pitch, rhythm, and aspects of timbre are the norm (and interestingly, they overlap). While the individual grains are isolated acoustic units, their dense generation is more akin to, and modeled as, a physical process like rain, pouring gravel, or the accumulation of echoes.

Nonstandard Synthesis

Anacoustic modes of digital sound construction employ types of *nonstandard* synthesis whereby "sound is specified in terms of basic digital processes rather than by the rules of acoustics or by traditional concepts of frequency, pitch, overtone structure, and the like."[9] The hallmark of anacoustic processes is their choice to model neither the physical behavior of sounding objects nor the acoustic characteristics they produce. By either the knowing use of an arcanely coded translation process or by the use of an incomplete characterization of physical models (or both), they model that which is neither physical nor acoustic, while producing acoustic artifacts. Sound in anacoustic modes is only tangentially specified.

Central to nonstandard synthesis is the waveform, or the time-domain representation, which plots amplitude over time. At an atomic level, the waveform is composed of a finite number of discrete time points and amplitude values which collectively outline (or approximate) the time-pressure curve on a computer. Nonstandard synthesis operates at this micro-sonic level, using abstract data sets or logical operations to build waveforms from their smallest digital element. Examples include the software applications *SSP* (1971) by Gottfried Michael Koenig, *SAWDUST* (1976) by Herbert Brün, and *GENDY* (1991) by Iannis Xenakis, all of which allowed the

[9] Holtzman, "An Automated Digital Sound Synthesis Instrument," 53.

direct construction of waveforms via processes that dictate discrete time/amplitude value pairings. Roads has described SSP and SAWDUST as examples of *waveform segment techniques* and GENDY as *dynamic stochastic synthesis.* Within my anacoustic framework, nonstandard synthesis extends into even more idiosyncratic addresses of basic digital processes in the work of Yasunao Tone and Ryoji Ikeda. Naturally, each composer's approach differs in terms of design and function, and each will serve as a subject of focus in Chapter 5.

Audification

The coupling of the waveform and data exhibited in nonstandard synthesis has also been researched in the practice of *audification*, a companion to *sonification*. Both audification and sonification are types of *auditory display.* For brief clarification, Walker and Nees explain that "an auditory display can be broadly defined as any display that uses sound to communicate information. Sonification has been defined as a subtype of auditory displays that use non-speech audio to represent information."[10] Gregory Kramer defines audification as "the direct translation of a data waveform into sound."[11] Dombois and Eckel elaborate further:

> Audification is a technique of making sense of data by interpreting any kind of one-dimensional signal (or of a two-dimensional signal-like data set) as amplitude over time and playing it back on a loudspeaker for the purpose of listening.[12]

[10] Walker, Bruce N. and Michael A. Nees. "Theory of Sonification," in *The Sonification* Handbook, eds. Thomas Hermann, Andy Hunt, and John G Neuhoff (Berlin: Logos Verlag, 2011), 9.

[11] Walker, B. and Kramer, G. "Ecological Psychoacoustics and Auditory Display," in *Ecological psychoacoustics*, ed. J. G. Neuhoff (San Diego: Elsevier, 2004), 152.

[12] Florian Dombois, and Gerhard Eckel, "Audification," in *The Sonification Handbook*, eds. Thomas Hermann, Andy Hunt, and John G. Neuhoff, 301-324 (Berlin: Logos Verlag, 2011), 301.

The conversion of data sets (wave-like or otherwise) to a time-domain representation is closely related to nonstandard synthesis. Dombois and Eckel assert that audification "discloses or makes emerge aspects of the data that might not have been discovered before."[13] They propose four categories for the classification of audification data:

1. *Sound recording data*, i.e. recordings with a microphone.
2. *General acoustic data*, which refers to all kinds of measurements in elastomechanics such as vibrational data of mechanical waves.
3. *Physical data*, are measurements of physical processes outside of the mechanical domain such as electromagnetic waves or EEG data.
4. *Abstract data*, refers to data that is not extracted from a physical system.

Under these categories *all* digital audio can be technically defined as audification, and anacoustic modes of sound construction might be considered audification of abstract data sets if not for its communicative end goals. Audification seeks to form meaningful links between data and its waveform representation following the assumption that sound will function as an alternative mode of communication, while many anacoustic processes erase the communicative prospects of both data and sound upon their negation of physically or acoustically grounded parameters. Anacoustic modes are more appropriately described as *anticommunicative* following the Brünian concept to be discussed in Chapter 5. Of course, the type of data and the manner by which it is constructed plays a significant role in the sounding result.

Precurors

Anacoustic modes are tightly coupled with the development of recording and playback media as technologies of sound inscription. Working with computer data to

[13] Dombois and Eckel, "Audification," 301.

construct waveforms can be viewed as an extension of Bauhaus professor László Moholy-Nagy's instruction when, in the 1920s, he wrote:

> Since it is primarily production (productive creation) that serves human construction, we must strive to turn the apparatuses (instruments) used so far only for reproductive purposes into ones that can be used for productive purposes as well.[14]

Given the example of a phonograph, Moholy-Nagy elaborates:

> An extension of this apparatus for productive purposes could be achieved as follows: the grooves are incised by human agency into the wax plate, without any external mechanical means, which then produce sound effects which would signify without new instruments and without an orchestra – a fundamental innovation in sound production (of new, hitherto unknown sounds and tonal relations) both in composition and in musical performance.[15]

Although Moholy-Nagy enlisted select composers in an attempt to fulfill his call to action, his project never actually came to fruition. Levin provides the following account:

> Despite published journalistic accounts describing early groove-script experiments by Moholy-Nagy and Antheil, Moholy-Nagy himself confirms that although he had been able to get both Stuckenschmidt and Antheil interested in exploring this possibility in the mid-1920s, [his suggestions were never fully worked out in detail.][16]

In light of limited success with the phonograph, Moholy-Nagy found a promising alternative in the medium of *optical sound*. "Optical recording technology translated sound waves via the microphone and a photosensitive selenium cell into patterns of light that were captured photochemically as tiny graphic traces on a small strip that ran parallel to the celluloid film images."[17] This development prompted Moholy-Nagy to

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[14] László Moholy-Nagy, "Production-Reproduction: Potentialities of the Phonograph," in *Audio Culture: Readings in Modern Music*, ed. Christoph Cox and Daniel Warner (New York: Continuum, 2009), 331.

[15] Moholy-Nagy, "Production-Reproduction," 332.

[16] Thomas Y. Levin, "Tones from out of Nowhere: Rudolph Pfenninger and the Archaeology of Synthetic Sound," *Grey Room* 12 (Summer, 2003): 47.

revise his term groove-script (vis-à-vis the phonograph) to *sound*-script, as he formally announced in 1932:

> Sound-script makes possible acoustic phenomena which conjure up out of nothing audible music without the previous play of any musical instrument. We are in a position today to be able to play written sounds, music written by hand, without involving an orchestra, by the use of the apparatus of the sound film.[18]

In this same lecture, Moholy-Nagy showed films by German pioneer of abstract animation Oskar Fischinger and Swiss engineer Rudolph Pfenninger, both of whom were experimenting with optical sound in the 1930s. Fischinger examined the correlation between different drawn shapes and their acoustic properties—what has been referred to as ornamental sound, beginning with visual patterns. Pfenninger developed visual archetypes of sound fragments from acoustic sources in what he called *tönende Handschrift,* or sounding handwriting.

Almost simultaneous developments occurred in the Soviet Union. According to Holzer's timeline tracing the history of optical sound, Soviet artist Arseny Avraamov produced the first hand-drawn film soundtracks in 1930, preceding Fischinger's ornamental approach. In the same year, Evgeny Scholpo developed the Variophone, an instrument that utilized optical sound technology as a basis for synthesis.[19]

Others continued activity in what became commonly known as graphical or drawn sound such as National Film Board of Canada animators Norman McLaren and Evelyn Lambart, and film composer Maurice Blackburn in the 1950s. While a complete

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[17] Levin, "Tones from out of Nowhere," 34.

[18] László Moholy-Nagy, "New Film Experiments," in *Moholy Nagy* by Krisztina Passuth (New York: Thames and Hudson, 1985): 322.

[19] Derek Holzer, "A Brief History of Optical Synthesis," Tonewheels, UMATIC, http://www.umatic.nl/tonewheels_historical.html (accessed July 14, 2017).

history of developments in graphical sound are beyond the scope of this document (see Levin, Holzer, and Smirnov), it is clear that graphical sound, in its correlation of auditory phenomena with visual patterns, set the stage for the waveform as a site for the conceptualization and construction of sound. Nonstandard synthesis can be viewed as a utilization of the paradigm of digital inscription for productive as opposed to reproductive purposes following Moholy-Nagy. Roads reinforces this view as he considers waveform segment techniques to be "idiomatic to the computer."[20]

Effective and Control Mechanisms

Another way of understanding the use of a computer for sound "production" as opposed to reproduction is explained by Gary Grossman in "Instruments, Cybernetics, and Computer Music," a companion article to Brün's *SAWDUST* Manual. Grossman analyzes the computer as an instrument in terms of its effective and control mechanisms. Related to the concept *idiomatic*, which can describe something structurally or physically particular to an instrument, an effective mechanism "directly accomplishes the purpose for which the tool is employed," whereas a control mechanism "mediates between the person using the tool and the effective mechanism."[21]

The incorporation of extended techniques into instrumental performance practice throughout the 20th century can be viewed as a turn to the effective mechanism. Extended techniques utilize the auxiliary effects of acoustic instruments and often reflect a conceptualization of performance in terms of an instrument's unique, if not

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[20] Roads, *The Computer Music Tutorial*, 319.

[21] Gary Grossman, "Instruments, Cybernetics, and Computer Music," in *A Manual for SAWDUST* by Herbert Brün, ed. Arun Chandra (1987), http://academic.evergreen.edu/a/arunc/brun/sawdust/node15.htm (accessed July 20, 2017).

idiosyncratic, sounds rather than those more universal sounds, which it makes to serve generalized structures of pitch, specified in traditional music notation. Nonstandard synthesis, similarly, exploits an artifact of computer-based music systems. Yet the distinction between effective and control mechanisms on a computer is far from obvious due to the multiple layers of mediation that stand between the user, a given command, and the effective response. Grossman explains:

> The invention of the computer was a principal impetus for the development of the study of cybernetics, because it is a tool that can be used to recursively redefine its own control mechanism (the software). Each layer of control mechanism is built on, and in terms of, the layer below. More important, each layer acts as part of the effective mechanism for the layers above, and as part of the control mechanism for the layers below. And all but the lowest of these layers (the hardware) can be created and modified by the same computer on which they are to operate."[22]

He argues that the digital-to-analog converter and the analog electronics are part of the effective mechanism along with the "software and hardware for storage of the samples and for delivering them to the converter at regular intervals."[23]

> And the software embodying the algorithms for computing the samples must also be considered part of the effective mechanism. Everything else, including the software and hardware whereby the user defines, selects, and directs the sample computation algorithms, must be classified as the control mechanism.[24]

In the high-level control mechanisms of Mathew's MUSIC-V, a user can define an instrument—a collection of interconnected *unit generators* (oscillators, filters, etc.), which are played in time according to the specifications of a score. The MUSIC-V assembly of sets of interconnected unit generators operated at specified times is closely

[22] Grossman, "Instruments, Cybernetics, and Computer Music."

[23] Ibid.

[24] Ibid.

related to the voltage-controlled, modular configurations of the classic analog studio. This fueled a fundamental concern of practitioners of nonstandard techniques: throughout the development of digital sound, many analog-based paradigms were applied to a fundamentally different technology—technology which, by its operational specifics, might suggest other approaches to design. The control mechanisms for nonstandard synthesis provided an alternative to the high-level, modular instructions of MUSIC-V and brought the composer closer to the effective mechanism of the computer. In Grossman's words, "if a computer-based music system produces sound by feeding samples to a digital-to-analog converter, then why should that not be the terms in which the composer confronts the system?"[25]

[25] Grossman, "Instruments, Cybernetics, and Computer Music."

CHAPTER 3
SEMIOTICS

> Semiology is not the science of communication. However we conceive of it, it is the study of the specificity of the functioning of symbolic forms, and the phenomenon of "referring" to which they give rise.[1]

The discipline of semiology, which is concerned with the functioning of signs and the "phenomenon of referring to which they give rise," elucidates the complex nature of signification.

A *sign* has the capacity to refer—to stand in place of. Its *object* is the "idea conveyed by the sign, which may or may not be an idea of a concrete thing. The *interpretant* (in its simplest form) is that by virtue of which the sign and object are linked."[2] Adopting the Piercian notion of the dynamic and infinite interpretant, Jean-Jacques Nattiez describes music as a symbolic form—a sign or collection of signs "to which an infinite complex of interpretants is linked." Furthermore, meaning emerges from "the constellation of interpretants drawn from the lived experience of the sign's user—the 'producer' or 'receiver'—in a given situation."[3]

Nattiez proposes a tripartite framework for semiotic analysis that identifies three different dimensions of an artwork, each of which represents a different avenue for the emergence of meaning. They are *poiesis*—acts of composition, *esthesis*—acts of listening, and the neutral or immanent level—the embodiment of a work in a material *trace*. It follows, he claims, that "the *essence* of a musical work is at once its genesis, its organization, and the way it is perceived." I have adopted the semiotic tripartition in

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[1] Jean-Jacques Nattiez, *Music and Discourse: Toward a Semiology of Music*, ed. Carolyn Abbate (Princeton, NJ: Princeton University Press, 1990), 15.

[2] Naomi Cumming, "Semiotics," in *Grove Music Online*, *Oxford Music Online,* Oxford University Press, http://www.oxfordmusiconline.com/subscriber/article/grove/music/49388 (accessed October 13, 2015).

[3] Nattiez, *Music and Discourse*, 10.

my own analyses for clarification and to frame interdisciplinary concepts in terms of where they appropriately function as analytical tools for music: whether they reveal something about compositional intention or process, listener interpretation, or something about the sound itself.

While my approach to semiotics in this writing follows Nattiez at a foundational level, it will be seen that the concept of semiotics transforms within diverging discursive formations. Composer Denis Smalley, following *Musique Concrète*, expands upon notions of intrinsic and extrinsic associations of acousmatic sound in the concepts of *source bonding* and *gestural surrogacy.* Herbert Brün touches upon aspects of semiotics in his concept of anticommunication, which I interpret as a poetic view of the human experience of noise as a generative phenomenon in art. In Chapter 5, I link Yasunao Tone's *Musica Iconologos* with Hayles's notion of the *flickering signifier*, which describes a radical shift in the semiotic space of information and communication technologies.

Synthesis vs. Sampling

In electronic music production, synthesis is distinct from sampling. The latter involves the use of acoustically recorded or reproduced fragments of audio, while synthesis involves the generation of "new" sounds electronically. According to Demers, synthesis denotes *sound construction,* which has different semiotic implications than *sound reproduction*. Sound constructions "are not spontaneously created from nothing but rather mediate empirical reality through technology, alienating (or literally, making strange) what was initially familiar."[4]

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[4] Joanna Demers, *Listening Through The Noise: The Aesthetics of Experimental Electronic Music* (New York: Oxford, 2010), 51.

Issues related to the semiotics of sound construction were notably foregrounded by early *elektronische Musik* produced at Westdeutscher Rundfunk (WDR) studio, Cologne, in the 1950s. Aspects of this body of work can be seen as foreshadowing certain issues within anacoustic modes, namely the split between composers' a priori schemata and the extrinsic associations they give rise to independently from any encoded logic.

Stylistically opposed to the *Musique Concrète* of Paris, which privileged sampled, *concrete* sound materials recorded from the natural world, elektronische Musik used synthetic sound exclusively. Composers at WDR championed the work of the Second Viennese School and sought to extend serial organization to the level of timbre, thus forging connections between the micro and macro levels of composition. Manning elaborates: "An increasing desire to exercise control over every aspect of musical composition led to a keen interest in the possibilities of electronic synthesis."[5]

By exerting more control over the totality of sound, Stockhausen and others at WDR furthered the Modernist quest for a pure, self-referential artwork, the substance of which is to be found in the elegance of formal design—in the unified structural principles that permeate various levels of the music. Stockhasuen's *Studie I* and *Studie II* are archetypes of the Cologne aesthetic. Upon his arrival at WDR in 1953, he requested a beat-frequency oscillator to generate sine waves, which enabled the serial organization of spectra via additive synthesis. The rendering of sound and music into quantities fostered an almost scientific authority behind claims that this was a truly new, unheard musical language. WDR composers were at pains to prevent the surrender of their work to unintended extrinsic associations that might negate their intrinsic order. As an

[5] Peter Manning, *Electronic and Computer Music*, 42.

extreme example of the general attitude, Herbert Eimert, a pioneer of electronische Musik, voiced a polarizing structuralist stance in *Die Reihe,* 1958:

> Today the physical magnification of a sound is known, quite apart from any musical, expressionist psychology, as exact scientific data. It cannot, however, be the function of electronic music to make the sine tone the living parasite to feign similarity where disparity exists.[6]

Eimert promotes what Rose Subotnick defines as *structural listening*, "a method which concentrates attention primarily on the formal relationships established over the course of a single composition."[7] Subotnick presents the concept following Schoenberg and Adorno, who viewed structure and form as a primary marker of a work's artistic value. Structural listening represents an aesthetic movement away from sound as a physical reality toward informational abstraction.

> [Structural listening] seeks to transcend the potential sloppiness and impreciseness inherent in the physical manifestations of sound; the written score is seen (!) as having more integrity than any sonic realization of the musical work, and as more indicative of the creative process of the composer, which manifests itself through the structural necessity and organic completeness of the musical ideas that unfold from the beginning to the end of a musical work.[8]

I should point out that composers of both elektronische Musik and Musique Concrète grappled with the schism between their artistic intentions and listener comprehension. With the traditional "musical frame" disrupted in part by Schaeffer's "world of sound" in its re-presentation of sounds from the natural world, elektronische Musik created similar esthesic ruptures by distancing materials from familiar musical

[6] Herbert Eimert "What is Electronic Music?" *Die Reihe* 1 (1958): 8-9.

[7] Rose Subotnick, "Toward a Deconstruction of Structural Listening," in *Explorations in Music, the Arts, and Ideas: Essays in Honor of Leonard B. Meyer*, ed. Eugene Narmour and Ruth A. Solie (Stuyvesant: Pendragon Press, 1988), 88.

[8] Andrew Dell'Antonio, ed, *Beyond Structural Listening? Postmodern Modes of Hearing* (Berkeley: University of California Press, 2004), 3.

configurations and known causal sources.[9] David Dunn articulates this poietic/esthesic tension when he suggests:

> The early Cologne school appears to have been concerned with an authentic and didactic display of the electronic material and its primary codes as if it were possible to reveal the metaphysical and intrinsic nature of the material as a new perceptual resource.[10]

The dynamic between anacoustic modes of sound construction and their acoustic byproducts, i.e. how they are heard, echo the tenuous poietic/esthesic relations of elektronische Musik. In the 1970s, the digital waveform signaled a new paradigm under which links between sound and musical structure could be forged. While forgoing the polemical charge of Eimert, nonstandard synthesis a la Koenig and Brün follows in this lineage of structuralism. Subsequently, Xenakis and Tone opened nonstandard methods to different degrees of non-deterministic influence. Both methods address the computer, in its representation of sound, at a sub symbolic scale. As a result the construction of the waveform and the nature of its organization is not always clear or meaningful at the esthesic level. Structural listening is but one possible mode of listening, accessible only to those who possess the proper cognitive decoding software.

When acousmatic music is cast into the domain of semiotics, regardless of its mode of construction, the way that sound is perceived is an integral dimension inherently bound up with extrinsic associations. While admitting the semantic pitfalls of the term sound construction, Demers describes the reality of the listener perspective:

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[9] Joanna Demers, *Listening Through The Noise* (New York: Oxford University Press, 2010), 12. Demers explains that "when the framing devices of Western art music – tools such as tonality, dance rhythms, predictable forms, standard orchestration, and concert venues – began to disappear or undergo critique, so, too, vanished many reasons for regarding music as separate from the outside world."

[10] David Dunn, "A History of Electronic Music Pioneers," David Dunn, http://www.davidddunn.com/~david/writings/pioneers.pdf (accessed August 2, 2017), 14.

> In identifying synthesis as an act of sound construction and in asserting that sound construction entails the creation of new sounds, I have set up an expectation for a tabula rasa listening experience that can perhaps never occur. Although synthesis might technically be defined as the creation of new sounds, listeners inevitably compare what they hear with preexisting sounds and categorize new sounds according to the type of equipment that might have produced them. This conclusion might at first seem verily to confirm what we know instinctually: we make sense of sensory perceptions on the basis of what we have already lived. Constructed sounds, no matter how much they might be intended as new, are ultimately experienced as metaphors likening the unknown to the familiar.[11]

Sound as Signifier

Composer Denis Smalley has elaborated on the nature of extrinsic connections that emerge from the acousmatic scenario and the recognition of causal sources. His concept of *source bonding*, for example, describes "the *natural* tendency to relate sound to supposed sources and causes, and to relate sounds to each other because they appear to have shared or associated origins."[12] In the contemporary world of electroacoustic music, sounds occupy a continuum from hyperreal to completely imaginary in their links to the material world. Anacoustic sound constructions potentially complicate the esthesic recognition of a causal source because of their encoded origins, suggesting at once a singular sound making paradigm and an immaterial, imaginary space. In Chapters 4 and 6, I explore in more detail the esthesic implications of anacoustic sound constructions following a thread (as suggested by Smalley) that centers on physical sounding bodies as a nexus for listener comprehension.

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[11] Demers, *Listening Through the Noise*, 50.

[12] Denis Smalley, "Spectromorphology: explaing sound shapes," *Organized Sound* 2, no. 2 (August 1997): 110.

Endnote

I use the term anacoustic to describe non-standard synthesis not just for its provocative charge, but also because it forms connections across discursive formations related to sound, information, and materiality. While the concept could apply to other avenues of music, my focus here is necessarily narrow. John Cage, for example, set a strong precedent for the use of non-sounding information to create music, opening an aesthetic space similar to the terra incognita of anacoustic modes. But my interest lies in the unique ontology of digital information (data), manifest in nonstandard synthesis and related practices. Nonstandard synthesis correlates abstract processes with abstract representations of sound pressure as a function of time constructed with strings of binary code. This low level-approach to sonic computing renders sound an indirectly determined afterthought with the potential (depending of the process) of not sounding at all. Cage's silence foregrounded the auxiliary world of sound that is ever present—the noise floor of the environment. Unlike Cage's silence, digital silence is an anacoustic, immaterial zone—space, material, and meaning replaced by signals of encoded messages. This affects the nature of sound, which becomes contingent on the hierarchical data structure. Bateson comments on the abstract status of information:

> "Information" and "form" resemble contrast, frequency, symmetry, correspondence, congruence, conformity, and the like in being of zero dimensions and, therefore, are not to be located.[13]

[13] Gregory Bateson, *Steps to an Ecology of Mind* (Chicago: University of Chicago Press, 1972), 414.

CHAPTER 4
INFORMATION AND NOISE

Nonstandard synthesis is a way of working with information of a particular configuration. Composers generally work with all kinds of information: about sound and hearing, technology, music, etc. We are flooded by information in our everyday lives. We may use the term to describe communication—something we read or heard or saw. We may think of information as instructive—the blueprints for a structure, or a police siren signaling you to pull over. Information is instantiated in different forms—it can be thought of as extracted from and embedded in our material and conceptual world and can be used to articulate and enhance our understanding of it. While the concept has multiple definitions and applications, most information can be understood as *semantic* information consisting of data *plus* meaning.[1]

Digital Audio Information

MTC

Claude Shannon conceptualized the kind of information that characterizes the composition of anacoustic constructs in his *mathematical theory of communication* or *MTC.*[2] MTC focuses on the effective transmission of signals via communication channels, and "is the theory that lies behind any phenomenon involving data encoding and transmission."[3] MTC is rooted in engineering and develops a quantitative approach to information.

Floridi explains, "MTC deals with messages comprising uninterpreted symbols encoded in well-formed strings of signals. These are mere data that constitute, but are

[1] Luciano Floridi, *Information: A Very Short Introduction* (New York: Oxford University Press, 2010), 20.

[2] Shannon is considered the "father of information theory."

[3] Floridi, *Information,* 38.

not yet, semantic information."[4] The meaning of a message is, in Shannon's words, "irrelevant to the engineering problem."[5] In this view, information becomes dimensionless, non-material, free-floating, and decontextualized. MTC is a study of information at the syntactic level, which is why it is so effective in information and communication technologies as computers are syntactical devices. Information is composed of data—sets of qualitative or quantitative variables. Data in a computer is composed of well-formed strings of binary digits or bits.

Audio Encoding

Coding and representing waveforms in digital form is called Pulse Code Modulation (PCM). In the encoding process, a continuous (analog) time based signal is broken up into a discrete time based signal. The periodic time points at which the signal is broken are called *samples*. At each sample, the signal is analyzed and assigned a corresponding amplitude value in the form of a binary word. Cook summarizes that "PCM means to Modulate the analog signal with a Pulse, measure the value for that instant, then Code it into a digital number."[6] The *bit depth* represents the size of the binary word at each sample and determines the number of available amplitude values, or quantization steps. The *Nyquist-Shannon Sampling Theorem* states that to accurately encode a given bandwidth, the sample rate has to be at least twice as high as the highest frequency to be captured. The frequency at half sample rate is typically referred to as the *Nyquist frequency*.

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[4] Floridi, *Information* 45.

[5] Claude Shannon, "A Mathematical Theory of Communication," *Mobile Computing and Communications Review* 5, no. 1 (January 2001): 3.

[6] Cook, "Sound Synthesis for Auditory Display," 199.

Figure 4-1 shows how the fundamental processes of audio encoding (its effective mechanisms) are tightly coupled with waveform construction.

