Anacoustic Modes of Sound Construction: Toward a Practice

Robert Seaback
Norwegian Academy of Music
seaback.r@gmail.com

Abstract

This paper provides an overview of anacoustic modes of sound construction and virtual semiotics—a propositional framework following N. Katherine Hayles's posthumanism for the creation and analysis of electroacoustic music. Anacoustic modes address 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.

Techniques by Brün, Xenakis, and Tone elucidate the anacoustic concept and form a basis for identifying sonic parameters unique to their methods. This paper concludes with an expanded view of virtual semiotics based on current artistic research by the author, which establishes a symbiosis of anacoustic modes with standard digital practices.

1. Introduction

The composition of music typically presupposes its ultimate manifestation in sound—in physical, acoustic vibrations that can be heard by humans. It follows that composers often employ rationale based on *sound* ideas.

There is, however, a body of work that challenges this seemingly fundamental notion. Its compositional strategies are enacted in the domain of digital sound synthesis in which abstract 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 derived from acoustic principles. This type of sound construction, divorced from representational intention, is suggestive of *anacoustic* [1] as opposed to acoustic origins. This research was originally published in *Organised Sound*,[2] from which sections 1-6 are excerpted with edits.

The common thread that links each example of anacoustic composition is the conception of *data* as sound. This article examines anacoustic modes from a technical and aesthetic

[1] An anacoustic zone, such as the upper region of the atmosphere or space, is unable to support the propagation of sound. The term here is synonymous with *soundless*.
[2] Robert Seaback, "Anacoustic Modes of Sound Construction & the Semiotics of Virtuality," *Organised Sound* 25, no. 1 (2020): 4-14.

standpoint, drawing attention to the way informational constructions (of sound or otherwise) relate to the material circumstances by which information is necessarily instantiated. Drawing from N. Katherine Hayles's *semiotics of virtuality*,[3] the term *anacoustic* links different discursive formations of sound, information, and materiality. When applied as an analytical device to the creation and interpretation of acousmatic music, the semiotics of virtuality illuminate relationships between embodied complexities, representational absence, informational patterns, and noise.[4] This orientation attributes significance to the digital audio medium as an idiomatic voice as well as a hyperreal window into the physical, acoustic world.

For preliminary clarification, I borrow the term *sound construction* from Joanna Demers to describe the production of 'new' sounds through synthesis, which is distinct from *sound reproduction*: the re-presentation of an acoustical event via recording or the use of pre-existing, sampled materials.[5]

2. Anacoustic Modes of Sound Construction

Representing an extreme position in virtual semiotics, anacoustic modes of sound construction reflect a conception of *data* as *sound*. They employ types of synthesis which address the computer at the most fundamental and abstract level of coding: the syntactic level of information. Claude Shannon described this form of information in his *mathematical theory of communication* or *MTC*. 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.'[6]

Floridi explains, "MTC deals with messages comprising uninterpreted symbols encoded in well-formed strings of signals. These are mere data that constitute, but are not yet, semantic information."[7] The meaning of a message is, in Shannon's words, 'irrelevant to the engineering problem.'[8] In this view, information is 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.

Digital audio encoding follows the principles of MTC, hence the commonly known Nyquist theorem is properly known as the Nyquist-Shannon sampling theorem. Sound construction that establishes digital audio encoding itself as a site for sound specification is called *nonstandard* synthesis. As described by Holtzman: in nonstandard synthesis, "sound is specified in terms of basic digital processes rather than by the rules of acoustics or by

---

[3] N. Katherine Hayles, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics* (Chicago: University of Chicago Press, 1999), 247-282.
[4] For convenience, I borrow the definition of acousmatic from Bayle to 'demarcate music on a fixed medium—representing a wide aesthetic spectrum—from all other contemporary music.' F. Bayle, *Musique acousmatique: propositions ... position* (Paris: Buchet/Chastel, 1993), 1.
[5] Joanna Demers, *Listening Through the Noise: The Aesthetics of Experimental Electronic Music* (New York: Oxford, 2010), 44.
[6] Luciano Floridi, *Information: A Very Short Introduction* (New York: Oxford University Press, 2010), 38.
[7] Ibid., 45.
[8] C.E. Shannon, 'A Mathematical Theory of Communication,' *Bell System Technical Journal* 27 (1948): 381.

traditional concepts of frequency, pitch, overtone structure, and the like."[9] 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.