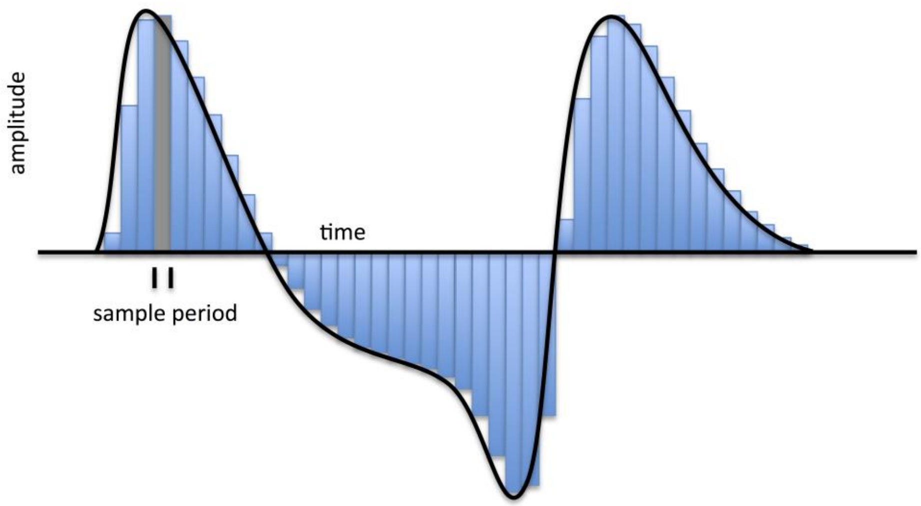

Figure 4-1. Sampling and quantization.

Parametric and Non-parametric Models

While the sound encoding process is, by design, linked to acoustics via the Nyquist theorem, I argue that the ontology of data has an effect on sound constructions that use data exclusively as the fundamental (im)material element. As Holtzman points out "instruction synthesis samples are determined through diacritically-defined relationships *among samples* which do not refer to some superordinate acoustic model or function."[7]

Perry Cook's definition of *non-parametric* modes of sound construction equally articulates the anacoustic condition. While a *parametric* model is "one that has a (relatively) few variable parameters that can be manipulated to change the interaction, sound, and perception," a non-parametric model is not predicated on perceptually determined variables and "has no small set of parameters that allows us to modify the

[7] S. R. Holtzman, "An Automated Digital Sound Synthesis Instrument," *Computer Music Journal* 3, no. 2 (1979): 53.

sound in meaningful ways."[8] Similar to a single pixel on a high-resolution computer screen, a single sample is, at best, barely perceptible as a durational value. Roads admits that "individual samples are subsymbolic—perceptually indistinguishable from one another. [Furthermore,] it is intrinsically difficult to string together samples into meaningful music symbols."[9]

Roads's assessment hits on the dependent hierarchic levels of coding and manipulation in a parametric model, adherence to which allows the coded sound to be manipulated and transferred back in a perceptually meaningful way. An analogy can be drawn with text structures in language from the level of the letter, to the word, to the sentence, paragraph and so forth. The words I am writing here are well formed in sentences, which allows them to carry meaning. To alter the order of words would damage the intelligibility of my sentences. Corruption at the lower level of words in their arrangement of letters would be even more damaging to communication.

Similarly with the representation of sound, there are levels of coding, which introduce different degrees of failure to carry and transmit information. Manipulating the shape of a digitized sound through parametric models is far less damaging to the encoded sound than the manipulation of samples or segments of samples, or, at worst, the order of the bits that comprise each sample, which could lead to complete (acoustic) noise.

A highly parametric model (i.e. many standard synthesis configurations) consolidates multiple functions into a top-down hierarchical control structure, in which small or large parameter changes yield corresponding changes in the acoustic output.

[8] Perry R. Cook, "Sound Synthesis for Auditory Display," in *The Sonification Handbook*, 198.

[9] Roads, *Microsound*, 31.

Cook addresses "parametricity" in the context of auditory display, where it plays a large role in the communicative prospects of data mapping.[10] Auditory display and sonification rely on the most perceptually salient features of music and sound synthesis to articulate relations within data sets. Figures 4-2 through 4-6 illustrate different levels of the digital audio hierarchy from individual samples to wavetables to parametric control structures. Higher levels impose more and more layers of mediation obscuring the low level technics as they are subsumed by the representations under which they operate.

The modular configuration shown in Figure 4-6 was made with a small string of code yet generates complex textures with only five parameter inputs. A number of unit generators (elements in blue capital letters) are interconnected, each with their own veiled hierarchy of underlying operations in the application SuperCollider.[11] The parameters driving each unit generator are, through their interconnection, reduced to a handful of perceptually meaningful variables. Parameters can change dynamically via modulation with other signals or user input with a controller such as a mouse or keyboard.

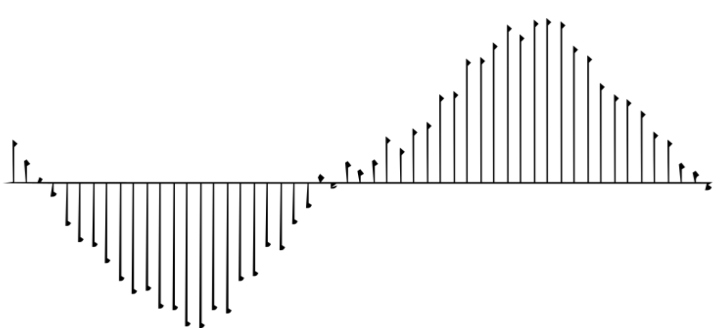

Figure 4-2. Individual samples of one millisecond of a complex waveform.

[10] Cook, "Sound Synthesis for Auditory Display."

[11] "SuperCollider is an environment and programming language for real time audio synthesis and algorithmic composition." (SuperCollider Documentation).

```
Wavetable.sineFill(1024, [1.0]).plot
```

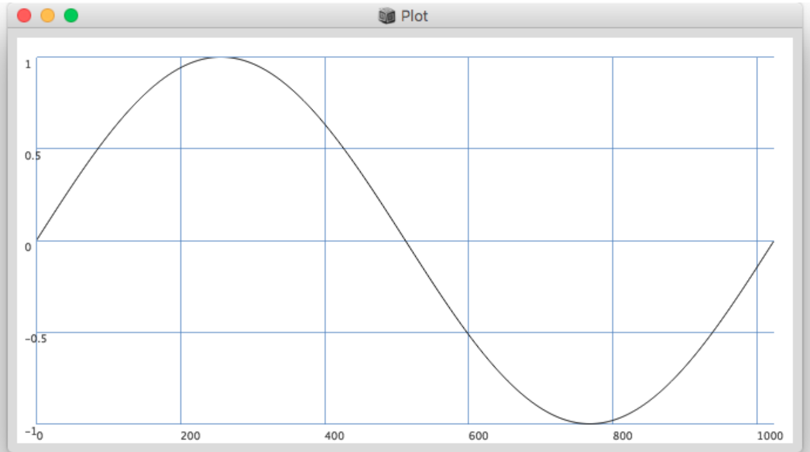

Figure 4-3. Sine wavetable (1024 samples in length).

```
a=Array.fill(100, {arg i; i+1});
Wavetable.sineFill(1024, 1.0/a).plot;
```

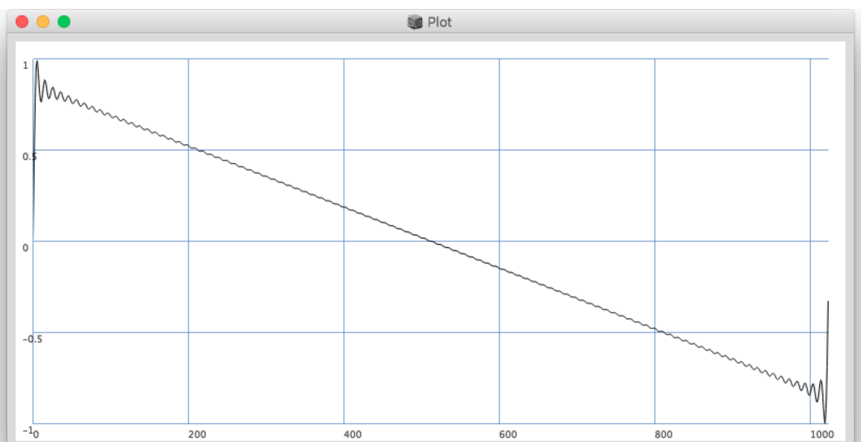

Figure 4-4. Sum of 100 harmonically related sines wavetable.

```
(
a=Array.fill(100, {arg i; i+1});

b=Array.fill(100, {arg i; 200 * (i+1)});

{Klang.ar(`[b, 1/a, nil], 1, 0) * 0.3}.scope
)
```

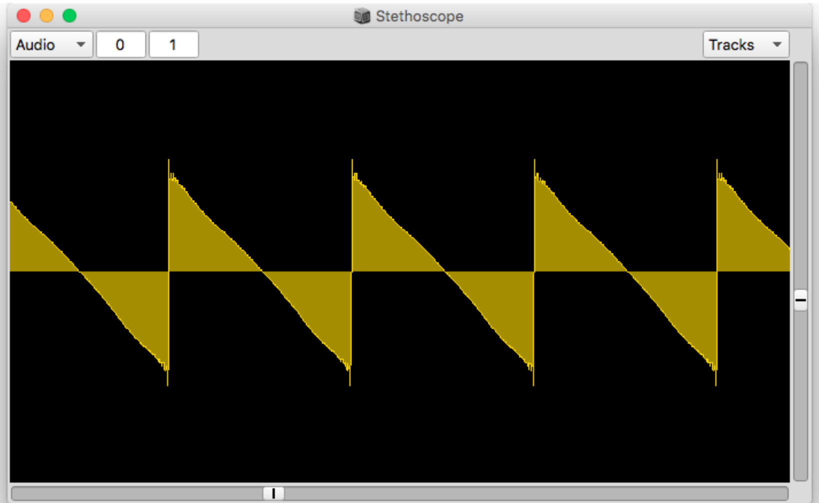

Figure 4-5. Sum of 100 harmonically related sines oscillator bank.

```
(
{
var dens, trig, grainDur, filePos, rate, panPos, grain1 ;

a = Buffer.readChannel(s, "/Users/rob/Desktop/sound.wav", channels: [0]);
b = Buffer.readChannel(s, "/Users/rob/Desktop/sound.wav", channels: [1]);

c= Env.linen(0.1, 0.8, 0.1, 1).discretize;
d = Buffer.loadCollection(s, c);

//GRAINBUF
dens = LFNoise0.ar(0.2).range(8, 30);
trig = Impulse.ar(dens);
grainDur = MouseY.kr(3.0, 0.01, 1);
filePos = LFNoise1.kr(0.15).range(0.0, 1.0);
rate = 1;
panPos = LFNoise1.ar(dens);
grain1 = GrainBuf.ar(1, trig, grainDur, [a.bufnum, b.bufnum],
rate, filePos, 2, 0, d.bufnum) * 1;

Balance2.ar(grain1[0], grain1[1], panPos) * SinOsc.ar(SinOsc.ar(0.2).range(0.1, 10.0)).range(MouseX.kr(0.0, 0.99), 1.0);
}.play
)
```

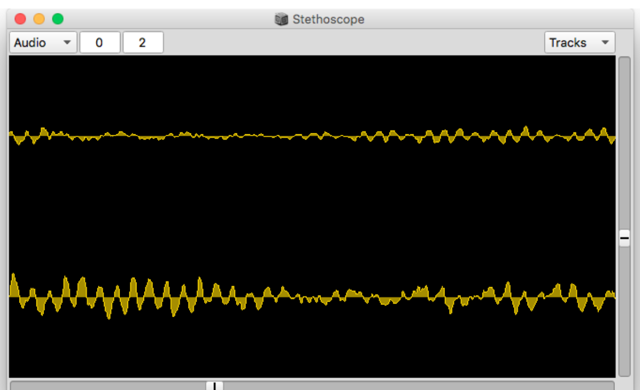

Figure 4-6. Parametric network of interconnected unit generators.

Non-parametric models as in nonstandard synthesis do not present a sufficient analog to sound, since the conditions of sampling, manipulating, and transferring sound as a message have been corrupted, which then causes aspects of the coding process to become evident instead of transparent.

Anacoustic strategies, by foregrounding the mechanical, processual, abstract nature of encoding, evoke a metaphoric distance between material and encoded realities. Waveform (i.e. visual) logic is fundamentally different from aural logic. Author N. Katherine Hayles poses a relevant question with regard to digital, on-screen text, which might apply equally to the sonic arts: "How should we fundamentally change our idea of signification when language is bound up with code in the integral way that it is today?"[12]

The Information/Matter Duality

Hayles, in *How We Became Posthuman*, explains how, in the second half of the 20th century, disciplines like information theory and cybernetics gave rise to a conceptualization of information and materiality as distinct entities—that information is "separate from the material forms in which it is thought to be embedded."[13] With Shannon's MTC, information is defined as a probability function "with no dimensions, no materiality, and no necessary connection with meaning. It is a pattern, not a presence."[14]

When information is divorced from materiality, the embodied circumstances by which it is always necessarily instantiated are easily obscured. In our creation of virtual worlds, we abstract information from materiality in an attempt to push technologically mediated simulacra closer to an indistinguishable replacement for such materialities. The new PlayStation VR, for example, promises "moments so intense your intuition takes over" and the headset is "designed to feel like it's not there – keeping you free

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[12] N. Katherine Hayles, "*How We Became Posthuman*: Ten Years On; An Interview with N. Katherine Hayles," *Paragraph* 33, no. 3 (November 2010): 327.

[13] Hayles, *How We Became Posthuman,* 2.

[14] Ibid.,18.

from distraction."[15] While it is not my intention here to discredit the expressive power of our simulated or modeled versions of the natural world, I find Hayles's reflection on the materiality of information a provocative reminder:

> It can be a shock to remember that for information to exist, it must *always* be instantiated in a medium, whether that medium is the page from the *Bell Laboratories Journal* on which Shannon's equations are printed, the computer-generated topological maps used by the Human genome Project, or the cathode ray tube on which virtual worlds are imagined. The point is not only that abstracting information from a material base is an imaginary act but also, and more fundamentally, that conceiving of information as a thing separate from the medium instantiating it is a prior imaginary act that constructs a holistic phenomenon as an information/matter duality.[16]

For the purposes of this writing, Hayles lays ground for an examination of the relation between computer-based arts, the technologies they depend on, and the ideologies entwined with said technologies. Thinking about the information/material duality in the context of sound design directed me to nonstandard synthesis, which on one hand represents a posthuman vision of information as a reified entity, and on the other, an appeal to the materiality of digital systems via the effective mechanism.

While hacker artists such as Nicolas Collins have, in a literal sense, extracted sounds from the physical components of the computer, I suggest that anacoustic modes reflect the data syntax by which these components communicate and operate.[17] In the poietic dimension, anacoustic sound construction brings the composer closer to the collapse of difference between information and its medium, understood as a holistic

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[15] PlayStation VR, Overview, https://www.playstation.com/en-us/explore/playstation-vr/?emcid=pa-pe-97928 (accessed August 6, 2017).

[16] Hayles, *How We Became Posthuman*, 13.

[17] The extraction of sound from the physical operations of the computer and other electronics is a practice well documented by Nicolas Collins as a kind of hacker art. It is also featured in the discourse of "post-digital" music.

construct, the origin of which does not precede its encoded form. By allowing atypical manipulations of low-level codes of represention, anacoustic modes corrupt what would otherwise be transmitted through such codes while revealing artifacts connected to the typically hidden encoding process.

Note on Posthumanism

Hayles's narrative in *How We Became Posthuman* weaves together a historical account from first wave to contemporary developments in cybernetics. It engages critically with cybernetic concepts and provides thought provoking analyses of science-fiction literature, connecting posthuman themes with the cultural imagination.

It should be noted that the information/matter duality is not an attempt to contest the value of MTC or cybernetic conceptions of information. In fact, the implications of cybernetics have, to Hayles, "remained potent … that is, the implications of large-scale complex systems characterized by communication–and information–flows with multiple feedback loops giving rise to emergent properties."[18] The information/matter duality is but one component in a complex web of affects surrounding the evolution of information and the formation of the posthuman. While Hayles articulates the potential pitfalls of defining the body as an information-processing machine with fundamental similarities to intelligent computers, she also defends the powerful epistemology born from this line of thinking. It is not my intention here to argue for or against the erasure of embodiment in the posthuman reification of information. Rather, I want to show how different composers' conceptions of sound as an informational entity articulates aspects of the metaphoric network branching from the information/material duality. I agree with Hayles when she espouses the contemporary relevance of cybernetic thinking. Consequently,

[18] Hayles, "Ten Years On," 323.

this dissertation identifies the composition and reception of acousmatic music as an engagement with pattern, noise, and materiality. Within this frame, anacoustic modes of sound construction establish one extreme while pointing to other possibilities.

Cybernetic Noise

Beyond MTC and the limitations of syntactic information, Floridi explains that "over the past decades, it has become common to adopt a *General Definition of Information* (GDI) in terms of *data + meaning.*"[19] Even within the years of first wave cybernetics and Shannon's information theory, the decontexualization of information was contested. Cyberneticians, who sought to expand the applications of information, were continually challenged in their attempts to reconcile the quantitative surety and universality of MTC with the subjectivity of message recipients in communication systems; in other words, the marriage of information and meaning. A central figure in this move was Gregory Bateson. "For Bateson, decontextualization is not a necessary scientific move but a systematic distortion." Furthermore, he believed "a truly cybernetic approach … concentrates on the couplings that bind the parts into interactive wholes."[20]

In his *Cybernetic Explanation*, Bateson explains certain properties of information as they relate to perception and communication. Of central importance is the concept of *pattern* or redundancy—the essence of communication. It is derived by considering how the maximum information carried by an object or event can be reduced by the surrounding patterns of which it is a component part.[21] Redundancy allows the recipient of message material to "fill in the gaps" or to guess when faced with incomplete

[19] Floridi, *Information,* 20.

[20] Hayles, *How We Became Posthuman*, 77-78.

[21] Quantity of information is typically expressed as the log to base two of the improbability of event.

messages or missing information. If you hear the sound of rainfall outside, you can infer (with better than random success) what you will see if you look out the window. The message material "sound of rain" introduces redundancy because of its correspondence with the referent "rain."[22]

Languages contain redundancy rules as do different conventions of art. What happens when an event or aggregate of events does not conform to known patterns – a message without a referent? Or a sign that is not linked to an object? Bateson states, "all that is not information, not redundancy, not form and not restraints – is noise, the only possible source of *new* patterns."[23] One can understand how, in this model, noise effectively stimulates the evolution of music. Historically important moments of stylistic upheaval can be analyzed in terms of noise being introduced into well established and widely understood musical tendencies (i.e. patterns). New patterns become incorporated into musical language until they are reconfigured again through noisy interjections. Anacoustic strategies for sound construction can be thought of as an introduction of noise into the traditional practice of sound making in music and sound synthesis in electronic music. Furthermore, the hierarchic level at which noise is introduced is so low that it inscribes electronic chaos into the sound itself.

Pattern/Noise. The pattern/noise dialectic suggested by Bateson represents another significant feature of Hayles's posthuman in her understanding of the "contemporary pressure toward dematerialization … as an epistemic shift toward pattern/randomness and away from presence/absence."[24] Information is "a pattern

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[22] Bateson, *Steps to an Ecology of Mind*, 412-14.

[23] Ibid., 416.

rather than a presence, defined by the probability distribution of the coding elements composing the message. If information is pattern, then noninformation should be the absence of pattern, that is, randomness."[25] Randomness in this context is synonymous with noise.

The distinction between presence/absence and pattern/noise is meaningful because presence/absence, Hayles argues, "connects materiality and signification in ways not possible within the pattern/randomness dialectic."[26] Presence, for example, is allied with "an originary plenitude that can act to ground signification and give order and meaning to the trajectory of history"—order, meaning, and history being the realm of humans.[27]

In Derrida's deconstruction, the originary plenitude of presence is destabilized and absence foregrounded by the argument that there is no unmediated expression. Consequently, *meaning* is never actually present, but continually defers to other signs.

> Thus 'nature' is always culturally defined, while speech (supposedly more authentic than writing, since it gives a more intimate access to the utterer's thoughts and feelings) is itself a kind of writing insofar as it bears all the marks (of structure, convention, the arbitrary … relation between signifier and signified) that thinkers since Aristotle have standardly attributed to written discourse.[28]

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[24] Hayles, *How We Became Posthuman*, 29.

[25] Ibid., 25.

[26] Ibid., 247.

[27] Ibid., 285.

[28] Christopher Norris, "Deconstruction," in *Grove Music Online,* Oxford Music Online, http://www.oxfordmusiconline.com:80/subscriber/article/grove/music/44653 (accessed September 5, 2017).

Derrida proves that only through mediated forms like language can one access signification. It follows then, that in representational media, presences, while a marker of physical absence on one hand, carry the significance of their origins on the other. As Amanda Bell points out, "for media theory, representational absence becomes a form of presence."[29]

Acousmatic music, as a technologically mediated form, presupposes representational absence. Yet, acoustically recorded sound can signify presence as a trace left by physical action. Sounds can imply, by their spectromorphologies alone, human agency or material embodiment in physical space. This dissertation assumes that presence is a meaningful branch in the semiotics of virtuality and is central to listener comprehension as he or she navigates acousmatic sound worlds with representational potential ranging from the virtually real to the impossible or imagined.

Standard synthesis techniques are allied with presence in their derivation from acoustic properties, yet represent these acoustic properties through information. They yield simulacra that can be seen as a play between representational absence and informational pattern.

Whereas standard synthesis derives information from sound, anacoustic modes of sound construction derive sound from information. They move away from acoustically reified paradigms of presence/absence and toward informationally based practices (pattern/randomness) whereby the physicality of sound is negated at the outset. In the pattern/randomness dialectic, "meaning is not front-loaded into the

[29] Amanda Bell, "absence/presence," in *Keywords*, The Chicago School of Media Theory, https://lucian.uchicago.edu/blogs/mediatheory/keywords/absence-presence/ (accessed June 12, 2017).

system, and the origin does not act to ground signification."[30] Anacoustic modes engage with pattern to produce a byproduct of sound, voicing the materiality of information (rather than the information of materiality).

These relationships can be drawn out of Hayles's *semiotics of virtuality,* which she uses in *How We Became Posthuman* for analyses of science fiction literature. The terms that comprise Hayles's semiotic square interact dynamically with their partners.[31]

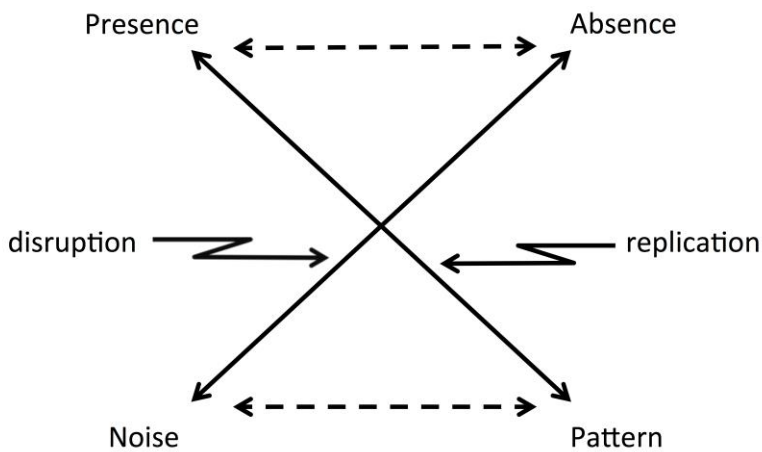

Figure 4-7. The semiotics of virtuality.[32]

> The dialectics can be set in motion by placing presence/absence along the primary axis, with pattern/randomness located along the secondary axis. The relation of the secondary axis to the primary axis is one of exclusion rather than opposition. Pattern/randomness tells a part of the story that cannot be told through presence/absence and vice versa. The diagonal connecting presence and pattern can conveniently be labeled replication, for it points to continuation. An entity that is present continues to be so; a pattern repeating itself across time and space continues to replicate itself. By contrast, the axis connecting absence and randomness [noise] signals disruption. Absence disrupts the illusion of presence, revealing its lack of

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[30] Hayles, *How We Became Posthuman*, 286.

[31] Hayles, *How We Became Posthuman*, 248. She explains, "the semiotic square appeals to me as a heuristic because of its unusual combination of structure and flexibility. The structure is defined by the axes and the formal relationships they express, but the terms composing those axes are not static."

[32] Ibid.

> originary plenitude. Randomness tears holes in pattern, allowing the white noise of the background to pour through.[33]

The scope of Hayles's semiotics of virtuality will be revealed gradually in the analyses that follow. I return to the semiotic square in Chapter 7, where it is explained more fully and expanded upon with synthetic terms that arise from the primary interactions. When applied as an analytical device to the creation and interpretation of acousmatic music, the semiotic square illuminates relationships between embodied complexities, informational patterns, and noise.

Importantly, I view the semiotics of virtuality as a creative springboard toward musical expression that considers the computer for both its productive and reproductive capacity, with an ear toward the extrinsic significance of materials as related to their modes of production and the metaphoric networks to which they give rise.

[33] Hayles, *How We Became Posthuman*, 248.

CHAPTER 5
COMPOSERS AND SYSTEMS

Sound Synthesis Program

The conceptual roots of Koenig's Sound Synthesis Program (1971), or SSP, can be traced in part to his foundation in European serialism. Koenig worked at WDR in Cologne from 1954-64 with composers such as Evangelisti, Ligeti, and Brün. He assisted Stockhausen with the realization of the landmark electroacoustic works *Kontakte* and *Gesang der Junglinge.* Koenig's work *Essay* (1960) for tape provides a lucid example of his output during this period. Foreshadowing an anacoustic modality, *Essay* is "not the realization of a preconceived acoustic ideal, but rather [the result of] serial manipulation of basic material and subsequent ordered transformations."[1]

Koenig further channeled the Cologne aesthetic as he began his long association with the Institute of Sonology at Utrecht University in 1964. Serial methods were central to his concept of *programmed music*, as shown in his earliest computer experiments, *Project 1* (1964) and *Project 2* (1966) or *PR1* and *PR2*: "by programmed music we mean the establishment and implementation of systems of rules or grammars, briefly: of programs, independent of the agent setting up or using the programs, independent too of sound sources."[2] PR1 and PR2 use compositional rules derived from serialism to generate score tables containing various performance data to be orchestrated for instruments.

Sound Synthesis Program was written after the Institute of Sonology obtained its own computer in 1971. Koenig writes:

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[1] Paul Berg, Robert Rowe, and David Theriault, "SSP and Sound Description," *Computer Music Journal* 4, no. 1 (Spring 1980): 25.

[2] G.M. Koenig, "Composition Processes," 1978, http://www.koenigproject.nl/indexe.htm (accessed May 20, 2017): 4.

> My sound synthesis program *SSP* endeavours to transfer the generating principles of musical form to sound synthesis, and hence has common links with electronic music which particularly in its developmental phase in Cologne, stressed the inseparable unity of sound and sound structure. My aim was to apply the idea of a form-generating principle, as can be studied in Project 1 and Project 2, to the genesis of sound; the changing sound-field should represent the development of the form "directly," as it were, without being communicated by musicians and traditional instruments.[3]

SSP's operation can be thought of as algorithmic composition at the audio rate. With this endeavor, Koenig continued the WDR structuralist tradition and reiterated the desire to distance composition from traditional modes of musical organization and presentation.

SSP Technical Details

> [In SSP, samples are] collected in sound segments which in their turn are taken from separate amplitude and time lists. The selection of amplitude and time values is made according to principles originating in PR2. The number pairs in a segment designate turning-points of the oscillation curve which are interpolated linearly in real time during sound production.[4]

SSP is composed of four primary functions described by Berg, Rowe, and Theriault as LIST, SELECT, SEGMENT, and PERMUTATION. The user's task is to:

1. "List the source material (amplitude values, time values).
2. Select all or part of that source material and put it into a 'working area.'
3. Construct segments from the material in the working area. Segments contain an equal number of amplitude and time values.
4. Order the segments."[5]

"On each level of activity in SSP [each functional level] there is a supply of data; a selection principle is applied to this data, producing an output of new data."[6] Selection

[3] G.M Koenig, "Programmed Music," 1985, http://www.koenigproject.nl/indexe.htm (accessed September 21, 2017): 3.

[4] G.M. Koenig, "Composition Processes," 1978, http://www.koenigproject.nl/indexe.htm (accessed May 20, 2017): 10.

[5] Berg, Rowe, and Theriault, "SSP and Sound Description," 34.

principles determine algorithms for carrying out each function. The data to which they are applied are called *elements.* Elements are amplitude or time values (in function LIST), indices of amplitude and time values (in functions SELECT and SEGMENT), and segment numbers (in function PERMUTATION)."[7]

Amplitude values correspond to the number of quantization levels determined by the system bit depth (Koenig was using a twelve-bit converter, so values from 0-4,095), and time values are durations expressed in microseconds. Berg, Rowe, and Theriault describe the general types of behavior of selection principles with the terms *expansion*, *reduction*, *reorder*, *isolation*, and *copy*. "For example, starting from one supply of data, the selection principle TENDENCY may be fed various input values that may cause it to exhibit the behavior described by each of the terms."[8]

Figure 5-2 illustrates the selection principle TENDENCY (for the LIST function), which defines a collection of tendency masks—moving boundaries between which elements are selected at random (Figure 5-1).[9] With TENDENCY, "N random values are chosen between boundaries that change in time. M number of masks may be specified. NN values are chosen in one mask that is indicated by initial boundaries (A1, A2) and final boundaries (Z1, Z2)."[10] Figure 5-3 shows other implementations of TENDENCY in which y-values could be used to represent time durations or amplitude values.

[6] Berg, Rowe, and Theriault, "SSP and Sound Description," 26.

[7] Ibid., 35.

[8] Ibid.

[9] Robert Rowe, *Machine Musicianship* (Cambridge: MIT Press, 2001), 208.

[10] Berg, Rowe, and Theriault, "SSP and Sound Description," 35.

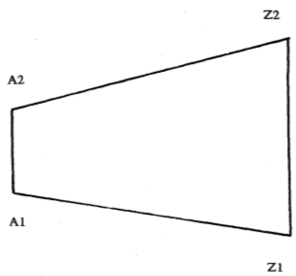

Figure 5-1. NN values in TENDENCY.[11]

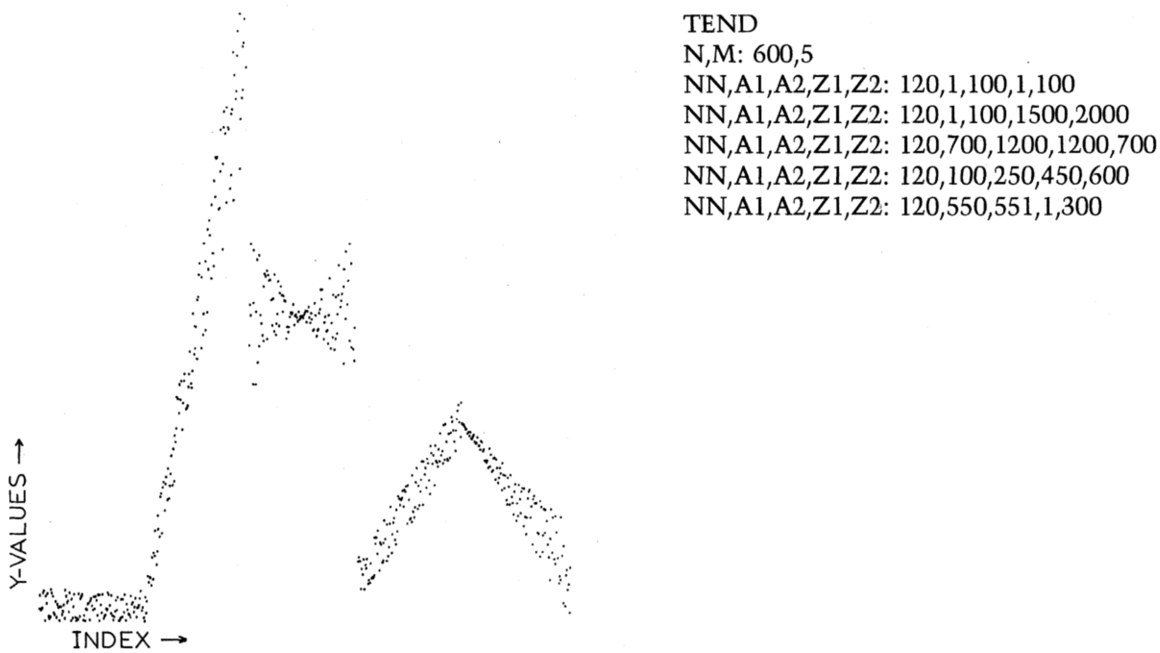

Figure 5-2. List of values generated with TENDENCY.[12]

[11] Paul Berg, Robert Rowe, and David Theriault, "SSP and Sound Description," *Computer Music Journal* 4, no. 1 (Spring 1980): 35. © 1980 by the Massachusetts Institute of Technology. Reprinted by permission of the publisher.

[12] Ibid., 27.

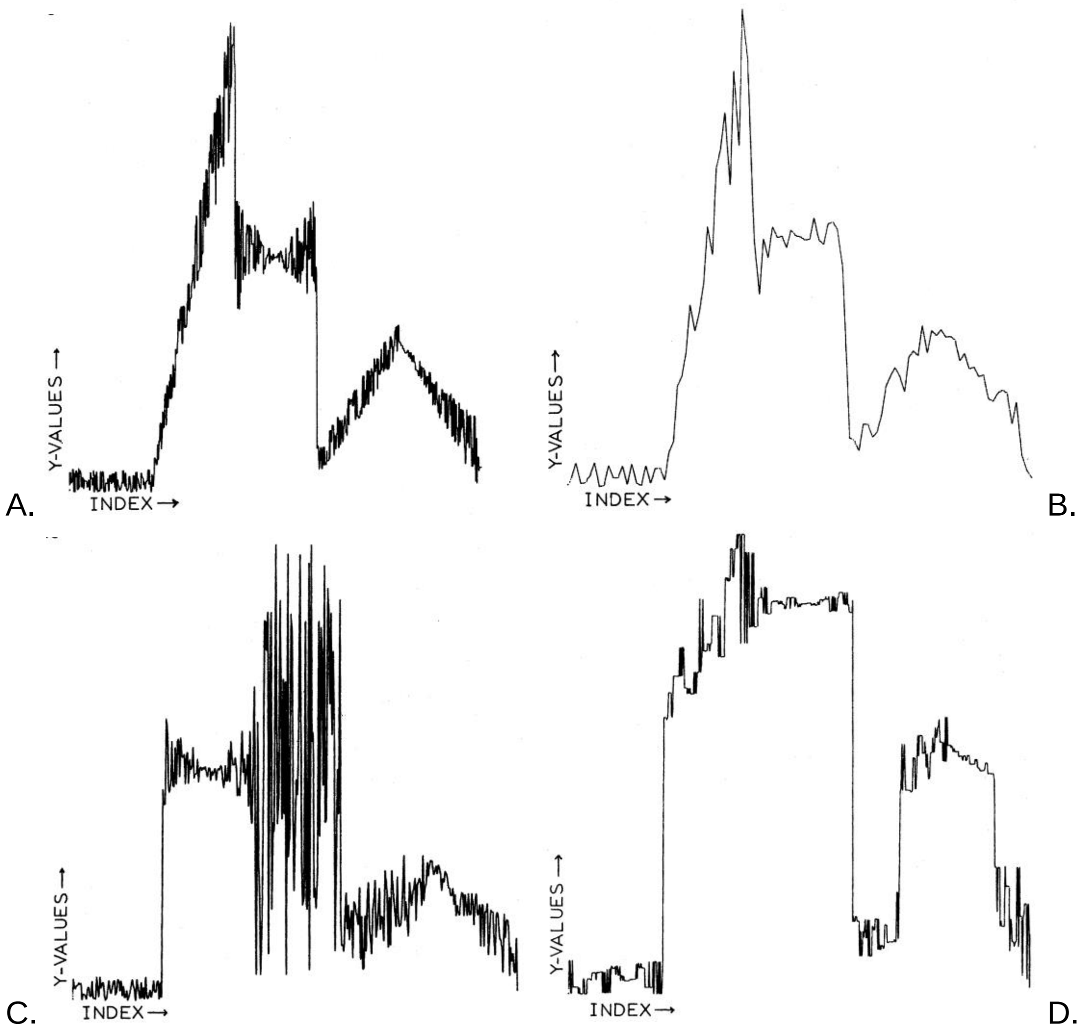

Figure 5-3. TENDENCY. A) Copy, B) Reduction, C) Reorder, D) Isolation.[13]

Figure 5-4 represents an example formation plan with unspecified selection principles applied at each functional level to construct a segment. The SELECT function operates on LIST output. SEGMENT combines amplitude and time values and PERMUTATION defines the order of segments for playback. The user can then specify the number of iterations of the combined segments and audition the result.

[13] Berg, Rowe, and Theriault, "SSP and Sound Description," 27-28.

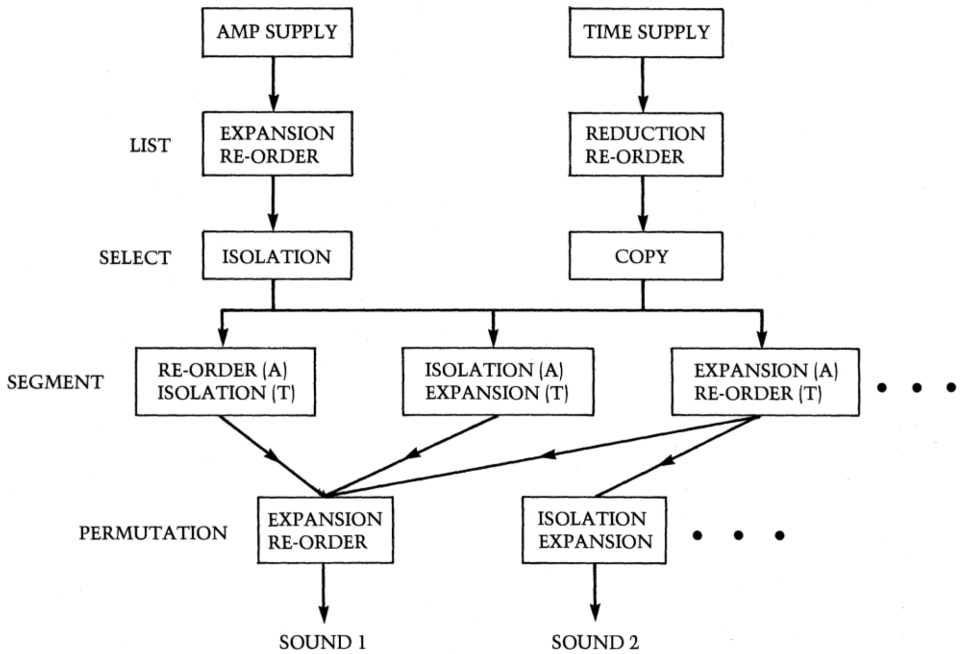

Figure 5-4. Example SSP formation plan.[14]

Acoustic Salvage

Despite the anacoustic origins of the SSP output, the system is configured for an audition scenario whereby a sound is generated and modifications are made following listening and evaluation, thus adding a level of aural logic to the composition process (albeit without acoustically meaningful parameters). While this technically contradicts the premise of sound construction that is entirely anacoustic in origin, I acknowledge that poietic compromises are inevitably made that ground otherwise anacoustically generated material in the physical world of sound. It is actually this dynamic between code (message) as received by the computer versus message as received by a human that is of interest as artist programmers address both humans and intelligent machines in their activities. In the context of digital text-based practices, Hayles argues, “the fact that it is a double address has a very significant impact on how language operates and

[14] Berg, Rowe, and Theriault, “SSP and Sound Description,” 30.

what language means."[15] The *sound* negotiations made on behalf of the (post)human in an anacoustic modality are an *acoustic salvage*.

Dual Addresses in Computer Art

In anacoustic modes of sound construction, the dual address of humans/computers is most evident in the negotiations made as part of an acoustic salvage, in which the logistics involved in waveform construction are compromised or reworked because of the trace they leave in sound. The dual address can yield an interesting dynamic in the juxtaposition of different coded representations of unique data, giving rise to another level of potential meaning in the idiosyncratic way that code can be linked to diverse (im)material instantiations.

Figure 5-5, "ox4.html," was taken from jodi.org – a complex network of unexplained pages and unwieldy links forming a dense maze of web content that encourages a sense of wandering and discovery as the user attempts to decipher what is on screen in some meaningful way.[16] "ox4.html" is a web page from one branch of the sprawling jodi network. As seen on the browser surface, it is a collection of jumbled, seemingly arbitrary text characters colored neon green over a black background.

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[15] Hayles, "Ten Years On," 327.

[16] jodi.org or Jodi is the collaboration of internet artists Joan Heemskerk and Dirk Paesmans.

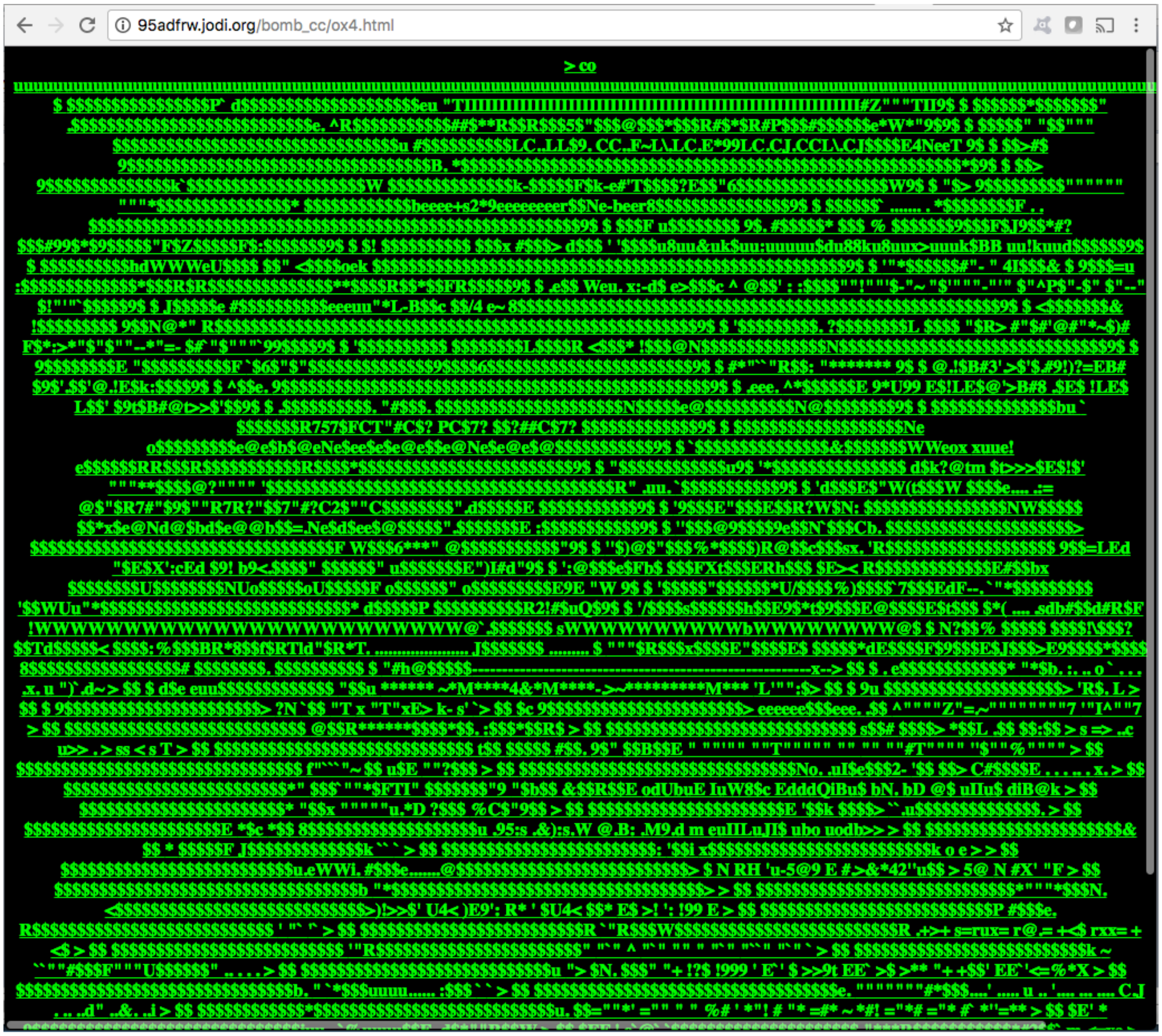

Figure 5-5. We browser front-end of “ox4.html” on jodi.org.[17]

Figure 5-6 presents the html source code—the unstyled text—for the same webpage. The array of characters from the incoherent front-end takes shape visually in an encoded form as an image of a clown. It took me a number of attempts (starting again and again from jodi.org) before I found the page titled “ox4.html.” And even then, it wasn’t clear that the html code was structured as a figurative image because the dimensions of the browser window can obscure the line by line ordering of unstyled text.

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[17] Joan Heemskerk and Dirk Paesmans, “ox4.html,” jodi.org, http://95adfrw.jodi.org/ (accessed January 16, 2018).

To see the image slowly emerge as I gradually adjusted the dimensions of my browser window felt like stumbling upon some weird encrypted message.

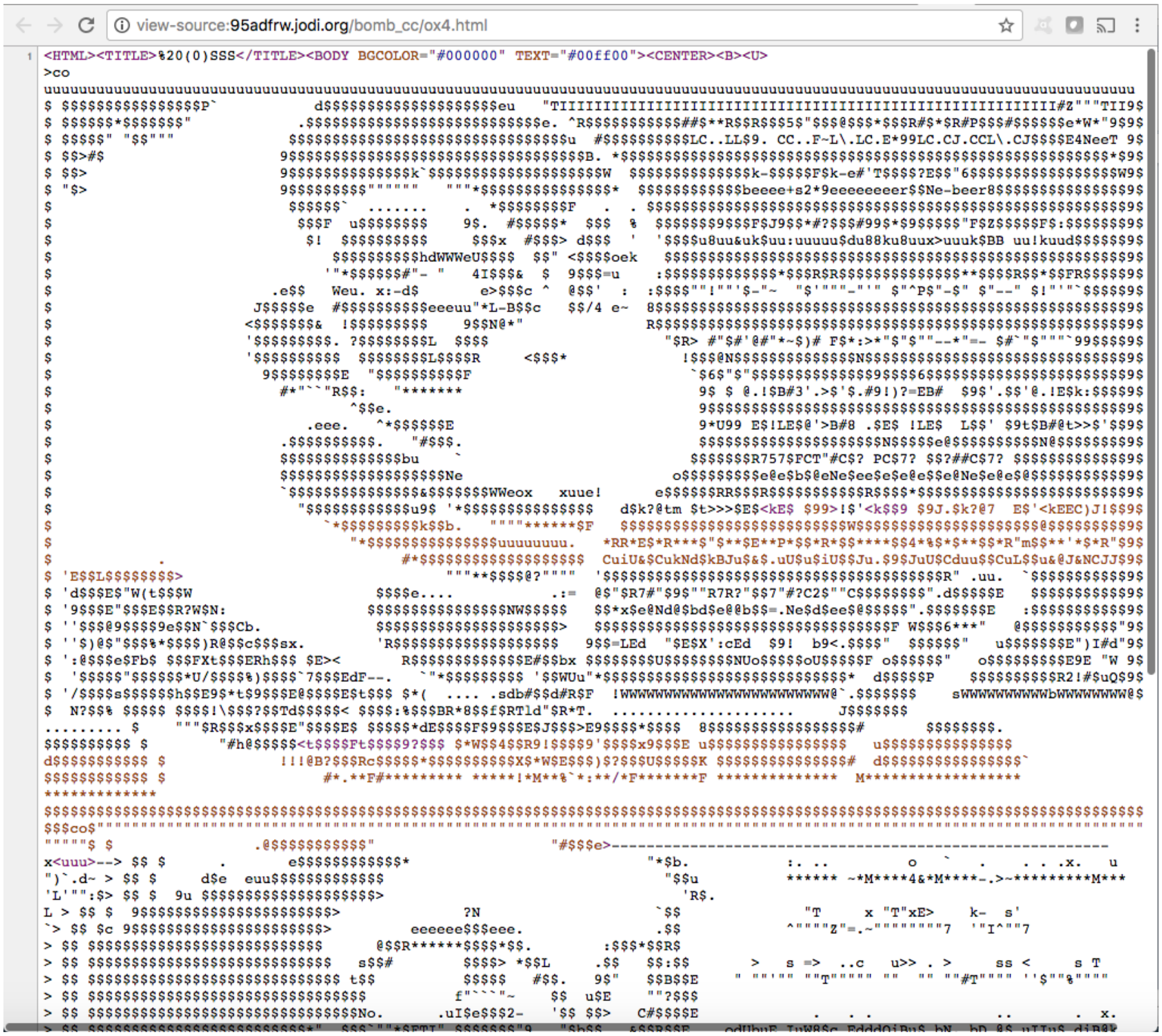


Figure 5-6. Unstyled text of “ox4.html.”

This work is interesting because of the play between code and communication. It serves as an analogy to anacoustic modes of sound construction in that the communicative content is located in the structure of the code rather than in what the code structures. That the user can discover this relationship strengthens the identity of “ox4.html” as a tongue-in-cheek deconstruction of digital semiotics.

Hayles's concept of flickering signification, discussed later in the analysis of *Musica Iconologos*, moves toward a theoretical position "that would begin the interrogation of what it means to have this 'dance' between code and language."[18]

The difference in anacoustic modes is that the ephemeral nature of sound breaks esthesic links to the patterns of encoded origins—the "picture" is erased upon its manifestation as physical vibration.

SSP Conclusion

> To explore a new field of sound possibilities I thought it would be best to *close* the classical descriptions of sound and open up an experimental field in which you would really have to start again. It would be the task of a later time or other people to map the new possibilities to the old experiences.[19]

Despite Koenig's forward-thinking outlook and the potential *noise* that SSP represented in the lineage of synthesis (as a source of new patterns), he has not published any music that actually makes use of the application. He admits:

> In practice, the execution of these ideas was restricted by the available computers, whose core memory was too small. I have nonetheless been able to use the SSP program in the classroom to demonstrate the problems involved.[20]

Other composers associated with the Institute of Sonology have composed work using SSP including Paul Berg, Robert Rowe, and David Theriault. Berg's *Mandolin* (1979) presents a stark continuum of spectra from pitch to noise, all exhibiting intense high partial energy in a fragmented counterpoint. The work features motives and sequences

[18] Hayles, "Ten Years On," 327.

[19] Gottfried Michael Koenig and Curtis Roads, "An Interview with Gottfried Michael Koenig," *Computer Music Journal* 2, no. 3 (December, 1978): 13.

[20] Koenig, "Programmed Music," 3.

that explicitly recall Brün's *Dust*, which was composed three years prior. Berg writes of *Mandolin*:

> The computer sound synthesis program SSP (designed by G.M. Koenig) was used to define 90 sound segments varying in length from 9 to 128 seconds. A basic idea was to distribute the segments in time using predetermined compositional rules. The outputs were mixed without any other electronic manipulation. It was made at the Institute of Sonology in Utrecht.[21]

Mandolin will be discussed further in Chapter 6, in which I explore the work's immanent dimension with the goal of uncovering spectromorphological attributes unique to digital sound construction.

SAWDUST

Herbert Brün first turned to electronic music during the late 1950s at studios in Paris, Cologne, and Munich. The first version of his nonstandard synthesis application SAWDUST was completed with the help of Gary Grossman in 1976 at the University of Illinois, with which he composed the works *Dust* (1976), *More Dust* (1977), *Dustiny* (1978), and *A Mere Ripple* (1979).[22] Brün writes:

> The computer program which I called SAWDUST allows me to work with the smallest parts of waveforms, to link them and to mingle or merge them with one another. Once composed, the links and mixtures are treated, by repetition, as periods, or by various degrees of continuous change, as passing moments of orientation in a process of transformations.[23]

[21] Paul Berg, "Mandolin (1979)," Crosslinks Electronic Frequencies, https://www.concertzender.nl/programma/electronic-frequencies-154/ (accessed October 12, 2017).

[22] Brün's works *U-TURN-TO* (1980) and *I toLD YOu so!* (1981) were constructed with a second version of SAWDUST.

[23] Herbert Brün, *SAWDUST Computer Music Project*, EMF 00644, CD, 1998.

SAWDUST: Technical Details

SAWDUST, like SSP, implements a waveform segment technique whereby a complex wave is constructed from the combination of segments of variable length and amplitude. A SAWDUST session begins by first specifying a list of *elements,* each with an identifying name, amplitude value (0-4096 by default), and duration in samples.

Next, a *link* is defined: a sequence of elements, and number of iterations. The frequency of a link can be calculated by dividing the sample rate by the link duration, which is the sum of the link's sequenced element durations. Processes can then be applied to concatenate or interleave different links with the commands *mingle* and *merge* respectively.