The hallmark of anacoustic processes is that they model neither the physical behavior of sounding objects nor the acoustic characteristics produced by such behavior. 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 operate in an immaterial space—that which is neither physical nor acoustic, while producing acoustic artifacts.

Nonstandard synthesis applications by Koenig, Brün, and Xenakis serve to elucidate the anacoustic concept. This article also examines a more idiosyncratic use of nonstandard synthesis in the work *Musica Iconologos* by Yasunao Tone and suggests how the anacoustic concept operates as a broad aesthetic territory. Section 7 offers an expanded view of virtual semiotics based on current research by the author, which establishes a symbiosis of anacoustic modes with standard digital practices.

2.1. Parametric and Non-parametric Models

While the sound encoding process is, by design, linked to acoustics and the Fourier series via the Nyquist theorem, the ontology of data has an effect on sound constructions that use data exclusively as the fundamental (im)material element. As Holtzman points out with regard to nonstandard synthesis (or *synthesis by instruction*), "instruction synthesis samples are determined through diacritically-defined relationships *among samples* which do not refer to some superordinate acoustic model or function."[10] This is contrary to *standard* synthesis, in which sound is specified according to high-level acoustic or psychoacoustic parameters.

Perry Cook's definition of *non-parametric* models of sound synthesis similarly 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 sound in meaningful ways."[11] Similar to a single pixel on a high-resolution computer screen, a single sample is, at best, barely perceptible as a sound event. Roads reinforces the idea that "individual samples are sub-symbolic—perceptually indistinguishable from one another. [Furthermore,] it is intrinsically difficult to string together samples into meaningful music symbols."[12]

This assessment emphasizes the dependent hierarchic levels of coding in a parametric model, adherence to which allows the coded sound to be manipulated and transferred in a perceptually meaningful way. When sound is represented digitally, intervention at different levels of the hierarchy introduce different degrees of failure for sound to carry and transmit

[9] S.R. Holtzman, "An Automated Digital Sound Synthesis Instrument," *Computer Music Journal* 3, no. 2 (1979): 53.
[10] Ibid.
[11] Perry R. Cook, "Sound Synthesis for Auditory Display," in *The Sonification Handbook*, ed. Thomas Hermann, Andy Hunt, and John G. Neuhoff (Berlin: Logos Verlag, 2011), 198.
[12] Curtis Roads, *Microsound*, (Cambridge: MIT Press, 2001), 31.

information. Manipulating the shape of a digitized sound through parametric models (such as pitch and partial specifications) is far less damaging to the encoded sound than the manipulation of samples or segments of samples, or, at an extreme, the order of the bits that comprise each sample, which could lead to complete (acoustic) noise.

A highly parametric model consolidates numerous functions into a top-down hierarchical control structure, in which small or large parameter changes yield corresponding changes in the acoustic output. Cook addresses *parametricity* in the context of auditory display, where it plays a large role in the communicative prospects of data mapping.[13] Auditory display and sonification rely on the most perceptually salient features of music and sound synthesis to articulate relations within data sets.

Non-parametric models, such as those used in nonstandard synthesis techniques, do not present a sufficient analog to sound since the conditions of sampling, manipulating, and transferring sound as a *message* have been damaged, which may cause aspects of the coding process to become evident instead of transparent.

2.2. The Information/Matter Duality

Beginning in the mid-20th century, digital computing, advanced via the inter-discipline of cybernetics, affected a shift in epistemology as our material world became more and more easily equated with the digital abstractions we use to represent and understand it. Hayles describes this "contemporary pressure toward dematerialization … as an epistemic shift toward pattern/randomness and away from presence/absence."[14] The proliferation/ubiquity of information and communication technologies has given rise to the posthuman conception of information and materiality as distinct entities—that information is "separate from the material forms in which it is thought to be embedded."[15] In Shannon's MTC, for example, 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."[16]

A dualistic conception of information and materiality can be seen in various strands of sonic computing—from the practices of auditory display to algorithmic composition to real-time analysis and feature extraction. The information/matter duality also links directly 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 non-parametricity. 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

[13] Cook, "Sound Synthesis for Auditory Display."
[14] Hayles, *How We Became Posthuman,* 29.
[15] Ibid., 2.
[16] Ibid., 18.