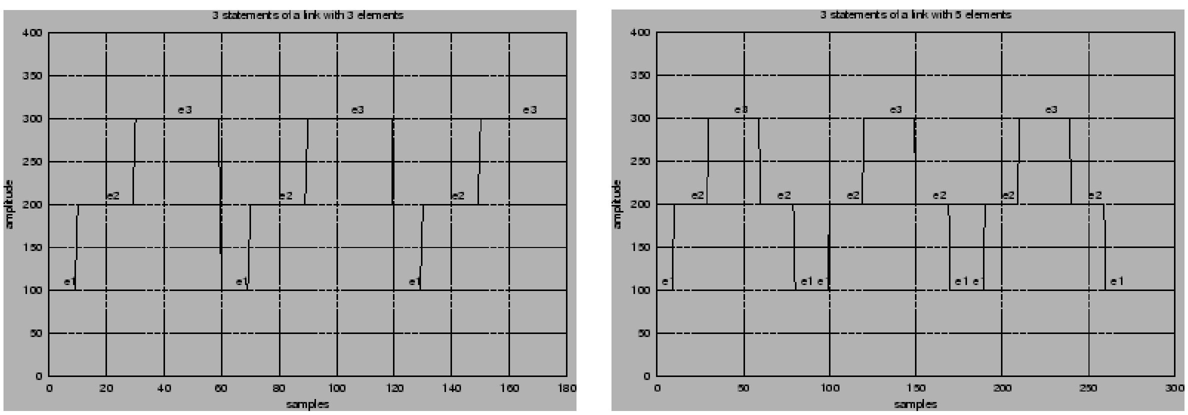
A  B

Figure 5-7. A) Link with three elements; B) Link with five elements.[24]

One link can be transformed into another with the command *vary.* Amplitude values and sample durations are changed independently according to different polynomials (curvilinear trajectories), shown in Figure 5-8. "At each step of the transformation, the magnitude of each elements' amplitude and duration are changed,

[24]Herbert Brün, *A Manual for SAWDUST*, ed. Arun Chandra, http://academic.evergreen.edu/a/arunc/brun/sawdust/sawdust.htm (accessed May 2, 2017).

as determined by its polynomial."[25] The SAWDUST session can then be played back or saved as object data or as an audio file.

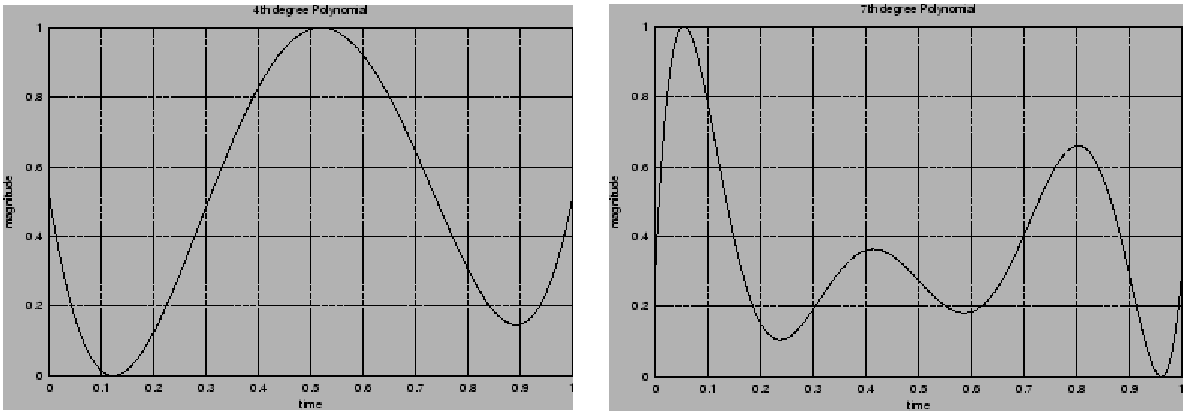
A  B

Figure 5-8. A) Polynomial for vary; B) Polynomial for vary.[26]

Again, a compromise to the anacoustic concept here is the easy calculation of the fundamental frequency of links, thus imposing pitch logic as in Koenig's SSP. SAWDUST, however, escapes the limitations of the fixed-wavetable style of SSP through its transformation processes. Vary computes a new link with each iteration instead of repeating the same wavetable in a loop.

SAWDUST and Anticommunication

Relative to noise as it has been discussed thus far, Brün elucidates an expanded and more nuanced view of the role of noise in the reshaping of language with his concept of *anticommunication*. Anticommunication—Brün's creative ethos—focuses on relationships between disparate systems of communication and forges links between them that instigate transformative periods whereby noise becomes assimilated by pattern. Links can be drawn, for example, at a syntactic or structural level.

Analogy: two systems are guided by one structure.

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[25] Brün, *A Manual for SAWDUST.*.

[26] Ibid.

> To make an analogy: construct a system in relation to another system such that the constructed system points at a structure which both share.[27]

Brün's work *Futility 1964* for electronically generated sound and voice embodies the concept of anticommunication.[28] He presents an austere recitation (by Maryanne Brün) of a self-authored text, fragmented and interleaved with a diversity of electronic textures—broadband, modulating spectra; static chords; filtered noises—that function as composed ruptures into the linguistic continuity. On *Futility*, Brün writes:

> I composed a context of words and sounds in which the sentence "A language gained is a language lost" would have a function that should prevent it from becoming unambiguously communicative, from becoming just words, from getting lost too soon.[29]

The piece exemplifies anticommunication in its unadorned thread of prose, destabilized by its integration into a system that sends electronically generated sounds through a parallel circuit. The syntactic hierarchy of language breaks. As soon as I register and reflect upon what is spoken, I simultaneously experience a different language of sounds that stretch and compress my sense of time and distract my semantic interest in what preceded.

> Anticommunication is an attempt at saying something, not a refusal to say it. Communication is achievable by *learning from* language how to say something. Anticommunication is an attempt at respectfully *teaching* language to say it. It is not to be confused with either noncommunication, where no communication is intended, or with lack of communication, where a message is ignored, has gone astray, or simply is not understood. Anticommunication is most easily observed, and often can have an almost entertaining quality, if well known fragments of a linguistic system are composed into a contextual environment in which they try but fail to mean what they always had meant, and, instead, begin showing traces of integration into another linguistic system, in which, who knows, they might

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[27] Herbert Brün and Mark Enslin, "Traces Left by Ten Dialogues," Herbert Brün: Texts, http://www.herbertbrun.org/BrunTexts.html (accessed May 24, 2017).

[28] Herbert Brün, *language, message, drummage*, EMF CD 00614, 1997.

[29] Brün, *When Music Resists Meaning*, 61.

> one day mean what they never meant before and be communicative again.[30]

Anticommunication describes both an esthesic property and a poietic stance. Noise creates new patterns. New patterns become redundant. Anticommunication poses new configurations, contexts, or vocabularies that gradually acquire new meanings and become communicative. SAWDUST is an extension of anti-communication in the domain of sound design and is potentially conducive to anticommunication at the esthesic level.

Musical practices born out of anticommunication stand in opposition to the commodification of musical styles and technologies, which can short-circuit the processes of invention that are integral to the continued renewal/revival of musical language. In Bateson's cybernetic epistemology, noise is the only source of new patterns. As digital audio technologies become simultaneously more powerful computationally and easier to use (vis-à-vis high-level control structures and graphic interfaces), styles and techniques that may originate in experimental contexts easily become coopted by communicative systems. Sample libraries and loops, virtual instruments, effects plugins, have all condensed a plethora of once specialized techniques into ready-made tools that can be used by anyone with a computer.

The fact that electronic music has splintered into domains that allow non-specialists to follow creative impulse without technology imposing a significant barrier presents a great opportunity for many. Yet, to this end, the most accessible professional tools reinforce the status quo, and are designed to privilege certain popular or well-established functions/processes over others. In order to maintain (or regain, or

[30] Brün, *When Music Resists Meaning*, 63.

discover) creative autonomy, especially toward anticommunicative ends, composers/artists necessarily need to confront the low-level functions of digital processes. This situation has catalyzed many artists to become as equally proficient with computer code as they might be with a piano or paintbrush. SAWDUST establishes an anticommunicative model for working with music technology in its low level address of sound, as digitally encoded, which problematizes sound's ability to exhibit acoustically grounded patterning.

Response to *Dust*

From a contemporary perspective, the work *Dust* (1976) often resembles sound worlds derived from standard synthesis (i.e. electronic sound synthesis with simple waveforms). The step-like, rectangular construction of links in SAWDUST naturally produces wave configurations similar to pulse or square waves—simple waveforms common to table-lookup procedures. The use of pulse waves with time-varying width, for example, is a common synthesis technique called *pulse width modulation*. When combined with amplitude and frequency modulations, one can approximate SAWDUST waveforms with standard synthesis.

The overlap with standard synthesis is particularly evident in the opening of *Dust*, which consists of a monophonic iteration of a four-note sequence, followed by a variation in an elongated, continuous glissando. For Brün, pitch structure may have been an *a priori* consideration and its explicit presentation is antagonistic to an anacoustic conception of this work. Luc Döbereiner asserts, "his sketches reveal that he was constantly linking waveform lengths to tempered pitch scales and even producing twelve-tone rows and chords for the organization of waveforms."[31]

However, as *Dust* progresses in time, its language too evolves. Pitch centrism gives way to more complex and playful spectromorphologies: rapid glissandi to extremes of frequency that correlate speed with register; stereophonic imaging; low frequency timbres that straddle the line between pulse and pitch.

While *Dust* has many compositional points of interest, it is also a testament to the elusive notion of "newness" in sound construction. The ubiquity of electronic sound today has created a normalizing environment in which sounds of electronic origin are not necessarily heard as different or new regardless of new modes of technical construction. Following the quote from Demers in Chapter 3, we inevitably compare sound constructions to what we have heard before, likening the new to the familiar. For instance, I tend to naturally associate the sounds of *Dust* with the "lo-fi" waveforms of 8-bit music and early video games despite the difference between their respective origins. But sound construction is not, on its own, a means to anticommunication. Even if *Dust* no longer contains *new* words in the domain of sound design, it has not decayed into unambiguous communication, challenging still in its combination of sound plus *syntax*.

In a *Computer Music Journal* review, Thomas Blum reinforces this view when he suggests:

> The fact that the SAWDUST software is not capable of producing a tremendous variety of timbres is a restriction that Brün accepted when he adopted the particular synthesis technique. However, it seems obvious

[31] Luc Döbereiner, "Models of Constructed Sound: Nonstandard Synthesis as an Aesthetic Perspective," *Computer Music Journal* 35, no. 3 (2011): 33.

> that the composer's major goal was to compose interesting structures and forms rather than new, unheard of sounds.[32]

From a monotonous beginning, simple waves evolve to reveal multi-dimensional processes of transformation in pitch, rhythm, timbre, and gesture. The four-note theme functions as an elusive point of reference, resurfacing throughout the piece in different guises.

GENDY

Iannis Xenakis is known for his use of mathematics and in particular stochastic processes as compositional tools. Aurally, this is one of the most distinguishing features of his musical output. Stochastic procedures use *distribution functions* that describe a set of probabilities applied to a continuous random input. Stochastics begin from a state of noise or chaos and apply restraints at various levels to create pseudo deterministic patternings. This approach to composition affords novel structural control over sound masses, group behavior, sound aggregates, a perceptual gestalt—in contrast to deterministic serial processes that grow outward from local relationships. In a commentary on the inadequacy of Fourier series construction, Xenakis proposes in early editions of *Formalized Music* from 1971:

> Instead of starting from the unit element concept and its tireless iteration and from the increasing irregular superposition of such iterated unit elements, we can start from a disorder concept and then introduce means that would increase or reduce it.[33]

Relating the activities of Xenakis and Brün, Di Scipio describes a difference in the "cybernetics" of their approaches: "whereas Xenakis's 'mechanism' is stochastic and

[32] Thomas Blum, "Reviews: Project SAWDUST by Herbert Brün," *Computer Music Journal* 3, no. 1 (March, 1979): 7.

[33] Xenakis, *Formalized Music*, 245.

thus essentially non-deterministic, Brün's could be seen as thoroughly deterministic, or even hyper-subjective. … The difference is heard as two distinct universes of sound."[34]

Xenakis's interest in stochastics runs parallel to his refutation of integral serialism, a stance he voiced bluntly in the 1955 article "La crise de la musique sérielle:"

> Linear polyphony is self-destructive in its current complexity. In reality, what one hears is a bunch of notes in various registers. The enormous complexity prevents one from following the tangled lines and its macroscopic effect is one of unreasonable and gratuitous dispersion of sounds over the whole sound spectrum. Consequently, there is a contradiction between the linear polyphonic system and the audible result, which is a surface, a mass.[35]

He later reflects upon his aesthetic turn in *Formalized Music*:

> 'Stochastics' studies and formulates the law of large numbers, which has already been mentioned, the laws of rare events, the different aleatory procedures, etc. As a result of the impasse in serial music, as well as other causes, I originated in 1954 a music constructed from the principle of indeterminism; two years later I named it 'Stochastic Music.' The laws of the calculus of probabilities entered composition through musical necessity.[36]

In the domain of sound synthesis, stochastic processes applied directly to waveform construction represented an alternative to Fourier approaches, which Xenakis referred to as synthesis by finite juxtaposed elements. With dynamic stochastic synthesis, he aimed to move beyond the "lifeless sound made up of a sum of harmonics produced by a frequency generator," and closer to the noisy complexity of transient sound phenomena, including the "second-order" variations in spectral strata that are present even in steady-state parts of acoustic sound. These, he argues, constitute the

[34] Agostino Di Scipio, "Systems of Embers, Dust, and Clouds: Observations after Xenakis and Brün," *Computer Music Journal* 26, No. 1 (Spring, 2002): 25.

[35] Iannis Xenakis, "La crise de la musique sérielle," *Gravesaner Blätter* 1, no. 1 (1955): 2.

[36] Iannis Xenakis, *Formalized Music: Thought and Mathematics in Composition,* revised edition (Stuyvesant, New York: Pendragon Press, 1992), 8.

difference between “lifeless” sounds of standard synthesis and those of orchestral instruments.[37] The 1991 edition of *Formalized Music* features a chapter entitled “Dynamic Stochastic Synthesis,” in which Xenakis fleshes out his concept:

> An attempt at musical synthesis according to this orientation is to begin from a probabilistic wave form (random walk or Brownian movement) constructed from varied distributions in the two dimensions, amplitude and time (a, t), all while injecting periodicities in t and symmetries in a. If the symmetries and periodicities are weak or infrequent, we will obtain something close to white noise. On the other hand, the more numerous and complex (rich) the symmetries and periodicities are, the closer the resulting music will resemble a simple held note. Following these principles, the whole gamut of music past and to come can be approached. Furthermore, the relationship between the macroscopic or microscopic levels of these injections plays a fundamental role.[38]

Xenakis first experimented with the application of stochastic processes to waveform construction at the University of Indiana in the 1970s and returned to this project in 1991 at the *Centre d’Etudes de Mathématique et Automatique Musicales* (CEMAMu), Paris, where he wrote the computer program, *GENDY* (GÉNération DYnamique).

GENDY Technical Details

In GENDY, an initial waveform is specified and repeated. With each repetition, it is distorted in both time and amplitude according to a stochastic algorithm. To achieve this, the waveform is first polygonized—divided into several segments—which are identified by the coordinates of their endpoints.[39]

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[37] Xenakis, *Formalized Music*, 244.

[38] Ibid., 289.

[39] Marie-Hélène Serra, “Stochastic Composition and Stochastic Timbre: *GENDY3* by Iannis Xenakis,” *Perspectives of New Music* 31, no. 1 (1993): 241.

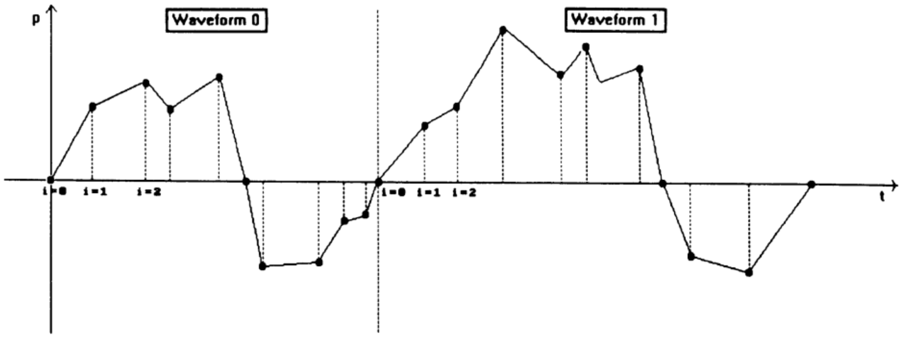

Figure 5-9. GENDY polygonized waveforms with ten segments.[40]

Because the x and y-coordinates of each endpoint vary, the waveform period is distorted in both shape and length, giving rise to amplitude, timbre, and frequency variations in the sound.[41]

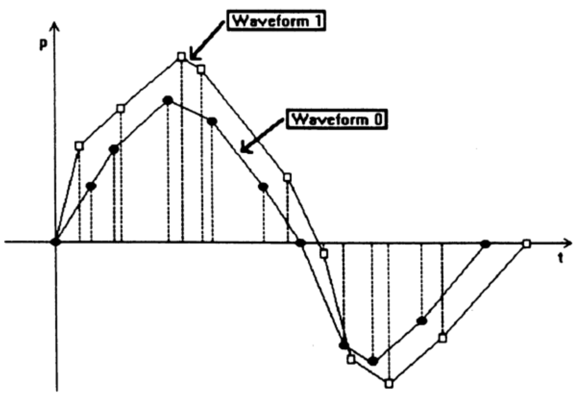

Figure 5-10. GENDY amplitude and time distortion.[42]

The synthesis algorithm takes into account the limitations of the digital audio system by imposing restrictions on the amount of stochastic variation using a mirror process. The mirror forces stochastic values in time and amplitude to remain within predefined intervals, thus countering the potential to exceed viable values for the

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[40] Serra, “Stochastic Composition,” 241.

[41] Ibid., 243.

[42] Ibid., 244.

computer (like amplitude values greater than one or wave periods shorter than the Nyquist frequency). Serra explains:

> The function MIR behaves as a pair of optical mirrors and reflects input values that exceed the barrier amplitudes back into the barrier range. There are as many reflections as needed, so that the output value stands between the barriers.[43]

The elastic barriers of each wave cycle allow Xenakis to control the degree of regularity versus randomness of the waveform shape, thus creating a spectral continuum from static pitch (high degree of periodicity and symmetry) to noise (low periodicity and symmetry). GENDY represents an approach to waveform construction, from conception to creation, with a focus on the relationship between waveform patterns and their spectral correlates.

The Materiality of Informatics

Xenakis saw in dynamic stochastic synthesis an avenue not toward simulation of acoustic sounds, but toward simulation of the acoustic condition. Serra suggests that “his primary intention is to (re)create the variety, richness, the vitality, and the energy that make sounds interesting in music.”[44] The assertion that transient states can be effectively simulated as stochastic variations in the time-pressure curve amounts to an experimental syntax carrying an anticommunicative vocabulary of sounds. One system *abstracted* from the visual waveform patterns of acoustic sound integrated with the system of nonstandard synthesis.

Ultimately, while it is true that acoustically derived waveforms exhibit patterning in periodicities and symmetries, the noise that affects said patterns in the material world

[43] Serra, “Stochastic Composition,” 245.

[44] Ibid., 239.

resists the normalizing tendencies of inscription practices. Encoded origins in nonstandard synthesis (digital inscription) reveal the inherent limitations of digital audio encoding as a site for sound construction as they fail to faithfully approximate the multi-dimensionality of sound in the physical world. Acoustic noise (transients, space, etc.), antagonistic to pattern, reflects the complexity of context bound, material circumstances. This dynamic is described by Hayles as an exchange between *inscription* and *incorporation*: one of two polarized relations that together articulate the dynamics of posthuman dematerialization:

> The first polarity unfolds as an interplay between the body as a cultural construct and the experiences of embodiment that individual people within a culture feel and articulate. The second polarity can be understood as a dance between inscribing and incorporating practices.[45]

In this analysis, body/embodiment and inscription/incorporation forge connections between ideologies of immateriality and the material conditions that enable such ideologies.

The body as a cultural construct differs from embodiment in that it is always normative relative to certain criteria. Meanwhile, embodiment never exactly coincides with "the body" because it is contextual, "enmeshed within the specifics of place, time, physiology, and culture, which together compose enactment."[46] Hayles elaborates further:

> Whereas the body is an idealized form that gestures toward a Platonic reality, embodiment is the specific instantiation generated from the noise of difference. Relative to the body, embodiment is other and elsewhere, at

[45] Hayles, *How We Became Posthuman*, 193.

[46] Ibid., 196.

once excessive and deficient in its infinite variations, particularities, and abnormalities.[47]

Inscription and incorporation are concerned with writing and action respectively. "Like the body, inscription is normalized and abstract, in the sense that it is usually considered as a system of signs operating independently of any particular manifestation."[48] An incorporating practice, on the other hand, cannot be separated from its material instantiation and exists only in a particular embodied circumstance: I move my hand, I move my wireless mouse, delete some text and return to the keyboard, translating my incorporation into a reduced account in prose. My hands and mouse and keyboard are specific to here and now, and to you they are transformed through symbolic language.

Inscription and incorporation along with the body and embodiment inform and modify each other in a recursive feedback loop. "Incorporating practices perform the bodily content; inscribing practices correct and modulate the performance."[49]

Consider how various music technologies (kinds of inscription) have affected musical performance (incorporation) and have been subsequently modified according to concerns that emerge from the live scenario (body). As predicted by Gould in "The Prospects of Recording," the studio recording has rivaled if not superseded the live performance as the authentic representation of a work.[50] As a consequence, live performance has adapted many techniques that originated in the studio to present

[47] Hayles, *How We Became Posthuman*, 196-7.

[48] Ibid., 198.

[49] Ibid., 200.

[50] Glenn Gould, "The Prospects of Recording," in *Audio Culture: Readings in Modern Music*, edited by Christoph Cox and Daniel Warner (New York: Continuum, 2009), 115-126.

hyper-real sound images in concert: enhanced monitoring and live processing, precomposed materials, real-time loop creation and manipulation, auto-tune and other corrective distortions, etc. Sound controllers and digitally integrated instruments have, in turn, become more and more responsive to bodily input as “real-time” systems. These tendencies bring instruments and bodies closer to acousmatic disembodiment as material/machine hybrids.

The inscription/incorporation and body/embodiment polarities manifest in the domain of sound in a number of ways:

1. Inscription: 24-bit words, grooves on a vinyl record, standard music notation …

2. Incorporation: what you are hearing now, playing guitar in your bedroom, projecting sound into a space via loudspeakers …

3. Body: Fletcher-Munson curve, Fourier series, equal temperament, Shannon-Nyquist Theorem, physical models …

4. Embodiment: Transients, reflections, localization (Hass effect), infra & ultra sonic content, ambient or environmental “noise” …

While all sound constructions and reproductions are forms of inscription, different approaches to the medium articulate certain orientations related to body/embodiment and inscription/incorporation. Standard synthesis relates to the body and is constructed out of abstractions of our physical mechanism of hearing or the physics of sound, while nonstandard synthesis arises from the mechanics of inscription in the digital domain.

GENDY takes as a point of departure the characteristics of time domain sound inscriptions that are translations of physical circumstances—acoustic phenomena that carry an inextricable link to the “noise of difference” out of which they emerge through incorporation. GENDY underscores the interplay between incorporating practices and the inscriptions that abstract the practices into signs.[51] Xenakis saw dynamic stochastic synthesis as a channel toward embodied complexity, hence his posthuman suggestion that "following these principles, the whole gamut of music past and to come can be approached."[52] But the complexity of the acoustic as a physical, summative phenomenon can only be approximated at best through non-parametric synthesis models, which relinquish perceptually meaningful controls.

In acoustic recording, the digital means of abstraction are secondary to the surface representations it manifests. When Xenakis foregrounds inscription, the particularities of incorporation that characterize acoustic recording tend to fade from view, obfuscated by artifacts that arise from the inscriptive mechanics.

Response to *Gendy3*

> There are paths that can be seen or heard with high entropy, without any coherence, which is a good thing, because there must remain always a small color of mystery, of not understanding, in every piece of art."[53]

Gendy3 (1991) is complex, dense, ritualistic, and musical. Typical of Xenakis's work is an affective integration of mathematical logic with dramatic intensity. Composer Roger Reynolds writes, "notable in his way and work is an improbable equipoise between the sternly rational and the flagrantly emotional."[54]

Microtonal harmonic configurations of sustained tones, unwieldy continuous pitch lines, colors of noise, abrupt textural shifts; sounds at times resemble brass or

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[51] Hayles, *How We Became Posthuman*, 199.

[52] Xenakis, *Formalized Music,* 289.

[53] Iannis Xenakis, "A Conversation," in *Aïs – Gendy3 – Taurhiphanie – Thalleïn* by Iannis Xenakis, NEUMA 450-86, CD booklet, 1994.

[54] Roger Reynolds, "Sublime Extremes," in *Aïs – Gendy3 – Taurhiphanie – Thalleïn* by Iannis Xenakis, NEUMA 450-86, CD booklet, 1994.

woodwind instruments and are orchestrated in an ensemble-like fashion. *Gendy3* appears intuitively calculated in its musical combinations. Despite the omnipresence of noisy strata, harmony, even if abstruse, maintains a central role. Peter Hoffman points out that Xenakis made sketches for *Gendy3* correlating GENDY parameters with discrete or approximate pitches.[55]

Both the micro and macro-structures of *Gendy3* were stochastically generated, but by different stochastic principles. Of the macro-structure, Xenakis explains:

> The overall form is mosaic-like, based on the superimposition of several "routes," or stochastically determined successions of fields. Each field in the several layers may be silent or not. The composer intends to create an interesting musical composition by what is, objectively, an arbitrary chain of these field sequences.[56]

Serra elaborates:

> *Gendy3* is a series of juxtaposed sections (time axis) in which we can find a different number of voices (vertical axis). … A voice-configuration is defined by the number of voices that play, the distribution of the voices on the vertical axis, and the assignment of a set of synthesis parameters to each voice.[57]

The presence of a given voice in the time-field is specified by a weighted probability to determine sound or silence, simulating a Bernoulli trial—the general name for random experiments with only two possible outcomes, success or failure. The durations of events in the time-field are automatically computed with an exponential distribution function. The result is a kind of rhythmically irregular ostinato over which different synthetic layers engage in a stilted counterpoint.

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[55] Hoffmann, Peter. "Something Rich and Strange: Exploring the Pitch Structure of *GENDY3*." *Journal of New Music Research* 33, No. 2 (2004): 139.

[56] Iannis Xenakis, *Aïs – Gendy3 – Taurhiphanie – Thalleïn* by Iannis Xenakis, NEUMA 450-86, CD booklet, 1994.

[57] Serra, "Stochastic Composition," 253.

Despite its generation via nonstandard synthesis, *Gendy3* fits comfortably within Xenakis's larger catalogue of both instrumental and electronic compositions—reflective of both his formal style and microtonal pitch language. *Gendy3* represents a natural extension of the composer's multifarious syntheses of mathematics and music.

Musica Iconologos

Yasunao Tone's first CD project, *Musica Iconologos* (1993), presents an idiosyncratic implementation of nonstandard synthesis that reconfigures audification into a noise incurring process. Tone writes:

> The original source material of the piece was a poetic text from ancient China. I converted the text's Chinese characters into appropriate photographic images from which the Chinese characters were derived by studying their ancient pictographic forms, which are closer to images than are their modern forms. I scanned the images into the computer and digitized them, converting them to binary code (simple 0s and 1s). I then obtained histograms from the binary code and had the computer read the histograms as sound waves; thus I obtained sound from the images. Therefore, I used visualized text (images) as the source—that is, the message—which after encoding was recorded on a CD. Now, when playing the CD, what is received are not images as message, but sound that is simply an excess. According to information theory the resultant sound is nothing other than noise. As the French word for (static) noise, *parasite*, indicates, noise is parasitic on its host, that is, the message. But in this case there is no host, only a parasite on the CD. Therefore, this CD is pure noise. Technically speaking, the sound of the CD is digital noise.[58]

Tone's approach to nonstandard synthesis is unique compared to others because it is not an attempt to formalize waveform construction. Tone demonstrates instead how synthesis can be driven entirely by chance or indeterminate procedures via an anacoustic modality. Echoing Moholy-Nagy's push for technologies of reproduction to be used for new modes of production, Tone explains, "I had to create something totally devoid of live performance, something that only the CD as a medium could

[58] Yasunao Tone, "John Cage and Recording," *Leonardo Music Journal* 13 (2003): 12.

produce."[59] His activity was not a reaction against standard synthesis or Fourier-based paradigms, but against the ubiquity of the medium of the compact disc to be used for representation (i.e. acoustic recordings, or digital simulations).

Musica Iconologos (or *MI)* carries Tone's artistic signature in its clear ties to Fluxus art. Fluxus artists, influenced largely by John Cage, cultivated an "anti-art" aesthetic by challenging traditional divisions between artist and audience, music and noise. Much of Tone's work involves the misuse of systems, perhaps to reveal the ideologies inherent in a given technology, or to inject noise into a system with the goal of catalyzing emergent properties. Koenig, Brün, and Xenakis knew well the design principles and limitations of the digital audio system and formulated their approaches based on mathematical and mechanical premises. Tone, through casually anticommunicative gestures, reveals a methodological orientation that ignores technique, concentrates on process, and embraces improvisation (as a combination of indeterminacy with subjective decision making). This is manifest in *MI* as an arbitrarily complex chain of data conversion.

Musica Iconologos Technical Details

Musica Iconologos consists of two tracks, *Jiao Liao Fruits* and *Solar Eclipse in October*. Below is an image of the ancient Chinese text from *Solar Eclipse in October* superimposed over its corresponding pictographic images. The source of the text is the *Shih Ching*, the earliest Chinese anthology.[60] After the images were digitized (scanned into a computer), Tone, with the help of engineer Craig Kendall, analyzed each image utilizing functions from *Optical Music Recognition* (OMR) software that was in

[59] Tone, "John Cage and Recording," 12.

[60] Yasunao Tone, *Musica Iconologos,* Lovely Music, Ltd. LCD 3041, CD, 1993.

development at McGill University. OMR collects projection data by analyzing an image as a two-dimensional matrix of pixels, scanning through x- and y-axes to detect the presence of black or white. It then generates a histogram of the projection data for each axis as seen below in figure 5-12.

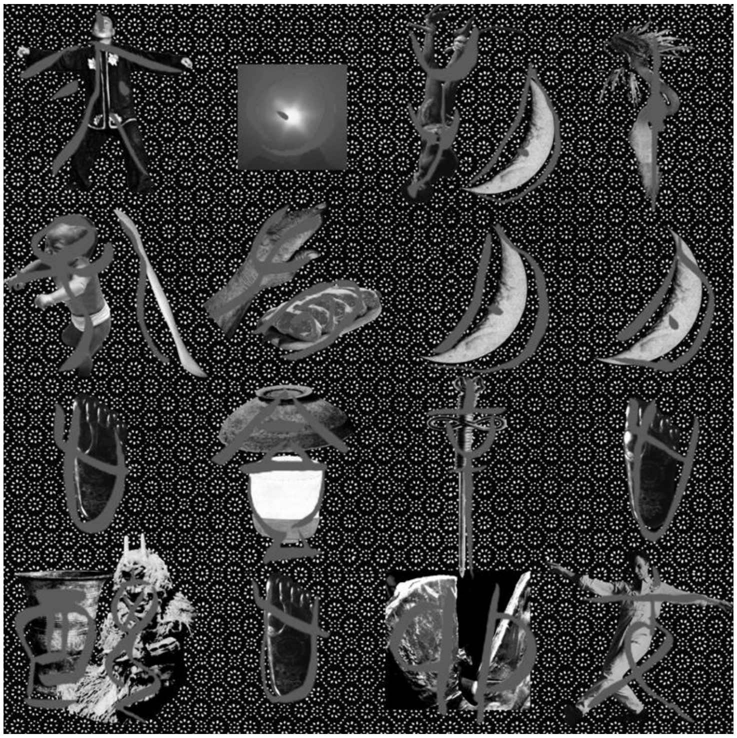

Figure 5-11. Solar Eclipse in October.[61]

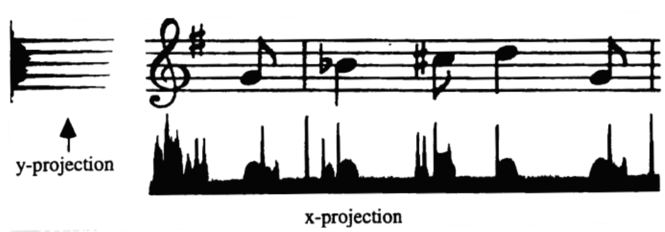

Figure 5-12. X/Y projection data from OMR software.[62]

[61] Yasunao Tone, *Noise Media Language* (New York: Errant Bodies Press, 2007), 36. Cited in text as Solar Eclipse in October, Group show, Ear as Eye: Drawings by Sound Artists, Los Angeles Contemporary Space Exhibition, Los Angeles, CA, Feb. 27 - Mar. 23, 1997.

[62] Ichiro Fujinaga, "Adaptive Optical Music Recognition," PhD Dissertation, McGill University, 1997.

Waveforms were then constructed with the C language program *Projector* based on combinations of the X and Y projection data, such as X+Y, X-Y, Y-X, and X*Y.[63] Such combinations represent, in my understanding, collections of binary words—bits (zero or one) being correlated to pixels (white or black).

The resulting 187 sounds – each derived from a single image, averaged only about 20 milliseconds each in duration. Kendall's task as digital editor was to "uncover and shape the larger sounds that lay within each short 20 ms burst."[64] He used common digital signal processes like time stretching and pitch shifting to reflect the time span and phonetic inflections of the corresponding words from the text. These last steps, presumably overseen by Tone, are another kind of acoustic salvage – the anacoustic origins of the source sounds rendered them unviable (by human standards) for music composition because of their inhuman timespan.

Kendall asserts that "Tone always remained true to the poem's structure regardless of his personal impressions of the music."[65] The form of *Musica Iconologos*—its continuity as a string of isolated sound events drawn, like words, from a finite vocabulary—is its one remaining tangible connection to the *Shih Ching*.

Signifying Noise. I return now to Tone's description of the work that, "according to information theory[,] the resultant sound is nothing other than noise," and propose a reorientation of his concept of *noise* because of the previously discussed limitations of MTC relative to meaning. Shannon's information theory is most effectively applied to the transmission of signals via communication channels, as in the analog-to-digital

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[63] Yasunao Tone, *Musica Iconologos*, CD booklet.

[64] Ibid.

[65] Ibid.

audio conversion and the Shannon-Nyquist Sampling Theorem. The sampling theorem actually describes how noise can effectively be suppressed in the conversion given a band-limited signal. In MTC terms, noise alters a transmitted signal in some way so that the received message is not the same as what was originally transmitted. Noise can interfere in digital audio if, for example, a signal contains frequencies above the Nyquist frequency. These frequencies are misinterpreted, folding back below the Nyquist frequency to produce artifacts called *aliasing*. Another form of digital audio noise is q*uantization error*, the difference between an input value and its quantized value (the resolution of which is determined by the bit depth).

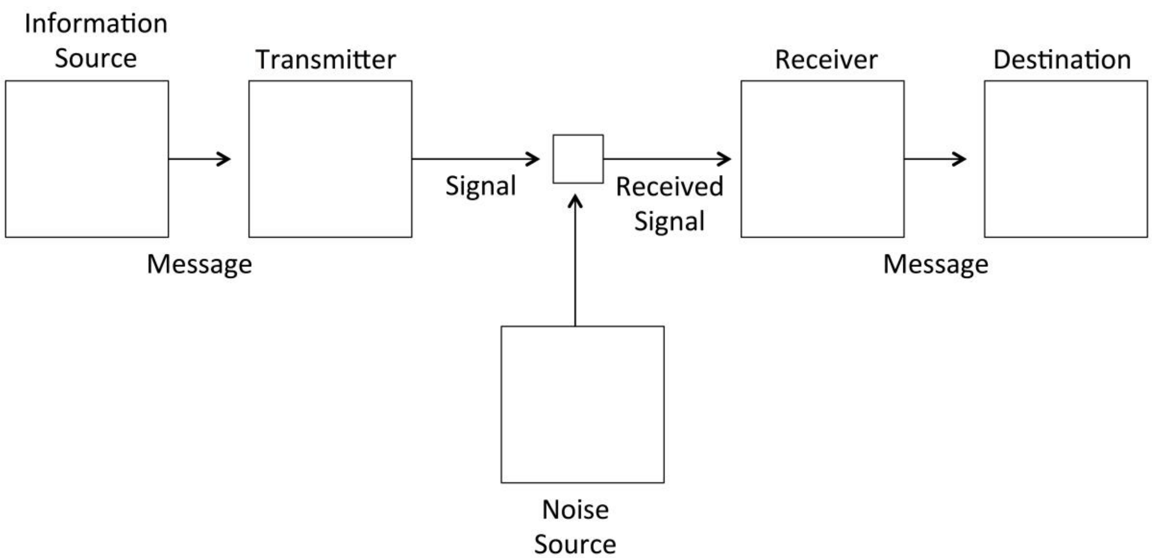

Figure 5-13. Shannon's general communication system.[66]

Technically speaking, *Musica Iconologos*, as a digital audio production, is virtually noiseless. It does not explore computer error via artifacts, which constitute the noise that would properly be defined by MTC. There is nothing that interferes with the

[66] Claude Shannon, "A Mathematical Theory of Communication." *Mobile Computing and Communications Review* 5, no. 1 (January 2001): 4.

transmission of the message (digital audio samples) and its reception via loudspeakers, provided your sound system works properly.

Another limitation of MTC as a poietic metaphor is its inability, as discussed previously, to encompass the subjectivity of the observer in relation to communication systems. If a message is received objectively intact, there is still no guarantee that its meaning is received as intended by a sender. This is why MTC is predicated on objective quantities – and noise measured by quantitative difference (it is, after all, a mathematical theory!). But from the developments following first order cybernetics (which increasingly expanded the conception of information systems and their relationships) and Bateson's cybernetic epistemology, we understand the larger implications of noise in its relation/opposition to pattern—patterns which arise from our perceptual and cognitive existence. *Musica Iconologos* is noisy in multiple dimensions when considered in light of well-established patterns of sound recording, synthesis, and composition.

Flickering Signifiers

Musica Iconologos is anticommunicative in the way that it channels and integrates fragments of language into a new system in which they fail to mean what they once meant. Traditionally communicative systems are transformed via their digital deconstruction and integration—the communication of poetry (language), image, and sound.

The relation between the visual, text based source and the sounding result draws attention to the dissonance between them and the noise incurred at each step of the compositional process. I relate the poiesis of *MI* to the altered mode of signification that underlies the operation of information and communication technologies, what Hayles describes as *flickering* signification. Flickering signifiers are characterized, "by their tendency toward unexpected metamorphoses, attenuations, and dispersions."[67]

> Information technologies operate within a realm in which the signifier is opened to a rich internal play of difference. In informatics, the signifier can no longer be understood as a single marker, for example an ink mark on a page. Rather it exists as a flexible chain of markers bound together by the arbitrary relations specified by the relevant codes. … A signifier on one level becomes a signified on the next-higher level. Precisely because the relation between signifier and signified at each of these levels is arbitrary, it can be changed with a single global command.[68]

Flickering signifiers expose the undercurrent of abstraction and transformation beneath representations in the virtual stimuli we (as posthumans) experience daily. Take as an example the analog-to-digital audio conversion. When an analog signal is sampled and converted to an abstract code, a sequence of binary words, it becomes susceptible to dramatic transformations in a chain of flickering signification. On screen, these binary words might be correlated with an amplitude contour in a time-domain visualization, which may correlate, in turn, to higher-level instructions determining how these values are to be manipulated, and so forth. Think of the high level "parametricity" in standard synthesis programs like MUSIC V or CSOUND, or to an even greater degree, DAWs such as Logic and Live.

Although flickering signifiers specifically apply to information and communication technologies in *How We Became Posthuman*, I view *Musica Iconologos* as an extension of this computational dynamic to compositional method. *MI* exploits the arbitrary relation between signifiers and signifieds in information technologies (flickering

[67] Hayles, *How We Became Posthuman*, 30.

[68] Ibid., 31.

signifiers) by intentionally foregrounding the disparity between an information source, its encoded form(s), and its (re-)embodiment in sound.

Post-Digital

> The problem of the schism between music and noise in the twentieth century clearly illustrates the mobility of interpretants that separate "musical" from "nonmusical."[69]

Post digital has been a term used by Kim Cascone and Ian Andrews since the beginning of the 21st century to describe an aesthetic that rejects the centrality of high fidelity and transparency in digital audio production. In the words of Andrews, "the familiar digital tropes of purity, pristine sound and images and perfect copies are abandoned in favour of errors, glitches and artefacts."[70] Post digital sub-genres including glitch and microsound are all "concerned with the foregrounding of the flaws inherent in digital processes."[71]

Cascone, in "The Aesthetics of Failure," traces the beginnings of post-digital practices to the early 1990s when artists following the wave of techno and electronica began to draw inspiration from modernist masters and electroacoustic pioneers.[72] He claims the Italian Futurists and John Cage as precursors for their disruption of the traditional musical frame: the Futurists' embrace of industrial noise, and Cage's use of incidental noise, error, and imperfection.

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[69] Jean-Jaques Nattiez, *Music and Discourse: Toward a Semiology of Music*, 54.

[70] Ian Andrews, "Post-digital Aesthetics and the return to Modernism." Ian Andrews. http://www.ian-andrews.org/texts/postdig.html (accessed May 15, 2017).

[71] Andrews, "Post-digital Aesthetics."

[72] Kim Cascone, "The Aesthetics of Failure: *Post-Digital* Tendencies in Contemporary Computer Music." In *Audio Culture: Readings in Modern Music*, ed. Christoph Cox and Daniel Warner (New York: Continuum, 2009), 395. Cascone claims "Once the door was opened to exploring the history of electronic music, invoking its more notable composers came into vogue. A handful of DJs and composers of electronica were suddenly familiar with the work of Karlheinz Stockhausen, Morton Subotnick, and John Cage, and their influence helped spawn the glitch movement."

Many works by Yasunao Tone, while steeped in a Fluxus aesthetic, are post-digital through their exploitation of digital errors. Tone began experimenting with CDs in the mid 1980s, manipulating CD information and error-correction algorithms in CD players. By affixing bits of tape with strategically placed pinholes on a CD surface, Tone blocked bits of information to be decoded for playback, thus generating unpredictable misreadings. In a discussion with the editors of *Music* magazine, he explains:

> The scotch tape enables me to make burst errors without significantly affecting the system and stopping the machine. The error-correcting software constantly interpolates between individual bits of misread information, but if adjacent bits are misread, a burst occurs and the software mutes the output. If a significant number of bursts occur in one frame, the error increases until it eventually overrides the system.[73]

The manipulation of the CD medium is a tangible echo of Maholy Nagy's call for new modes of production, but the medium of the CD (and the flickering signifiers of digital audio) transforms the nature of this anticommunicative gesture. If you scratch analog recordings you can predict what kind of sound will result, while altering bits on a CD is much less predictable.[74]

Tone's *Wounded CD* projects are closely related to anacoustic modes of sound construction through their generative strategy of distorting binary words that otherwise carry predetermined audio content. The materiality of the digital system is manipulated to affect its low-level informational processes. Post-digital musics such as *Wounded CD* are more congruous with the noise of MTC as they harness the technical detritus of

[73] Christian Marclay and Yasunao Tone, "Record, CD, Analog, Digital," in *Audio Culture: Readings in Modern Music*, edited by Christoph Cox and Daniel Warner (New York: Continuum, 2009), 342.

[74] Artist Christian Marclay has, since the 1970s, explored the creative use of turntables and vinyl records for production as opposed to reproduction.

digital audio by forcing the failure of the system. *Noise* is not seen as destructive interference but as generative affordance, reflecting the cybernetic pattern/noise configuration post first wave cybernetics.[75]

> Identifying information with *both* pattern and randomness proved to be a powerful paradox, leading to the realization that in some instances, an infusion of noise into a system can cause it to reorganize at a higher level of complexity. Within such a system, pattern and randomness are bound together in a complex dialectic that makes them not so much opposites as complements or supplements to one another. Each helps to define the other; each contributes to the flow of information through the system.[76]

But not all examples of post-digital music bear such clear ties to anacoustic modes or to noise. The digital artifacts used by many post-digital artists no longer function as noise in an MTC sense when they coalesce into musically communicative aggregates based on regular meters and repetition, harkening both to minimalism and electronic dance music. The message material changes with the syntax. Demers describes:

> Regular rhythm … exerts a nearly irresistible pull on the material, making what seemed abstract and inscrutable sound, ironically, musical. And musical sound, as Scruton states it, encourages perhaps the only practicable type of reduced listening: since we know that what we are listening to *is music,* we cease to attend to its source-causes.[77]

Used in a musically explicit way, the noise of MTC no longer signifies failure, but operates within a communicative system that is explicitly patterned from a formal perspective. This brings into question the degree to which some post-digital music is related to failure apart from the surface level integration of digital artifacts. Tone is

[75] Whereas first wave focused on homeostasis, second and third wave focused on concepts of reflexivity and autopoiesis respectively, which broadened the scope of cybernetic epistemology to include the observer and the evolution of systems in new directions.

[76] Hayles, *How We Became Posthuman*, 25.

[77] Demers, *Listening through the Noise*, 87.

unique because an aesthetic of failure is inherent in the methodology behind wounded CD. It is curious that he is not typically part of the "post-digital" discourse (following Cascone and Andrews) as I have situated him here.

Cascone has come to acknowledge the assimilation (a decade later) of the glitch aesthetic by commercial software and mainstream music, rendering its initial significance as counter-cultural statement disingenuous at best in current uses. Cascone has even inverted his original title, the Aesthetics of Failure, to describe what he now perceives as a "Failure of Aesthetics."[78] Nicolas Collins laments: "By 2000 the CD-derived glitch aesthetic had become so widespread as to feature on a Madonna album."[79]

Dataphonics

Ryoji Ikeda is known for using raw digital timbres, extreme registers, and polarizing textural contrast. According to his website biography:

> Ikeda focuses on the essential characteristics of sound itself and that of visuals as light by means of both mathematical precision and mathematical aesthetics. … He elaborately orchestrates sound, visuals, materials, physical phenomena and mathematical notions into immersive live performances and installations.[80]

Ikeda's post-digital tendencies of repetition and regularity may encourage the "reduced listening" described by Demers, his idiosyncratic use of nonstandard synthesis in *dataphonics* represents an attempt to portray/express data as an inherently substantial entity with extrinsic significance.

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[78] Kim Cascone, "The Failure of Aesthetics," Piemonte Share, https://vimeo.com/17082963 (accessed December 3, 2017).

[79] Nicolas Collins, "Hacking the CD Player," Nicolas Collins: Texts, Website, 2009, http://www.nicolascollins.com/texts/cdhacking.pdf (accessed July 16, 2017), 5.

[80] Ryoji Ikeda, "Ryoji Ikeda," http://www.ryojiikeda.com/biography/ (accessed October 29, 2017).

Drawing parallels with audification, *dataphonics* exemplifies an anacoustic mode in which "non-audio" data is converted to waveforms. But rather than salvaging communicative content from data sources, Ikeda elicits symbolic value from the self-conscious use of data as a reified entity with flickering potentialities.

> *dataphonics* (2006-07) … focuses on the relationship between the sound of data and the data of sound. It spans various formats – multi-channel sound performance, radio broadcasts and audio/data research. … Various non-audio data were converted forcefully to audio data, which became the materials from which the tracks were composed. … *dataphonics* forms part of *datamatics*, an ongoing project by Ryoji Ikeda since 2006, in which he explores the potential to perceive the invisible multi-substance of data that permeates our world through audiovisual concerts, installations, CDs and publications.[81]

Figure 5-14 shows a sequence of waveforms with corresponding binary data arranged in pixel matrices, which I generated following Ikeda's process of data conversion using the software Max. The bit sequence at each sample of the waveform is mapped to a matrix (1=black, 0=white). The figure recalls jodi.org in its juxtaposition of different manifestations of common, coded sources. The book *dataphonics* includes an audio CD and an accompanying timeline of the visual binary reduction of the music. As summarized on the book's back cover:

> [*dataphonics*] is a highly physical auditory response to the ever-present binary numerical system of today's digital age, ultimately seeking to materialize the invisible domain of 'totally-pure-digital-data.' This book and audio CD include the mathematical and graphical examinations of the fundamental binary reduction/representation of sound waveforms, and 10 audio tracks composed from non-audio data as their elemental materials.[82]

[81] Ryoji Ikeda, *dataphonics* (Paris: Éditions Dis Voir, 2010).

[82] Ibid.

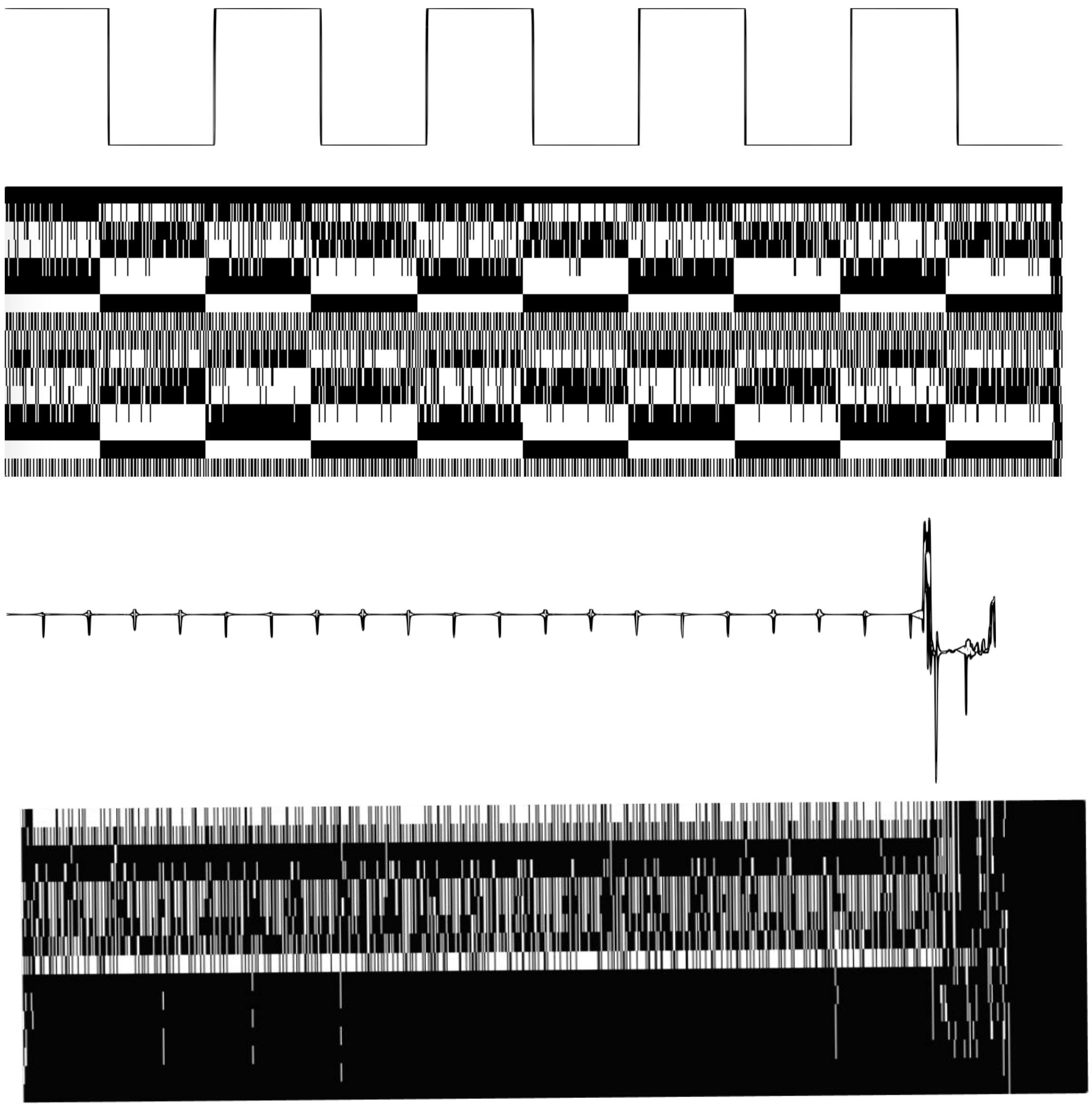

Figure 5-14. binary conversion of waveform in the style of *dataphonics*.[83] A) waveform 1, B) binary reduction 1, C) waveform 2, D) binary reduction 2.