> 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.[17]

The posthuman primacy of information necessitates the recuperation of materiality in the critical navigation of informatics. For Hayles, the distinction between presence/absence and pattern/randomness—the central dialectics in posthuman epistemology—is meaningful because presence/absence, she argues, "connects materiality and signification in ways not possible within the pattern/randomness dialectic."[18] 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."[19]

Acousmatic music, as a technologically mediated form, presupposes representational absence—the physical objects that may be *heard* are never truly present. Yet, acoustically recorded or physically modelled sound can signify presence as a trace left by physical action. Sounds can imply human agency or material embodiment in physical space without visual cues. Part of what distinguishes anacoustic sound constructions is their deviation from such acoustic patterns as they cross over to exclusively informational origins where "meaning is not front-loaded into the system, and the origin does not act to ground signification."[20]

Anacoustic strategies, by foregrounding the mechanical, processual, abstract nature of encoding, evoke a metaphoric distance between material and encoded realities. 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?"[21]

3. Waveform Segment Techniques

Gottfried Michael Koenig's *Sound Synthesis Program* (1971) is an early example of nonstandard synthesis. Serial techniques were central to Koenig's concept of *programmed music*, as shown in his earliest computer experiments, *Project 1* (1964) and *Project 2* (1966): "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."[22]

Berg, Rowe, and Theriault provide a detailed account of the SSP's operation, which can be viewed as algorithmic composition at the audio rate.[23] Waveform segments are constructed

[17] Hayles, *How We Became Posthuman,* 13.
[18] Ibid., 247.
[19] Ibid., 285.
[20] Ibid., 286.
[21] N. Katherine Hayles, "How We Became Posthuman: Ten Years On; An Interview with N. Katherine Hayles," *Paragraph* 33, no. 3 (November 2010): 327.
[22] G.M. Koenig, "Composition Processes," 1978, http://www.koenigproject.nl/indexe.htm (accessed May 20, 2017): 4.
[23] Paul Berg, Robert Rowe, and David Theriault, "SSP and Sound Description," *Computer Music Journal* 4, no. 1 (Spring 1980): 25.

and manipulated with algorithmic functions before they are sequenced and looped for a specified duration.

Similar to SSP, Herbert Brün's SAWDUST implements a waveform segment technique whereby a complex wave is constructed from the combination of segments of variable length and amplitude:

> 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.[24]

A novel aspect of SAWDUST was its ability to gradually transform from one waveform to another by computing a new wave (or *link* in the program's terms) upon each wavetable iteration.[25]

Both SSP and SAWDUST represent a distancing of composition from an embodied experience of sound—both performative bodies and the experience of human listening as sound is rendered an epiphenomenon superseded by abstract code structures.

Despite the anacoustic origins of sounds specified in SSP and SAWDUST, both systems entertained the possibility of perceptually determined interventions. In SSP, a sound is generated, and modifications are made following listening and evaluation, thus adding a level of aural logic to the process. Brün's work exhibits a tendency to temper the unpredictable spectra of nonstandard synthesis with traditional modes of pitch organization. Luc Döbereiner suggests, for example, that Brün's 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."[26] While this technically contradicts a premise of sound construction that is purely anacoustic, I acknowledge that poietic compromises are inevitably made that tether otherwise anacoustically generated material to 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 what language means."[27] The *sound* negotiations made on behalf of the (post)human in an anacoustic modality can be thought of as an *acoustic salvage*.