Ikeda harnesses these digital fragments by formal continuities marked by unmetered pulse and monolithic drones. Textures are built slowly with a minimalist touch, layer by layer. The surface continuity is sometimes punctured by jagged sequences. When repetition dominates, the listener becomes aware of micro-variations

[83] Ryoji Ikeda, "binary conversion of sound waveform," in *dataphonics* (Paris: Éditions Dis Voir, 2010).

in the sonic texture. Listening to *dataphonics* as a kind of portrait of the flux of information, it is at times ironically organic in its evocation of homogenous microcosms of sonic activity as in the surface of rippling water. At other times, the listener enters an anechoic space where sharply delineated streams of signal are activated or short-circuited. With broadband orchestrations that approach the edge of the audible range of frequencies and pulses on the verge of audio rate fusion, Ikeda gives the impression of a system of inhuman proportions: one that is barely aware of our perceptual finitude while it still appeals to basic musical sensibility.

In general, the *datamatics* project feels distant from material origins as Ikeda paints a picture (via audio and visuals) of a stylized scape of MTC-style channels of flowing information. By doing so he effectively capitalizes on the posthuman notion of information as a reified entity permeating our material and social existence. More so than the aforementioned composers, Ikeda appeals to cultural formulations of the posthuman immaterial in *datamatics* in a way similar to how writers such as Phillip K. Dick expressed the feeling of the cybernetic paradigm in science-fiction—the “emotions and deep unconscious responses it would unleash.”[84]

A constant and perfect pulse is inhuman; a marker of the machine vis a vis tireless precision. The computer’s operation is one of discrete time intervals—at a rate and constancy far beyond our perceptual and physical limits. What are our imaginings of this abstract, immaterial zone? What are the metaphors we use to make it tangible? Pure, simple geometries, straight lines, perfect grids, matrices, symmetries …

---

[84] Hayles, “Ten Years On,” 321.

> "Information" and "form" resemble contrast, frequency, symmetry, correspondence, congruence, conformity, and the like in being of zero dimensions and, therefore, are not to be located.[85]

dataphonics presents a simple order. The "noises" that comprise the musical surface collectively amount to a form that is virtually *noiseless* as in a mathematical proof, a perfect circle, or a sine function. Ikeda's work shows the degree to which certain creative expressions of a computational universe have become communicative. *dataphonics* demonstrates an anticommunicative mode of sound construction within a communicative syntax, resulting in an affective but somewhat obvious play on informational tropes. Instances of *dataplex* and google image searches of the terms "virtual" and "cyberspace" (Figures 5-15 through 5-18) both portray human figures embedded in channels of code.

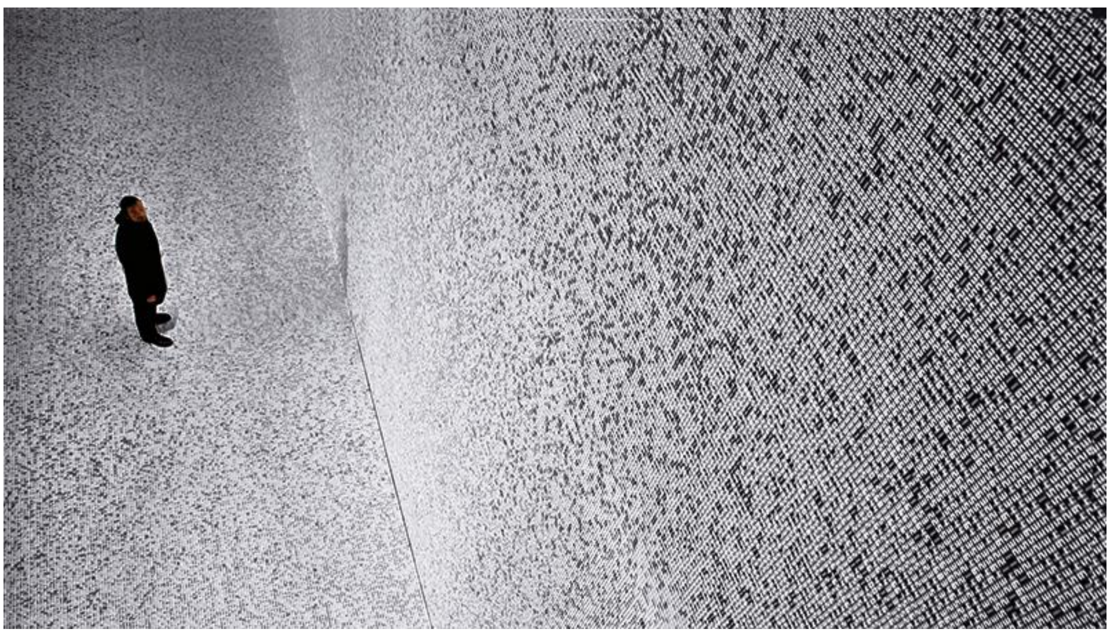

Figure 5-15. *data.tron* (2008-9).[86]

[85] Bateson, *Steps to an Ecology of Mind*, 414.

[86] Ryoji Ikeda, "data.tron," datamatics, http://www.ryojiikeda.com/project/datamatics/ (accessed November 2, 2017). Photo by Liz Hingly. Reprinted by permission from Ryoji Ikeda.

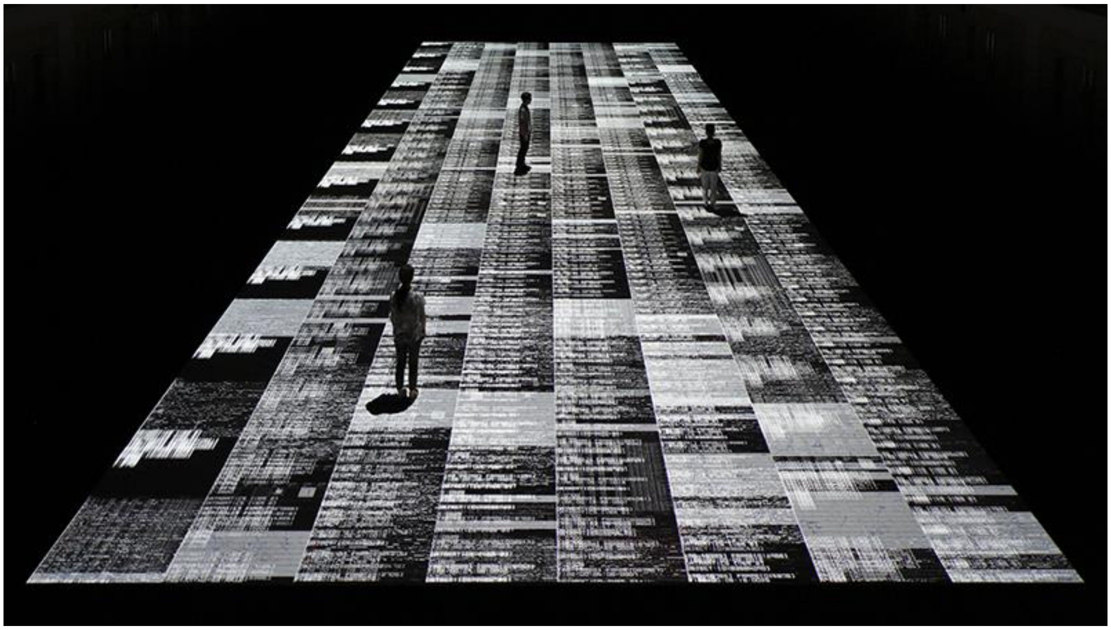

Figure 5-16. *data.tecture* (2015).[87]

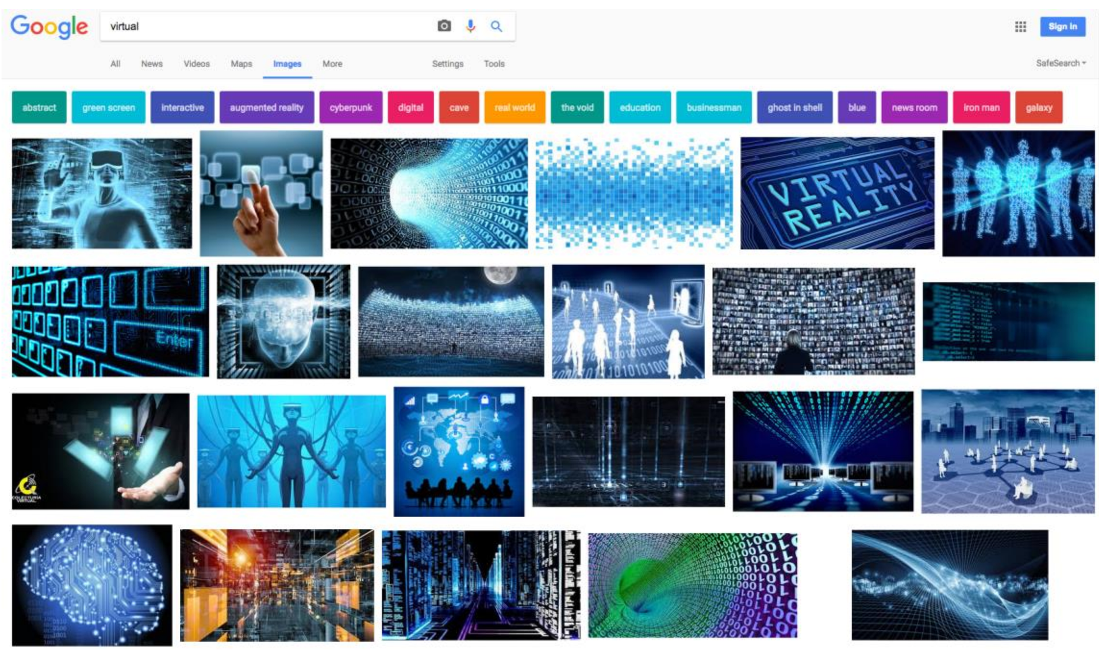

Figure 5-17. Google image search for "virtual."[88]

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[87] Ryoji Ikeda, "data.tecture," datamatics, http://www.ryojiikeda.com/project/datamatics/ (accessed November 2, 2017). Photo by Keizo Kioku, courtesy of Dojima River Forum. Reprinted by permission from Ryoji Ikeda.

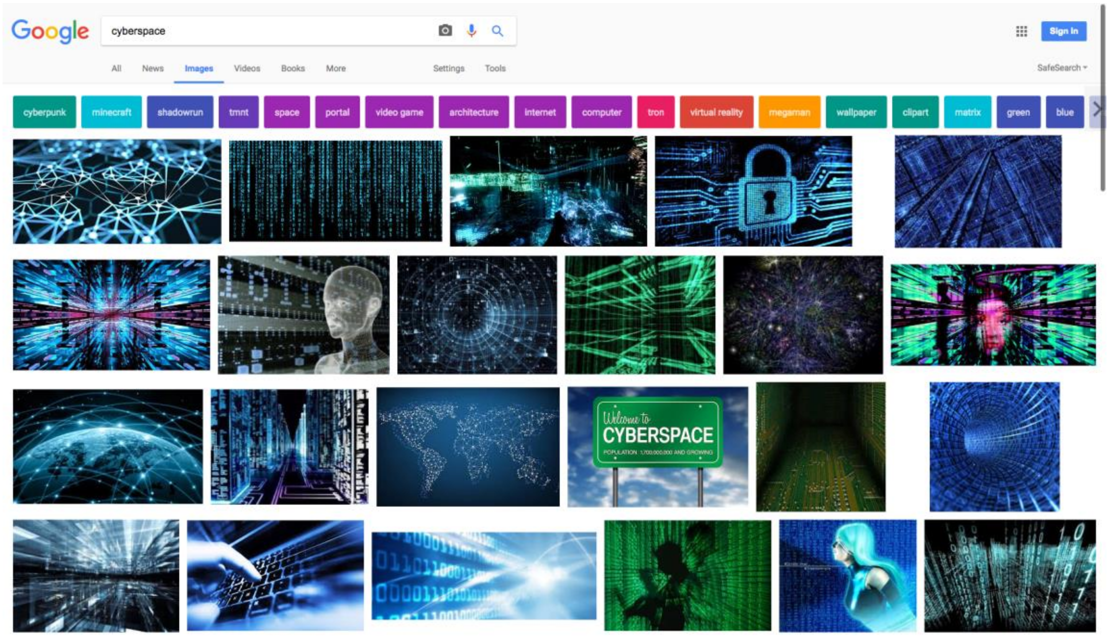

Figure 5-18. Google image search for “cyberspace.”[89]

[88] “virtual,” Google image search, https://www.google.com/search?q=virtual&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjBl-TbzsvZAhVojlQKHeQ_B_0Q_AUIDCgD&biw=1257&bih=796 (accessed July 5, 2017).

[89] “cyberspace,” Google image search, https://www.google.com/search?biw=1257&bih=796&tbm=isch&sa=1&ei=vzOYWqTMA8uS0wKOrLyYDw&q=cyberspace&oq=cyberspace&gs_l=psy-ab.3..0l10.36519.38485.0.38800.10.8.0.2.2.0.207.862.1j4j1.6.0....0...1c.1.64.psy-ab..2.8.871...0i67k1.0.KmzGPmEXmao (accessed July 5, 2017).

CHAPTER 6
SOUNDS OF SYNTHESIS

This chapter examines the immanent qualities of both standard and nonstandard synthesis, which often share spectromorphological attributes that are products of the time-domain synthesis paradigm. I suggest that the immanent level carries information that can be identified for its contribution to esthesic impressions of artificial origins. I do not claim this list to be comprehensive; rather it is a selective contribution to my heuristic framework built around the anacoustic concept.

Resonance Analysis

As described in Chapter 2, acoustic resonance is a fundamental property in the sounding of acoustic instruments and other materials. It is a marker of the physicality of sound as the direct result of physical input. Certain sound synthesis techniques are generative of spectra marked by their deviation from acoustic resonance patterns, which will be expanded upon in the sections that follow.

These patterns can be visualized by representing amplitude over frequency via a transfer function, which Cook describes as an extension of resonant modal analysis. "The transfer function of a linear system describes what happens to a signal traveling through that system."[1] Modal resonances manifest as distinct amplitude peaks called *formants.* As shown in Figure 6-1, acoustic resonances naturally concentrate most energy in modes closest to the fundamental frequency, whereas the highest partials are transient and low amplitude.

[1] Perry R. Cook, "Voice Physics and Neurology," in *Music, Cognition, and Computerized Sound*, ed. Perry R. Cook (Cambridge: MIT Press, 1999), 109.

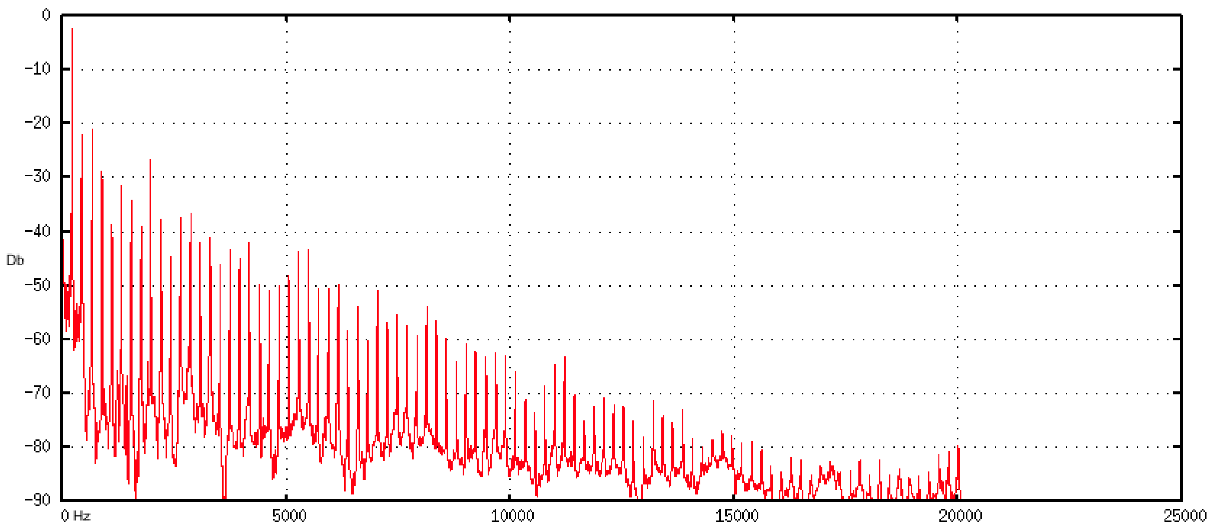

Figure 6-1. Formant transfer function of the note A3 on the cello.

Acousmatic Bodies

Resonant bodies are set in motion by incorporated practices. Part of what marks sound constructions as distinct from acoustic recordings is a lack of those ephemeral sonic details that emerge from incorporation—details that collectively signify presence.

Central to presence is embodiment, and central to embodiment is the human body. At an extreme, composer Bob Ostertag shares the view of his collaborator Pierre Hébert who says "the measure of a work of art is whether one can sense in it the presence of the artist's body."[2] In the acousmatic scenario, where there is no visual source of embodiment or action, we often listen for traces of the body, tuned in to those specific sound qualities (patterns) that signify the movements or utterances of a human agent. Katharine Norman provides a uniquely poetic account of this process in her journal entry response to *Petit Jardin* by Magali Babin, in which she navigates the cognitive dissonance of hearing a performance without seeing it, calling forth the presence/absence duality: "nearly all the sounds imply actions. Someone or something

[2] Bob Ostertag, "Human Bodies, Computer Music," *Leonardo Music Journal* 12 (2002): 11-14.

'did' these things."[3] The way that we relate sound to incorporated practices (and by extension, embodiment) has been referred to by Andrew Mead as *kinesthetic empathy*.[4] Marc Leman's synopsis of Broeckx's theory of expressive meaning formation in music goes further when he discusses *kinesthetic processing*:

> Kinesthetic processing concerns the sensing of musical dynamics. Music is dynamic in the sense that physical properties (frequency, amplitude, and so on) evolve through time and generate in our perception segregated streams and objects that lead, via ideomotor processing, to impressions of movement, gesture, tension, and release of tension.[5]

Composer Denis Smalley expands upon the concept of *gesture* in acousmatic listening:

> Sound-making gesture is concerned with human, physical activity which has spectromorphological consequences: a chain of activity links a cause to a source. A human *agent* produces spectromorphologies via the motion of gesture, using the sense of touch or an implement to apply *energy* to a *sounding body*. A gesture is therefore an *energy-motion trajectory* which excites the sounding body, creating spectromorphological life …[6]
>
> [Furthermore] we should not think of the gesture process only in the one direction of cause-source-spectromorphology, but also in reverse—spectromorphology-source-cause. When we hear spectromorphologies we detect the humanity behind them by deducing gestural activity, referring back through gesture to proprioceptive and psychological experience in general.[7]

The concepts of gesture and kinesthetic empathy provide ways of understanding presence as a key node in the semiotics of acousmatic listening; they articulate our recognition and affective response to certain patterns related to sounding bodies in the

---

[3] Katherine Norman, *Sounding Art: Eight Literary Excursions through Electronic Music* (Aldershot: Ashgate, 2004), 5.

[4] Andrew Mead, "Bodily Hearing: Physiological Metaphors and Musical Understanding," *Journal of Music Theory* 43, no. 1 (Spring, 1999): 1-19.

[5] Marc Leman, *Embodied Music Cognition and Mediation Technology* (Cambridge: MIT Press, 2008), 93-94.

[6] Denis Smalley, "Spectromorphology: Explaining Sound Shapes," *Organised Sound* 2, no. 2 (1997): 111.

[7] Ibid., 111.

physical world. Gesture and *source-bonding* (defined earlier in Chapter 3) describe the evocative potential of acousmatic sound rooted in recording practices (following musique concrete) and the sense of presence it affords.

Sound constructions, on the other hand, are distinguished by their tenuous relation to incorporation/embodiment as Norman again demonstrates in her response to *zero degrees* by Ryoji Ikeda: "He is absent now. Nobody performs, hits a gong, or trails a hand through implicitly substantial sounds. Instead the sound is apparently laid bare and has no aural secrets."[8] This kind of impression can be traced to the erasure of transient complexity in favor of discreetness and invariance. There is nothing below the surface; no one behind the acousmatic veil. Norman's notion that sounds can carry implicit substance is a testament to the "front-loaded" meaning of presence, whereas the crossover to informational pattern is subject to contingencies. Exasperated, she continues, "identifying with a click is to become brutally irradiated by sound. No time at all. Quick, get rid of it in favour of records of human presence!"[9] *Zero Degrees* presents starkly digital material at polarized extremes of timbre, frequency, and duration, extending the binary ontology of data to a formal continuity.

The anacoustic works of Brün, Xenakis, and Tone similarly place the listener in a scenario where sound origins may be unrecognizable or at least untraceable to known physical causes. Smalley describes this as *remote surrogacy* "where source and cause become unknown and unknowable as any human action behind the sound disappears."[10] Smalley's definition is helpful. Yet, in this analysis, it does not fully

[8] Norman, *Sounding Art*, 13.

[9] Ibid., 14.

account for what I suggest is a shift from source-bonding grounded in incorporation (i.e. Smalley's gestural surrogacy) toward source-bonding grounded in inscription. I propose that the remote surrogacies of sound constructions today, in our increasingly electronic-industrial soundscape, are often associated with the tools used to create them or the environments in which they are typically found despite the absence of tangible physical causes. An anacoustic discourse considers the loudspeaker as either a window (through source-bonding and recorded sound) or as a voice in itself—an independent instrument, or the computer feeding it as one, distinguished from what a microphone might capture and subsequently feed it.

Invariance

Invariance might be used to describe many facets of an informational ontology: invariance manifest in quantization, in replication, or in the widely applicable but ultimately invariable syntax of MTC. The computer can be conceptualized as a template for sound in the form of an invariant time and frequency grid to be filled with discrete sound particles, or acoustic *quanta*. Quantum approaches to sonic computing have been defined by Roads as *microsound.* To provide some context, he explains:

> The contemporary scientific view of microsound dates back to Dennis Gabor, who applied the concept of an acoustic quantum (already introduced by Einstein) to the threshold of human hearing. With Meyer-Eppler as intermediary, the pioneering composers Xenakis, Stockhausen, and Koenig injected this radical notion into music.[11]

The acoustic quanta at WDR began with the sine tone, the atomic element for additive synthesis that enabled the serial composition of timbre. In granular synthesis, a type of time-domain microsound, the atomic unit is the grain—an enveloped fragment of a

---

[10] Smalley, "Spectromorphology: Explaining Sound Shapes," 111.

[11] Roads, *Microsound*, 84.

waveform usually between one thousandth and one tenth of a second. Time-domain granular synthesis capitalizes on the *temporal invariance* of audio encoding, which I will expand upon in relation to my composition *in surge* in Chapter 7. Nonstandard synthesis represents an extreme approach to time-domain microsound, operating below the level of micro-time at the sample time scale. The perceptual effects of constructive or destructive interventions at this scale are most easily observed in the frequency domain.

Spectral Invariance

Spectral invariance is at the heart of attacks on Fourier methods and fixed-wavetable lookup synthesis. With synthesis that is spectrally invariant, acoustic quanta are conceived as static spectral units of infinite duration (such as a sinusoidal wavetable looping continuously). Koenig's SSP, despite its nonstandard operation, was inhibited by the spectral invariance of the fixed-waveform paradigm. SSP segments, upon specification, were iterated periodically without input parameters that might allow dynamic change to successive periods. Paul Berg's *Mandolin*, composed with SSP, contains static layers of synthetic sounds that are superimposed without additional spectral or envelope modifications.

Frequency domain properties of *Mandolin* can be observed via a sonogram visualization, which displays frequency over time. The brightness of frequency bands indicates the amount of energy they carry. From 1:34 to 2:24 of *Mandolin* (Figure 6-2), sound events take shape as discreet, broadband panels. Separate voices can be easily identified by their sharp geometric delineation. *Mandolin* looks visually congruous, concise, and symmetrical. By contrast, the sonogram excerpt from 5:15-6:05 of my own work, *in surge* (Figure 6-3), features an asymmetrical energy distribution, blurred transitions between successive sounds, and spectra that change over the course of each sound event.

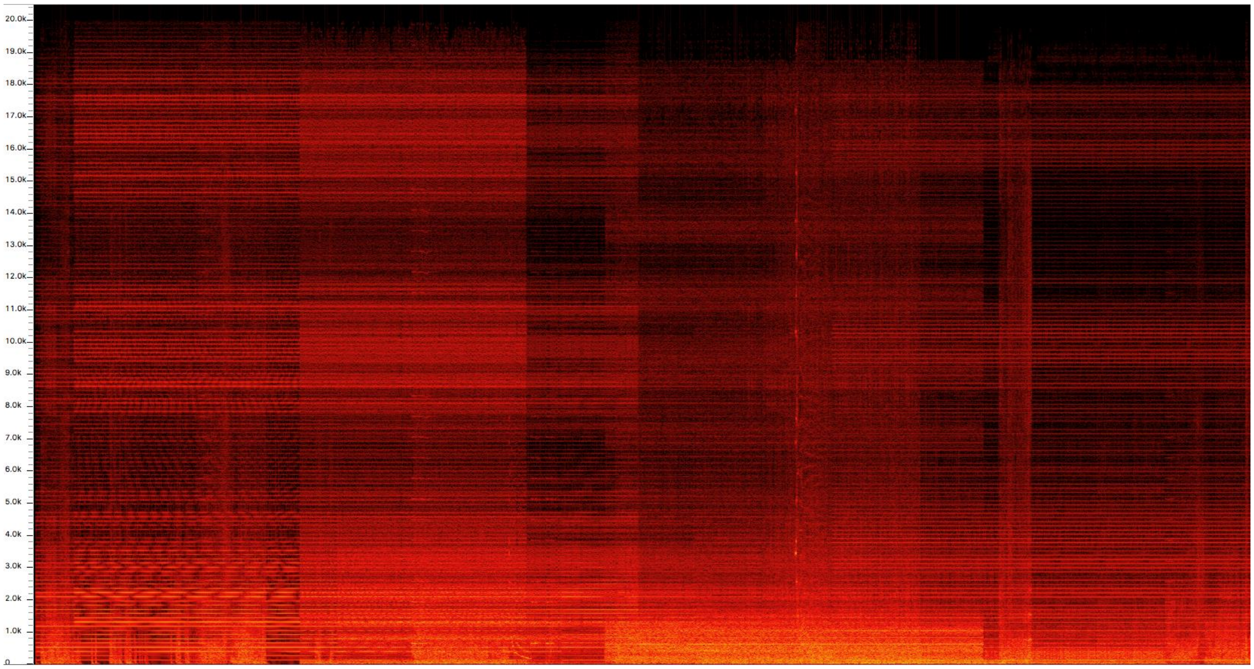

Figure 6-2. Sonogram excerpt of Berg's *Mandolin* (1:34-2:24).

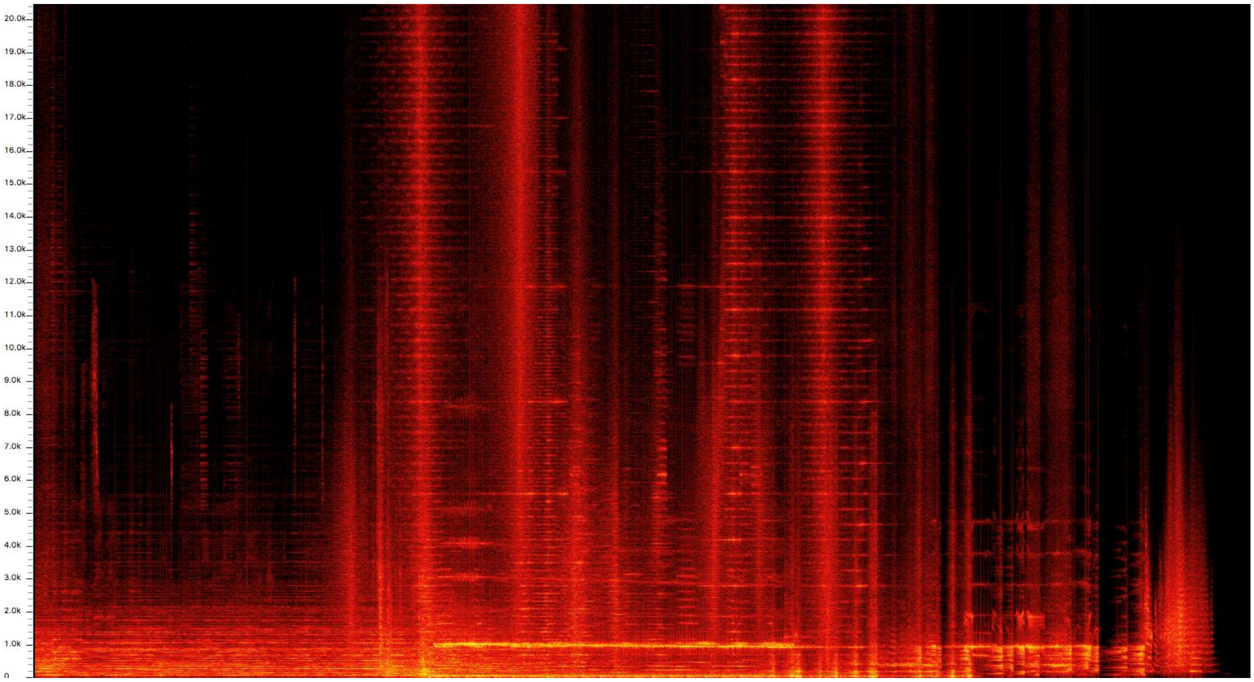

Figure 6-3. Sonogram excerpt of *in surge* (5:15-6:05).

The fact that *in surge* appeals less to visual logic than *Mandolin* represents a systematic difference in the works' respective approaches to sound design. While Berg necessarily navigates an acoustic reality in the process of salvaging desirable imminent properties, his navigation is corrupted at the outset because of the non-parametric synthesis model. My source materials and synthesis methods follow the acoustic reality of sound. My conception of a work is influenced as much by the act of listening as it is the act of imagining sound potentials. The outcome of this process reflects the asymmetry of my perceptual mechanism, and to deviate from what is perceptually seductive is a strategic compositional choice that has less to do with the technical mode of sound construction than with its emotional affect. Roads is blunt in his assessment of nonstandard synthesis when he suggests that instead of attempting to incite meaningful musical sequences, "users of sample-based synthesis programs must be willing to submit to the synthesis algorithm, to abandon local control, and be satisfied with the knowledge that the sound was composed according to a logical process."[12]

While Roads articulates the difficulties, nonstandard methods did not prevent composers from intervening at different stages to regain local control. Furthermore, in a move toward complexity, Brün and Xenakis devised strategies to apply continuous variation to the wave shape in order to counter spectral invariance. Indeed, a significant affordance of nonstandard synthesis is the unique spectra generated from the placement of elastic boundaries on waveform dimensions. A sonogram view of 2:40-3:30 of *Dust* (Figure 6-4) reveals restrained upper partials and dynamic change over the course of sound events.

[12] Roads, *Microsound*, 31.

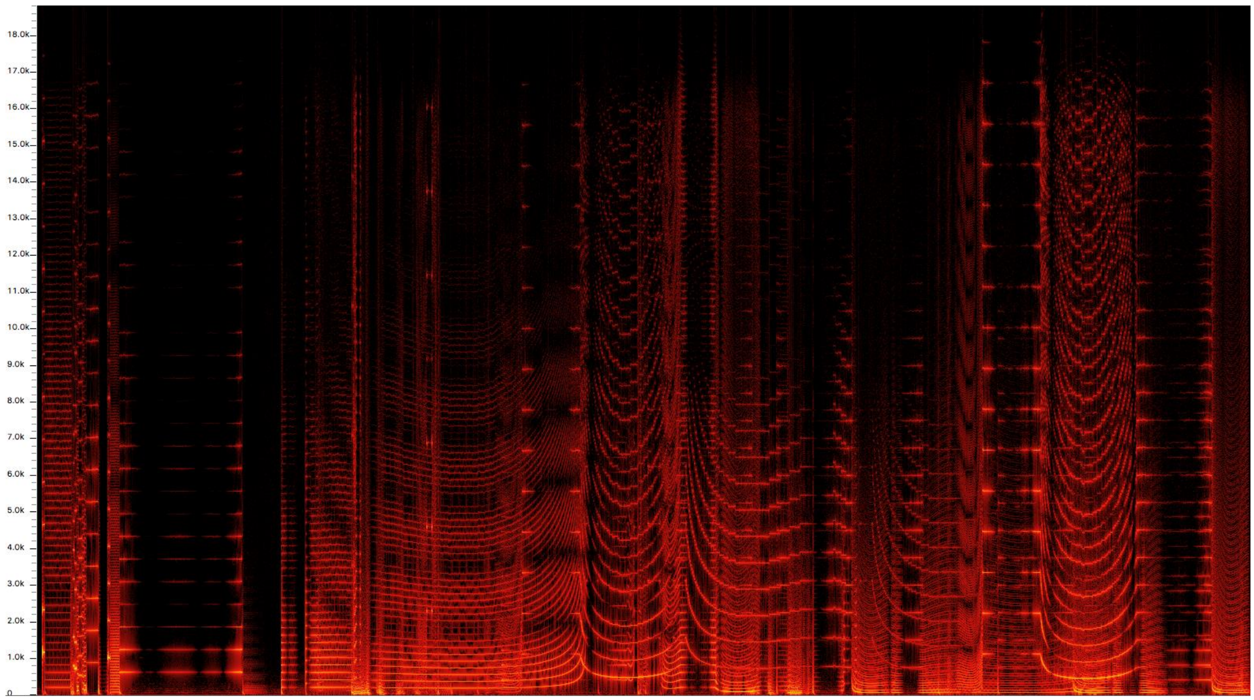

Figure 6-4. Sonogram excerpt of *Dust* (2:40-3:30).

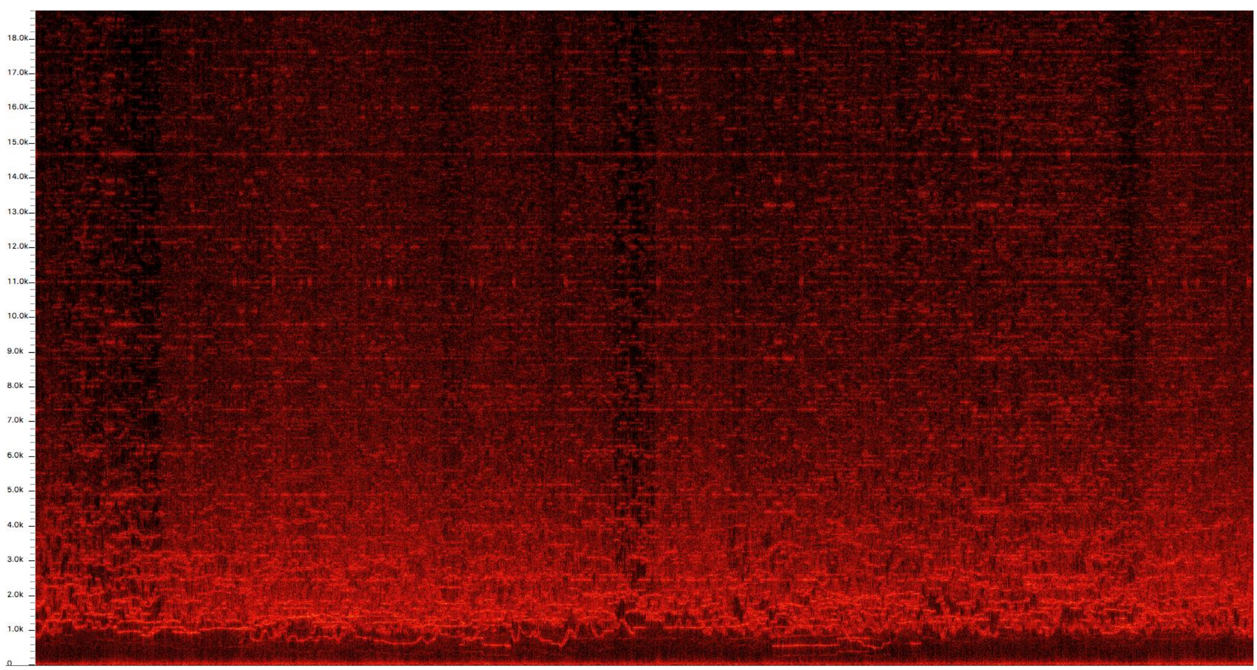

Figure 6-5. Sonogram excerpt of *Gendy3* (9:00-9:50).

Brün's eccentric counterpoint of sliding pitches punctuated with broadband bleeps is seen as parallel harmonic lines following curved pathways. The excerpt from 9:00-9:50

of *Gendy3* (Figure 6-5) depicts a dense spectral cloud with tangled and complex internal behavior. *Gendy3* clearly derives from a concept of noise and its manipulation via varying degrees of restraint. It is interesting that these images represent a common practice yet are strikingly different—apt reflections of their respective methodological orientations.

Tonal Balance

Brün describes a second immanent property unique to sound construction as "the beauty of the unnatural."

> While technicians and composers are terribly proud that they can generate wonderful sounds that have far more audible partials than [acoustic] instruments allow, if we want to hear them, we have to turn up the volume really high. This brings out some very high partials, and they hurt. The moment we turn it down out of consideration for humanity, the sounds turn into the familiar realm of church organ, where there is a certain richness, but it does not have what I call the beauty of the unnatural: namely, that the higher partials can be louder than the lower ones, which is not the case in a flute or a bassoon or a trombone, but can be the case in an electronically synthesized sound. I would say that some of the charm of these sounds—and we speak now only of sounds, not yet of music—is that they really are not natural.[13]

This property of tonal balance—the distribution of spectral energy across the audible range—is significant in the relation of sounds to artificial modes of production. Standard and nonstandard synthesis naturally generate spectra characterized by (at an extreme) a flat frequency response, meaning a relatively equal (and invariant) distribution of energy among partials. This property deviates from the spectral patterns of acoustic instruments, which are predicated on resonance and the natural concentration of energy around vibrational modes close to the fundamental. The difference between a flat and natural tonal balance can be seen in the dramatic contrast

[13] Herbert Brün, *When Music Resists Meaning*, ed. by Arun Chandra (Middletown, CT: Wesleyan University Press, 2004), 117.

between sonograms of a sawtooth wave and a violin (Figures 6-6 and 6-7), both sounding A, 440 Hz. The sawtooth wave carries energy into the highest regions of the spectrum while the violin loses most energy above 8 kHz.

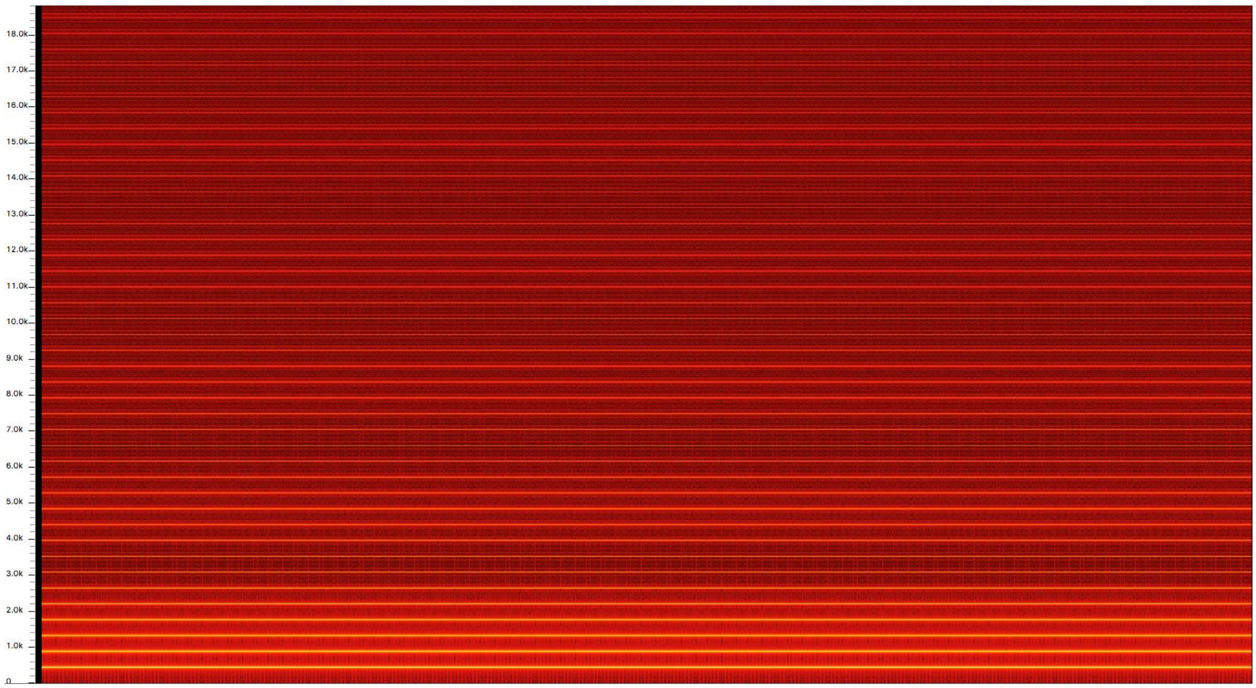

Figure 6-6. 440 Hz sawtooth wave.

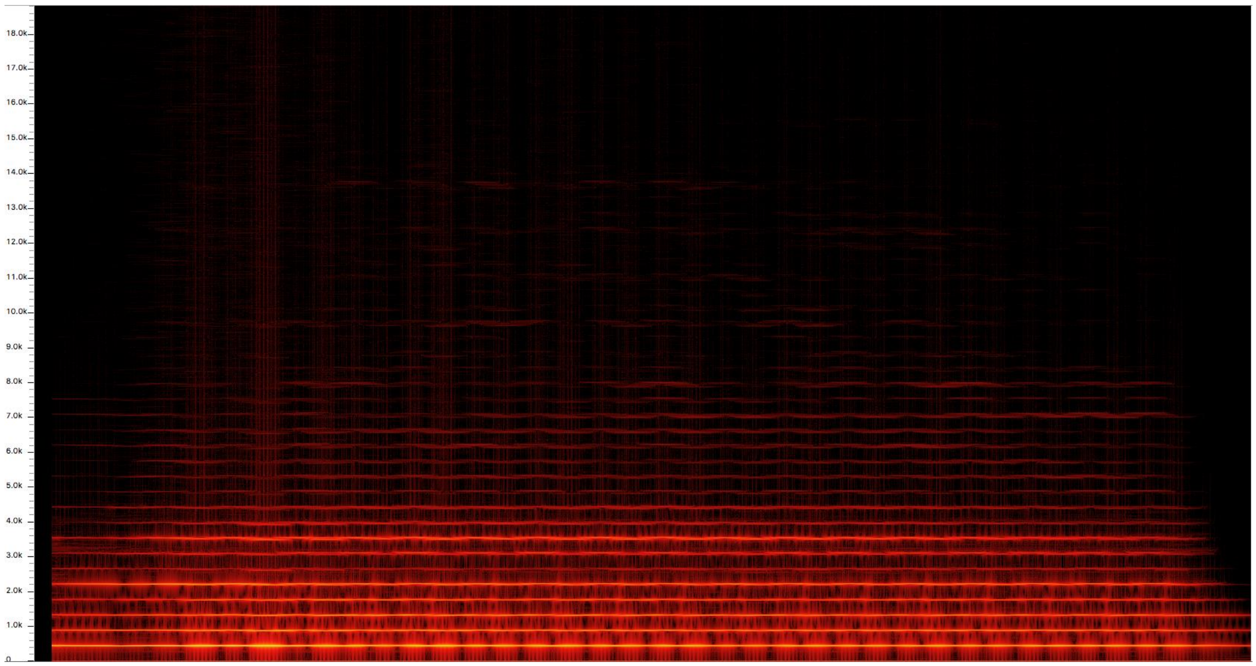

Figure 6-7. 440 Hz violin tone.

Fixed waveforms with sharp contours such as pulse or sawtooth waves carry much energy into the high frequency register, as do the jagged edges of nonstandard waveform constructs. Certainly, one of the affordances of synthesis is the ability to explore and manipulate high register partials that are inaccessible or transient in the instrumental domain. However, the difficulty with nonstandard synthesis lies in the formation of meaningful relationships between waveform shapes and spectra. Some general observations can be made toward this end, as summarized by Moore:

> Waveforms exhibiting *impulsive behavior* tend to have spectra that *do not decrease* with increasing frequency.
>
> Waveforms that tend to have *sharp steps* tend to have spectra that roll off at the rate of *6dB per octave*.
>
> Waveforms that tend to have *sharp corners* tend to have spectra that roll off at the rate of *12 dB per octave*.[14]

[14] F. Richard Moore, *Elements of Computer Music* (Englewood Cliffs, NJ: Prentice-Hall, 1990), 95.

SAWDUST generates step-like behavior in waveforms and *Dust* consequently has a gradual roll-off from the mid to high frequency range with concentrated spikes in the high register. *Musica Iconologos* is characterized by waveforms that exhibit pulse and step-like behavior (Figure 6-8)—spectra do not decrease in energy with increasing frequency. Observe the average frequency distribution of *Jiao Liao Fruits* in comparison to Xenakis's orchestral work *Ata* (1987) for 89 musicians (Figures 6-9 and 6-10). *Ata* has an approximate -24 dB roll-off from the mid (1 kHz) to high register, while *Jiao Liao Fruits* has an approximate -10 dB roll-off with much more concentrated high frequency content between 5 and 15kHz.

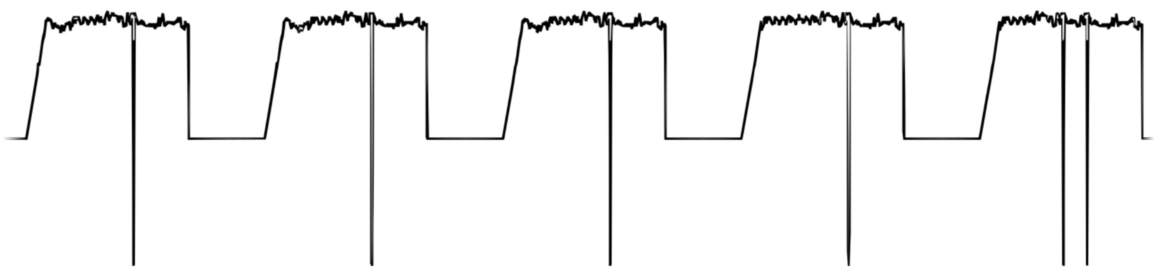

Figure 6-8. Waveform segment from *Jiao Liao Fruits*.

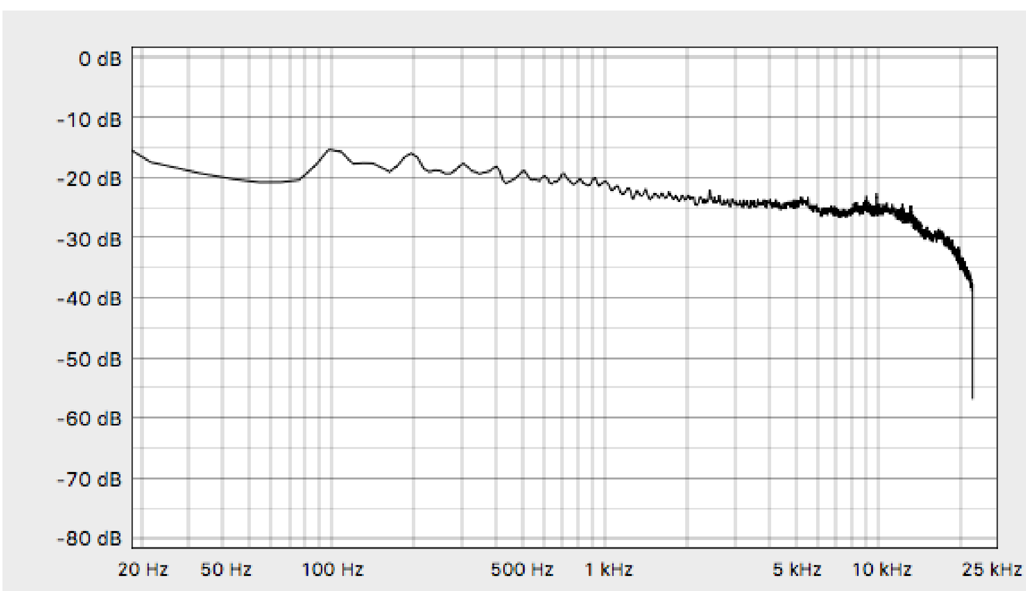

Figure 6-9. Average frequency distribution of *Jiao Liao Fruits.*

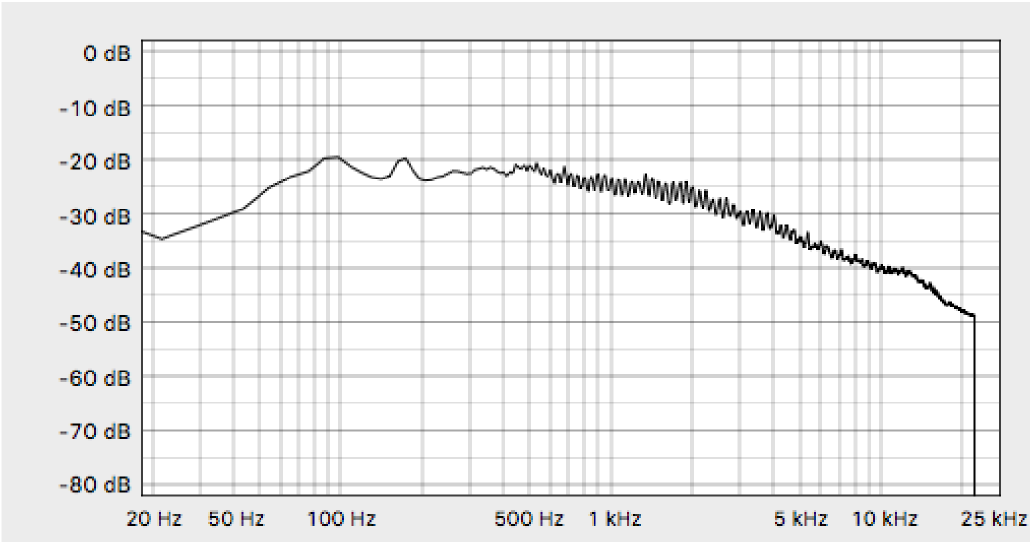

Figure 6-10. Average frequency distribution of *Ata.*

Anechoic Spaces

The last immanent property I wish to propose which characterizes sound construction is an *anechoic spatial profile*. *Anechoic* implies without reflections. When an acoustic source vibrates in the real world, it causes the air molecules surrounding it to vibrate in an analogous manner, expanding outward in an omnidirectional pattern. When sound arrives at the ear of the listener, it is typically a combination of the direct sound vibration with many time-delayed reflections that have bounced off of various surfaces within a space. These reflections constitute the acoustic properties of the space—its resonant and reverberant characteristics. Sound constructions do not typically carry intrinsic attributes that signify diffusion within a physical space; nor the resonant patterns of the objects that, as micro spaces, reinforce and cancel different frequencies over time. They are completely “dry.” The impact of the anechoic profile might be compared to the threat response elicited in listeners from equally dry, close-miked acoustic recordings, especially of sounds without resonance. A loud, near field noise sound, lacking in resonance, signals a threat, as it associates with something that is breaking, being no longer contained or in vibrational balance. In many cases, anacoustic composers embrace the unnatural starkness and close proximity of the anechoic profile, and do not attempt to salvage reflective properties through artificial reverb or delay. They deploy the speaker not as a window (i.e. representation) but as a voice in itself.

Conclusion

In summary, there are intrinsic properties of synthetic sound that can suggest digital origins and, by extension, anacoustic modalities. Acoustic sound is characterized by the diffusion of vibration within physical systems and the resonance and reverberation that results. Acoustic sound is set in motion by incorporated practices, from which the concepts of source bonding, gesture, and kinesthetic empathy are derived. Sound constructions are often distinguished by immanent qualities that distance them from the acoustic, such as an anechoic spatial profile, spectral invariance, and an unnaturally flat tonal balance. Nonstandard synthesis, with as much potential for broadband noise as untamed extreme upper partials, arguably has more imposing effects on the ear than other synthesis methods. Still, sounds and music of anacoustic origin exhibit interesting and varied spectral properties, and provide a model for cultivating an idiomatic voice for digitally constructed sound.