4. Dynamic Stochastic Synthesis

With *dynamic stochastic synthesis*, Xenakis moved beyond the "lifeless sound made up of a sum of harmonics produced by a frequency generator," and closer to the noisy complexity of

---

[24] Herbert Brün, Liner notes to *SAWDUST Computer Music Project*, EMF 00644, CD, 1998.
[25] Herbert Brün, *A Manual for SAWDUST*, ed. Arun Chandra, https://sites.evergreen.edu/arunchandra/wp-content/uploads/sites/395/2018/05/sawdust.pdf (accessed December 5, 2021).
[26] Luc Döbereiner, "Models of Constructed Sound: Nonstandard Synthesis as an Aesthetic Perspective," *Computer Music Journal* 35, no. 3 (2011): 33.
[27] Hayles, "Ten Years On," 327.

transient sound phenomena.[28] He 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 CEMAMu, Paris, where he wrote the computer program, *GENDY* (GÉNération DYnamique).

Focused discussions on GENDY's operation can be found in Di Scipio (1998), Hoffman (2000), Luque (2009), Serra (1993), and Xenakis (1992) among others. GENDY divides a waveform into several segments and applies continuous variation (via stochastic functions) to the end-points of each segment, affecting both time and amplitude components of the wave. The elastic barriers that define each wave cycle allow control over the degree of regularity or randomness of the waveform shape, thus creating a spectral continuum from static pitch (high periodicity and symmetry) to noise (low periodicity and symmetry).

GENDY is a unique approach to waveform construction because it attempts to link waveform patterns with types of spectra. In "Anacoustic Modes of Sound Construction", I describe GENDY as a dance between practices of inscription (i.e. time-domain synthesis) and incorporation (which cannot be separated from material origins).[29]

5. *Musica Iconologos*

Yasunao Tone's first CD project, *Musica Iconologos* (1993), presents an idiosyncratic implementation of nonstandard synthesis that reconfigures the practice of audification into a noise-incurring process. Starting with excerpts from the *Shih Ching*, the earliest Chinese poetry anthology, Tone matched text characters with photographic images derived from the text's ancient pictographic forms.[30]

After the images were digitized, Tone analyzed each utilizing functions from *Optical Music Recognition* (OMR) software developed by Ichiro Fujinaga 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. A histogram is then generated based on the projection data for each axis as seen below in Figure 1.[31]

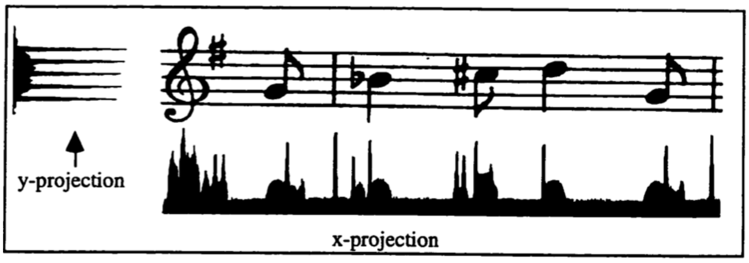

Figure 1. X/Y projection data from OMR software (Fujinaga 1997: 35).

[28] Iannis Xenakis, *Formalized Music: Thought and Mathematics in Composition*, revised edition (Stuyvesant, NY: Pendragon Press, 1992), 244.
[29] Seaback, "Anacoustic Modes of Sound Construction," 7-8.
[30] Yasunao Tone, "John Cage and Recording," *Leonardo Music Journal* 13 (2003): 12.
[31] Craig Kendall, Liner notes to *Musica Iconologos,* Yasunao Tone, Lovely Music, Ltd. LCD 3041, CD, 1993.

Waveforms were 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.[32] These combinations represent collections of binary words—bits (zero or one) generated from pixels (white or black).

The resulting 187 sounds – each derived from a single image, averaged only about 20 milliseconds each in duration. Digital editor Craig Kendall's task was to "uncover and shape the larger sounds that lay within each short 20 ms burst."[33] Another form of acoustic salvage, he used common digital signal processing techniques such as time stretching and pitch shifting to reflect the time span and phonetic inflections of the 'words' as if they were spoken.

In *MI,* traditionally communicative systems are transformed via their digital deconstruction and integration—the communication of poetry (language), image, and sound. *MI* comments on the volatility of information through its disparate translations of a common source. This altered mode of signification underlying the operation of information and communication technologies is referred to by Hayles as *flickering* signification.