CHAPTER 7
ANACOUSTIC MODES OF COMPOSITION

Semiotics of Virtuality

The practice of nonstandard synthesis has contributed to only a small percentage of content within the electroacoustic canon. Berg's *Mandolin*, Brün's *Dust,* Xenakis's *Gendy3*, Tone's *Musica Iconologos,* and Ikeda's *dataphonics* are each unique in terms of quality and construction. Yet, the limited interest and activity in nonstandard synthesis may be attributed to the homogeneity and severity of its sonic results. How best to use nonstandard materials without limiting oneself to such an oppressively singular paradigm of sound construction? My intention with the concept of anacoustic is to open a discourse where sound-less synthesis is one potential within a larger system derived from Hayles's *semiotics of virtuality*, which explicates a dynamic between epistemologies centered in presence/absence and pattern/noise. The semiotics of virtuality are formulated in Hayles's semiotic square, expanded upon here from the preliminary introduction at the end of Chapter 4.

> The structure is defined by the axes and the formal relationships they express, but the terms composing those axes are not static. Rather, they interact dynamically with their partners, and out of these interactions new synthetic terms can arise.[1]

In Figure 7-1, Hayles's synthesizing terms comprise the outer layer surrounding the semiotic square.

> On the top horizontal, the synthetic term that emerges from the interplay between presence and absence is materiality. I mean the term to refer both to the signifying power of materialities and the materiality of signifying processes. On the left vertical, the interplay between presence and randomness gives rise to mutation. Mutation testifies to the mark that randomness leaves upon presence. … On the right vertical, the interplay

[1] Hayles, *How We Became Posthuman*, 248.

between absence and pattern can be called, following Jean Baudrillard, hyperreality.[2]

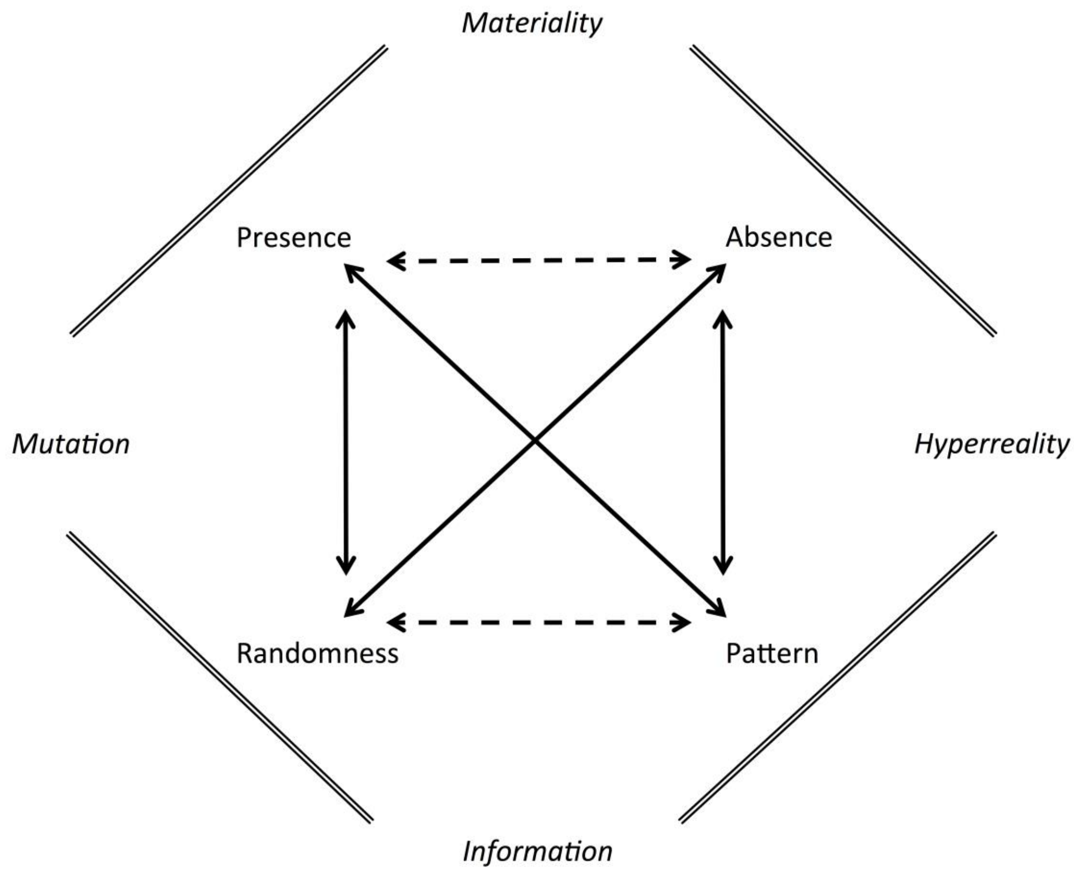

Figure 7-1. Hayles's semiotic square with synthetic terms.[3]

On the concept of hyperreality, Hayles elaborates:

> Baudrillard has described the process as a collapse of the distance between signifier and signified, or between an "original" object and its simulacra. The terminus for this train of thought is a simulation that does not merely compete with but actually displaces the original.[4]

---

[2] Hayles, *How We Became Posthuman*, 249.

[3] Ibid.

[4] Ibid., 250.

Finally, the bottom horizontal is labeled *information*, “to include both the technical meaning of information and the more general perception that information is a code carried by physical markers but also extracted from them.”[5]

The semiotics of virtuality represent a creative space within which to consider the symbolic networks stemming from modes of digital sound construction and reproduction. Anacoustic modes highlight the ontology of information and articulate a distance from material circumstances. By doing so, information becomes a reified entity in itself, collapsing the top-down structural hierarchy used in parametric coding in favor of a low level address that corrupts the waveform as a carrier of meaning. Unlike parametric modes, which encode the physicality of sound objects into mechanisms of performative control, the computational techniques of nonstandard synthesis have no ground in human experience. This calls to mind Hayles’s analysis of the science-fiction dynamic of materiality in *Galatea 2.2* by Richard Powers, in which she describes the precarious relation between the artificial intelligence Helen and its creator, Rick:

> [For Helen,] there is nothing in her embodiment that corresponds to the bodily sensations encoded in human language. … To feel estrangement in language, as Rick comes to feel as he works with Helen, is to glimpse what it might be like to be incorporated in a body that finds no image or echo in human inscriptions.[6]

Beyond anacoustic modes, I imagine music that engages with other dimensions of the semiotics of virtuality—those equally anchored in presence, which can be coopted by pattern or transfigured by noise. A voice sings and becomes frozen in time—a static aggregate of overtones—a body representation. Or it is mutated by noise—pitch modulated and filtered to sound like water or birds, or distorted beyond

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[5] Hayles, *How We Became Posthuman*, 250.

[6] Ibid., 265-66.

recognition. A variety of digital signal processing techniques in the time and frequency domains can be implemented toward these ends. Of particular relevance in light of nonstandard synthesis is granular synthesis, which, as mentioned in Chapter 2, Roads considers an alternative to "representations at the sample level that do not capture frequency-domain information, and abstract Fourier methods that presume that sounds are summations of infinitely long sinusoids."[7]

Microsound

Roads's *Microsound* is a comprehensive volume that traces the history of the practice and serves as a guide to a number of related synthesis techniques. Roads contends that the contemporary perspective of microsound began with the acoustic theory and experiments of Denis Gabor in the 1940s. Contrary to the continuous wave theory of sound, which dominated acoustics until 1907, Gabor proposed that *acoustic quanta* were significant because our perceptual mechanism is not infinite in resolution. Rather, "hearing is governed by quanta of difference thresholds in frequency, time, and amplitude."[8]

"Gabor's quanta are units of elementary acoustical information. They can be represented as elementary signals with oscillations at any audible frequency *f*, modulated by a finite duration envelope (a Gaussian curve)."[9] The *Gabor matrix* follows this conception and plots frequency over time in sequences of discrete cells similar to windowed analyses a la the fast Fourier Transform or FFT.

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[7] Roads, *The Computer Music Tutorial*, 168.

[8] Roads, *Microsound*, 59. Albert Einstein predicted the existence of acoustical quanta or *phonons* in 1907, which was verified in 1913.

[9] Ibid., 58-59.

Gabor's theory informed approaches to sound making since early *elektronische Musik*. Werner Meyer-Eppler, a founding member of the WDR studio, described the Gabor matrix along with examples of Oskar Fischinger's optical sound as the "scores of the future" in a 1950s Darmstadt lecture.[10] Meyer-Eppler's 1959 book on information theory also presented the Gabor matrix, which was influential to Xenakis, specifically in his composition, *Analogique B*. Xenakis actually coined the term "grains of sound" and "was the first musician to explicate a compositional theory for sound grains."[11]

Norbert Weiner, the founder of cybernetics, also knew well of Gabor's acoustic quanta and similarly "rejected the view that time, space, and matter are infinitely subdivisible or continuous."[12] This view, of course, is integral to computational representation/simulation and at the heart of cybernetic theories that construe the body and materiality as informational entities.

Today, microsonic conceptions of sound permeate digital audio in both time and frequency domain processes. In the frequency domain, the *short-time Fourier transform* (STFT) is part of a class of techniques called *windowed analyses.* The STFT deconstructs sound by extracting successive sample segments (shaped by a window function) and applying a bank of filters to each segment. "The output of each filter indicates the amplitude and the phase of the spectrum at that particular frequency."[13] The information derived from the STFT can be used to make subtle to extreme modifications to the analyzed sound before resynthesis.

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[10] Roads, *Microsound*, 62.

[11] Ibid., 65.

[12] Ibid., 63.

[13] Ibid., 239.

In the time domain, granular synthesis iterates continuous streams of small sound fragments or grains. A grain is composed of a waveform shaped by an amplitude envelope and represents a unique superimposition of time and frequency domain parameters. According to Roads:

> The grain is an apt representation of musical sound because it captures two perceptual dimensions: time-domain information (starting time, duration, envelope shape) and frequency-domain information (the pitch of the waveform within the grain and the spectrum of the grain).[14]

Grains with durations less than around two milliseconds are too small to carry perceptual spectral attributes, and instead sound like clicks with variable tone color. Longer grain durations are more tonally distinguished, revealing the internal grain makeup.

Granular synthesis carries the atomic nature of PCM samples to a perceptually salient scale and has been of great interest to me in my own creative work in sound design and composition. The precision and control over temporal patternings with granular synthesis give rise to a wide variety of rhythmic and spectral metamorphoses.

sequence (bloom)

My work, *sequence(bloom)*, composed in 2013, is the first composition in which I self-consciously experimented with creating a musical counterpoint between the human voice, piano, and a catalogue of explicitly digitized reconfigurations. The traditional context of voice and piano is extended into an imaginary digital soundscape in which vocal fragments pulse with rapid precision and disperse in different virtual spaces. Sung tones become frozen in time: static pitches with overtones affixed to perfect harmonic relationships, or dissonant clusters extracted from the outer poles of a wide

[14] Roads, *Microsound*, 87.

vibrato. Granular pulse streams were generated with a simple instrument and routine coded in SuperCollider.

The phase vocoder software PVCplus enabled sophisticated control over various spectral modifications. Using frequency domain analyses, I extracted portions of spectra from sources and generated a continuum of spectral harmonicity by strategically displacing overtones—folding them into lower registers.

The work aims not to transform the digitally mediated “duo” far beyond its familiar nature, but to present an exaggerated performance that draws attention to its own acoustic/electronic hybridity via a dialogue between recorded presences and their patterned simulations.

in surge

My work *in surge* (2017) for eight-channel audio was made with a variety of granular synthesis processes and two dimensional, multichannel spatialization techniques. I constructed undulating granular streams characterized by pulse speeds that accelerate and fuse into continuous, modulating timbres, or disperse and dissolve into small particles. Recognizable sounds from the piano, voice, and other sources are subject to granular decomposition and re-assembly as in a pixelated surface where images coalesce, smear, and interpenetrate.

The source material of *in surge* includes recordings I made of the interior of a piano played in unorthodox ways, such as dropping or dragging objects across the strings. Additionally, I recorded a collection of pitches and note clusters that roughly correspond to a harmonic spectrum over a low B flat. I utilized samples of a female voice drawn from a volume of audio poetry and incorporated field recordings of beehives, beach waves, and the striking of a large metal sculpture located at the

Atlantic Center for the Arts in New Smyrna, Florida. Purely synthetic elements derived from frequency modulated sine waves were used as well.

Granular decomposition of sources in *in surge* imposes patterns of inhuman precision and determinism, while retaining the rich complexity of the acoustic fragments embedded within each grain. Granular techniques provided a means to the mutation of sources, which sway toward and away from the quantized invariance of sound constructions.

I applied *synchronous granular synthesis* (SGS) to a variety of sound files. SGS iterates grains at regular intervals. The user can generate streams of precise, metric pulses with sample-level accuracy. When rates exceed the low frequency limits of audibility, grains fuse into a continuous stream, opening a continuum between pulse and pitch.

High grain rates within the audible range have a strong fundamental frequency, and may carry sidebands depending on the grain envelope and size. Roads elaborates, “the sidebands may sound like separate pitches or they may blend into a formant peak.”[15]

I coded routines in SuperCollider that would iterate synchronous grain streams at rates between 30 and 70 Hz with low frequency modulations that slowly shifted the formant region of each stream. These sounds were automated with different amplitude and spatial envelopes that explore spatial imaging possibilities within a two dimensional octophonic speaker array.

[15] Roads, *Microsound*, 93.

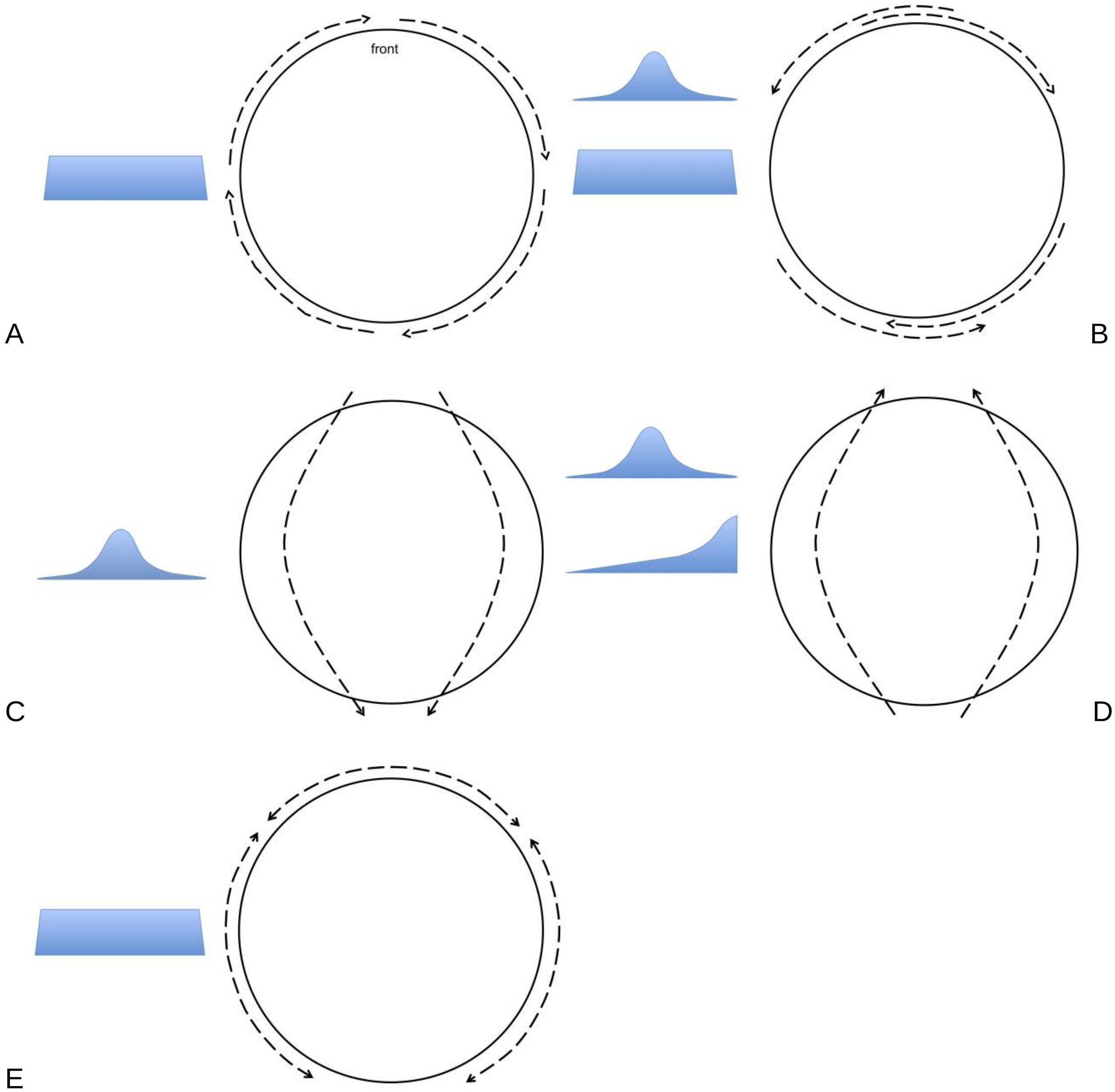

Figure 7-2. Spatial and envelope archetypes. A) circular spatial motion with sustained envelope; B) concentric circles with sustained envelope or swells that peak at random points; C) alternating swells that approach the listener from the front; D) alternating swells or hairpins that approach the listener from the back and converge in the front; E) sustained envelope with random, linear panning.

As shown in Figure 7-2, I created different archetypal shapes to dictate amplitude envelopes and spatial motions: arrows indicate the spatial trajectory relative to the circular speaker array and the shapes represent the dynamic evolution of sound events, which range from approximately five to fifteen seconds in duration. The amplitude envelopes are not linear, guided, rather, by an algorithm derived from the physical correlation between distance and loudness simulating a moving sound source.

For the spatialization, I used unit generators in SuperCollider to implement Vector Based Amplitude Panning (VBAP), a method for positioning virtual sources within a two or three-dimensional speaker array. I also used ambisonic encoders from AmbIEM, and the Ambisonic Toolkit (ATK). Whereas VBAP is useful for discrete, panning-style localization, ambisonics approximates a sound field using spherical harmonics—three-dimensional coordinates within a sphere. This simulates the way an omnidirectional (three-dimensional) source would arrive at the ear of the listener in a real acoustic environment. Ambisonics ideally utilizes high density loudspeaker arrays (HDLAs) in circular or spherical configurations with the listener at the center. The ambisonic *order* corresponds to the degree of spatial resolution. High order amibisonics capture or synthesize more spherical harmonics and are thus characterized by more precise and localized spatial imaging than lower orders. In practice, high order ambisonics (HOA) can be used to create realistic spatial perspectives and motions that are easily transferred to different HDLA configurations. The combination of VBAP and ambisonics in *in surge* had the effect of varying degrees and qualities of spatial resolution within different voices, which became an orchestrational asset.

The passage from 1:09-1:35 of *in surge* features a sharply articulated sound of struck piano strings subjected to a process of gradually decreasing grain size. The source material in this passage is gesturally rich and full of implied agency: a complex percussive strike followed by bounce and resonance. It is broken into psuedo-pitched grain streams that surround the listener following spatial archetype C. Spectral characteristics slowly fade away over the course of the passage as grains evaporate into broadband clicks like water drops falling onto a hot surface. The piano-derived source dissolves into the inherently discreet electronic pulse. This evolution is partially visible in Figure 7-3.

Figure 7-3. Waveform excerpt from 1:17-1:31 of *in surge*.

Using sound sources with strong connections to human agency are an effective way to anchor presence as a semiotic polarity in acousmatic composition. Sounds of traditional instruments, of course, are tightly connected to the human body. Traces of force, resistance, and tactility are inscribed in the recorded medium. The voice casts the heaviest anchor as suggested by Hayles in the context of tape manipulations:

> Whereas sight is always focused, sharp, and delineated, sound envelopes the body, as if it were an atmosphere to be experienced rather than an object to be dissected. Perhaps that is why researchers in virtual reality have found that sound is much more effective than sight in imparting emotional tonalities to their simulated worlds. Their experiences suggest that voice is associated with presence not only because it comes from within the body but also because it conveys new information about the subject, information that goes deeper than analytical thought or conscious intention. Manipulating sound through tape-recorders thus becomes a way of producing a new kind of subjectivity that strikes at the deepest levels of awareness.[16]

[16] Hayles, *How We Became Posthuman*, 219-220.

While not always center stage, the voice functions in *in surge* as an important carrier of emotional content. The section from 5:30 to 5:50 (pictured in the sonogram excerpt in Chapter 6) features a female voiced alveolar trill (a rolled "r"), time-stretched to a super human duration and combined with a version of itself, which is frequency modulated to a destabilizing vibrato. In the background, another voice (spoken, taken from audio poetry) reiterates a pseudo intelligible utterance characterized by an echo-like spatial profile and band-limited spectrum (the result of a combination of low density SGS and a frequency domain brick-wall filter). I utilize the mutated voice in this section for its heightened emotional affect—a trace of presence immersed within a busy texture of bright, distorted tones that swell and fade at different points around the listener in a climactic and intense sequence. A stereo reduction of *in surge* can be downloaded here from the University of Florida Digital Collections.

Virtuality in Classic Works

The precursors to anacoustic modes of sound construction presented in Chapter 2 confirm that anacoustic modes of thought were formulated in musics that well predate digital synthesis. It can even be said that Western Music has traditionally been a posthuman venture in that the *music* is not located in any particular material instantiation, but exists on an immaterial ontological plane as neatly quantified pitch and metric relations. A Bach score, for example, is independent from the specific performer, the particular instrument, and the acoustic space. Separate, too, from the mind of the conductor who voices the music internally. The integral serialists contended that the music of the future would emerge from elegant mathematical formulae that have yet to manifest physically as sound.

Similarly, in much analog and digital acousmatic music from the past half-century, the semiotics of virtuality are at play as the voice and body are subject to radical transformations, mutations, and hyper-real presentations. Stockhausen's *Gesang der Jünglinge* (1955-56) is an iconic example that signaled a turn from an informational (pattern/randomness) exclusivity at WDR to an engagement with presence. The work features electronically generated sounds with recordings of a boy soprano. The voice is deconstructed into phonemes and juxtaposed with representations in purely electronic form. In the analysis by Decroupet, Ungeheuer, and Kohl, "vowels are like harmonic unfoldings, setting out from sine tones; the fricatives and sibilants are like filtered noises; and the plosives are like impulses with variable intensity and attack."[17] The embodied voice is subsumed by body representations: synthetic approximations of phonemic timbres. *Gesang* represents an early example, made with primitive tools, of a dialogue between presence and pattern (where each pole disrupts the other).

Concurrent with the development of digital signal processing throughout the latter 20th century, the body and voice were subject to even more radical transformations with levels of unprecedented control and fidelity. Jonathan Harvey's *Mortuos Plango, vivos voco* (1980) uses spectral analyses, additive synthesis, and *fof* synthesis (a type of formant synthesis) to create a catalogue of hybrid sounds derived from the tenor bell at Winchester Cathedral and the voice of Harvey's son, a chorister. Both sources are extended by artificial timbral modulations and interpenetrate in a process of digital

[17] Pascal Decroupet, Elena Ungeheuer, and Jerome Kohl, "Through the Sensory Looking Glass: The Aesthetic and Serial Foundations of *Gesang der Jünglinge*," *Perspectives of New Music* 36, no. 1 (Winter, 1998): 100.

mutation. Underlying the polyphony is a common pitch collection extracted from the bell spectrum.

Harvey writes:

> The text for the voice is the text written on the bell: *Horas Avolantes Numero, Mortuos Plango: Vivos ad Preces Voco* (I count the fleeing hours, I lament the dead: the living I call to prayer). In the piece, the dead voice of the bell is contrasted against the living voice of the boy.[18]

In a mystical and cyborgian encounter, the computer provides a metaphorical channel between the living and the dead. The benefits of standard synthesis become clear in light of master works like *Gesang* and *Mortuos Plango*, as they provide a means to draw links between material presence and informational pattern. Current practices in recording, digital signal processing, and sound field simulation such as ambisonics and wave field synthesis, approach the complex multidimensionality of our embodied experiences of sound and exert an even stronger pull as signs of incorporation and presence.

Final Thoughts

In sound construction, whether the computer is used as a *voice* in itself or as a window into something else, it is nothing more than an extension of what we know. It is a channel which, through its own unique ontology, demands a posthuman methodology where sound exists simultaneously as informational pattern and material trace. Sound becomes a real, but malleable substance that can be altered via commands that send chain reactions through a multitude of computational structural hierarchies. Diverging from the instant and continuous feedback a performer receives from an acoustic

[18] Jonathan Harvey, "*Mortuos Plango, Vivos Voco*: A Realization at IRCAM," *Computer Music Journal* 5, no. 4 (Winter, 1981): 22.

instrument, the computer musician must constantly alternate between an embodied experience of sound and its abstract underpinnings in code, tracing connections in a continuous feedback loop until a sufficient model is constructed.

While the inscriptive mechanics of digital audio offer an interesting paradigm to ground sound construction, it is ultimately difficult to create perceptually meaningful aggregates of samples based on logical operations. Acoustic sound is a complex, summative phenomenon with dimensionality that is not simply or easily deconstructed as a linear waveform pattern. But this anacoustic endeavor also serves as a reminder of the materiality of information—of the binary undercurrent flowing beneath the most complex representations and simulations. With different modes of sound construction in the digital domain, the medium offers the potential to function both as an idiomatic voice (the materiality of information) and as a window into the physical world (the information of materiality). I find the engagement between these two polarities an interesting prospect in acousmatic composition and continue to cultivate a musical aesthetic around what might be called an (an)acoustic discourse.

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BIOGRAPHICAL SKETCH

Robert Seaback composes electronic music that incorporates acoustically recorded sound—from the environment, of non-musical objects, and of traditional instruments—and synthetic or modified sound unique to the digital medium. With these materials, he seeks to establish a dynamic interplay between embodied complexities, informational patterns, and noise. He has composed mixed works for acoustic instruments and electronics, multichannel acousmatic music, and sound installations.

Seaback holds degrees in music composition and technology from Northeastern University, Mills College, and the University of Florida. His music has been presented at numerous international festivals and conferences such as ICMC, ISCM World New Music Days, NYCEMF, Sonorities Festival, and TIES. Select compositions are featured on SEAMUS and Ablaze records.