6. Anacoustic Traces

This section examines the immanent dimension of anacoustic modes—the trace in sound—which exhibits spectromorphological attributes engendered by the time-domain synthesis paradigm. I suggest that the immanent level carries information that can be identified for its contribution to listener impressions of artificial (or digital) origins. I do not claim this analysis to be comprehensive, but rather, a selective contribution to my heuristic framework built around the anacoustic concept.

Of central importance in analyzing the anacoustic trace is its relation to the phenomenon of resonance, a marker of the physicality of sound.

6.1. 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 physical action—details that collectively signify presence.

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 that signify the movements or utterances of a human agent. The way that we relate sound to incorporated practices (and by extension, embodiment) has been referred to by Andrew Mead as *kinesthetic empathy*.[34] 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)

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

> 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.[35]

Embodiment is also central to composer Denis Smalley's concept of *gesture* in acousmatic listening:

> 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 …
>
> When we hear spectromorphologies we detect the humanity behind them by deducing gestural activity … [36]

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

Sound constructions, on the other hand, are distinguished by their tenuous relation to embodiment as Katharine Norman 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."[37] This kind of impression can be traced back to the erasure of transient complexity in favor of replication 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!"[38]

Musica Iconologos and other anacoustic works similarly place the listener in a scenario where sound origins may be unrecognizable or at least untraceable to known physical causes. But despite the absence of physical origins, many sound constructions in today's predominantly electronic-industrial soundscape are associated with the tools (digital or otherwise) used to create them or the environments in which they are typically found. Some general observations can be made about the spectromorphological ramifications of sound construction, which help to identify idiomatic properties of digital audio.

6.2. Invariance

Invariance might be used to describe many facets of an informational ontology: invariances 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

[35] Marc Leman, *Embodied Music Cognition and Mediation Technology* (Cambridge: MIT Press, 2008), 93-94.
[36] Denis Smalley, "Spectromorphology: Explaining Sound Shapes," *Organised Sound* 2, no. 2 (1997): 111.
[37] Katherine Norman, *Sounding Art: Eight Literary Excursions through Electronic Music* (Aldershot: Ashgate, 2004), 13.
[38] Ibid., 14.

invariant time and frequency grid to be filled with discrete sound particles, or acoustic *quanta*. Quantum approaches to sonic computing have been comprehensively documented by Roads and defined as *microsound*.[39] 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.

6.2.1. Spectral Invariance

The 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. Nonstandard synthesis naturally generates spectra characterized by (at an extreme) a flat frequency response, meaning a relatively equal (and invariant) distribution of energy among partials. This property contrasts the spectral patterns of acoustic instruments, which are determined by resonance and the natural concentration of energy around vibrational modes close to the fundamental frequency.

Certainly, one of the affordances of synthesis is the ability to explore and manipulate high register partials that are inaccessible or transient in the acoustic instrumental domain. The difficulty with nonstandard synthesis lies in the formation of meaningful relationships between waveform shapes and timbre. Some correlations (well known to electronic musicians) 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*.[40]

SAWDUST generates sharp steps by design and GENDY, sharp corners. *Musica Iconologos* is characterized by waveforms that exhibit pulse and step-like behavior (Figure 2)—spectra do not significantly decrease in energy over the audible range.

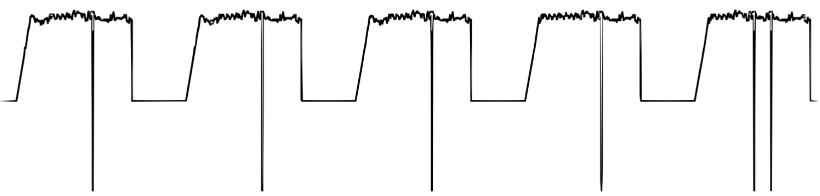

Figure 2. Waveform segment from *Jiao Liao Fruits*.

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

6.2.2. Temporal Invariance

The temporal invariance of sound constructions can be heard in the mechanical precision of pulse-based computer music like *zero degrees* or in the sample-accuracy of time-domain granular synthesis. It is also evident in fixed-wavetable lookup synthesis, i.e. digital oscillators, which generate invariant spectra—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.

6.2.3. Anechoic Spaces

Lastly, an *anechoic* spatial profile characterizes anacoustic and other types of sound construction. Anechoic implies without reflections or echo. When sound arrives at the ears of the listener, it is typically a combination of this direct sound vibration with many time-delayed reflections that have bounced off surfaces within the listener's 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 objects that, as micro spaces, reinforce and cancel different frequencies over time.

7. Synthesis & Virtual Semiotics

Hayles's semiotic square, encompassing her *semiotics of virtuality*, is a heuristic device used to map the posthuman concept as a literary phenomenon, linking the central dialectics of presence/absence with pattern/randomness. When applied as an analytical framework to the creation and interpretation of acousmatic music, the semiotic square (Figure 3) illuminates relationships between embodied complexities, representational absence, informational patterns, and noise (synonymous with randomness). I view the semiotics of virtuality as a creative springboard toward musical expression that considers the computer for both its idiomatic and representational capabilities.

The terms that comprise Hayles's semiotic square interact dynamically with their partners:

> 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 originary plenitude. Randomness tears holes in pattern, allowing the white noise of the background to pour through.[41]

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

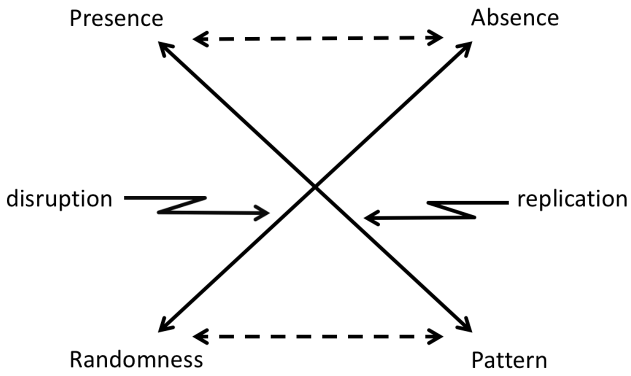

Figure 3. The semiotics of virtuality.[42]

Bringing the dynamic interaction between the primary dialectics to the foreground, new synthetic terms emerge (Figure 4):

> 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 between absence and pattern can be called, following Jean Baudrillard, hyperreality.[43]

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.[44]

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."[45]

[42] Ibid.
[43] Ibid., 249.
[44] Ibid., 250.
[45] Ibid.

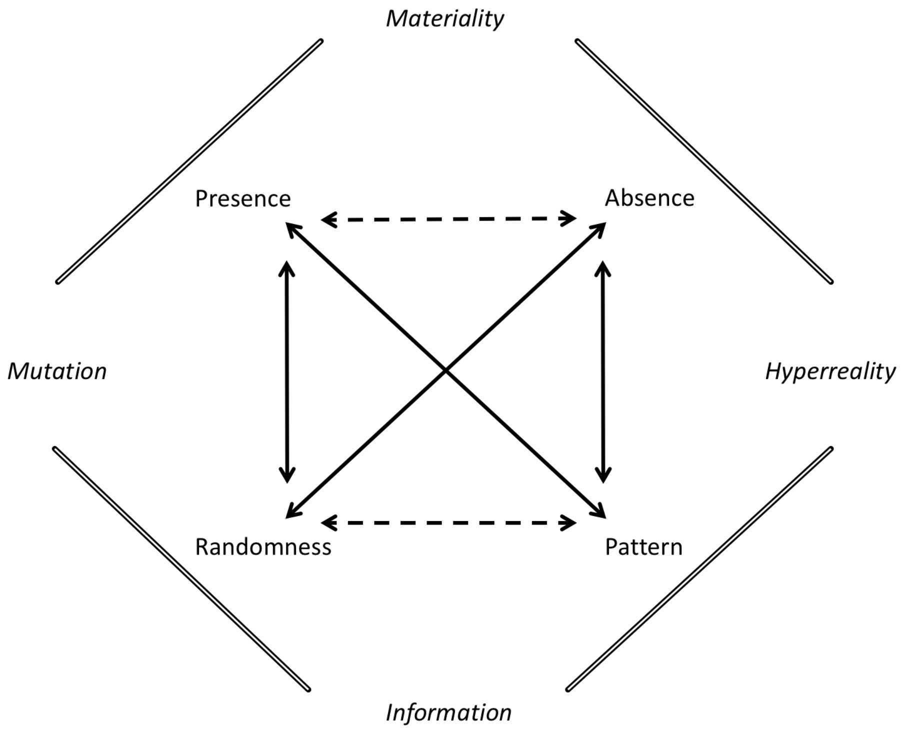

Figure 4. Semiotic square with synthetic terms.[46]

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 disrupts 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 embodied human experience.

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

In *Musica Iconologos*, Yaunao Tone channels the information of materiality through the digital abstraction of image while, in sound, presenting something closer to the materiality of information as there is no parametric barrier (at least at the production stage) between the sound and its code structure (remember that all sounds were edited to make them 'acoustically' viable).

7.1. Current & Future Developments

Beyond the anacoustic, I am exploring methods to illuminate other dimensions of the semiotic square—those equally anchored in presence, which can be coopted by pattern or transformed by noise. A voice sings and becomes frozen in time—a static aggregate of overtones—a body representation. Or it is mutated—a physical model extended beyond physical boundaries, or a

[46] Ibid., 249.

distorted semblance of language. 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, functioning as powerful signs of presence in a hyperreal aesthetic space.

These dimensions are the subject of my current artistic research project, “The Semiotics of Virtuality,” supported by the Norwegian Academy of Music. This research is practice-based, culminating in a body of work exploring sound as both an acoustic phenomenon and informational entity.

Since beginning this project in the Fall of 2020, the anacoustic concept which preceded it has acquired new critiques and considerations. In contemporary practice, a strict expression of anacoustic sound construction can be nebulous. Low-level interventions in the encoding hierarchy are most easily performed within high-level, object-oriented platforms using high-level objects which, themselves, encapsulate deeper layers of computation. No matter the origin, when rendered as *sound*, data becomes perceptually viable and acoustic salvage necessarily occurs at various stages. Noise is composed.

But the concept leads to other questions regarding the ontology of information: the effect of digital translation in the context of sonic-informational renderings and idiosyncratic mapping processes. Levels of computational intervention then, are not necessarily equated with ‘low-level’ coding schemes, but with ad-hoc models of signal and noise. The arbitrary links composed in the hierarchy of parametric models are referred to by Hayles as “flickering signifiers,” characterized, “by their tendency toward unexpected metamorphoses, attenuations, and dispersions.”[47]

Enriching the notion of presence in virtual semiotics, studies in embodied music cognition integrate digital tools to show how certain aspects of sound and music are ‘encoded’ in our bodies, thus giving credence to the notion of an original plenitude of presence and conceptions of tacit knowledge. For the *Semiotics of Virtuality* project, anacoustic modes present a condition of immateriality that both problematizes and enriches prior notions of materiality. The interplay of these diverging orientations becomes the focus as presence/absence (to re-quote Hayles), “connects materiality and signification in ways not possible within the pattern/randomness dialectic.”[48]

Some of my guiding research questions are:

- To what degree do informational renderings, re-mappings, or manipulations preserve or erase the ‘implicit substance’ of acoustic *presence* (to which concepts of *gesture* and *embodiment* are closely tied)?
- What continuums exist in performance, time, timbre, and spatiality that articulate certain positions within the semiotics of virtuality?
- How might orientations toward embodiment & materiality (presence/absence), and informational abstraction (pattern/noise) be expressed technically and metaphorically?

[47] Hayles, *How We Became Posthuman*, 30.
[48] Ibid., 247.

8. Summary

In digital sound construction, the computer functions as a channel which, through its own unique ontology, encourages a posthuman orientation where the materiality of sound is linked to the parametric reductions of digital tools. Sound becomes a real, but malleable substance that can be altered via commands sending chain reactions through a multitude of informational hierarchies. Diverging from the instant and continuous feedback a performer receives from an acoustic instrument, the computer musician must constantly alternate between an embodied experience of sound and its abstract underpinnings in code. The semiotics of virtuality offers ways to view the digital medium as an idiomatic voice via anacoustic modes and as a window into the physical world through acoustic simulation and parametric models. Composers enact this dynamic by considering hierarchic levels of intervention in the sound design process and correlated byproducts of digital invariance, which, in turn, spills into the world of sonic metaphor and musical poetics.

9. References

Bayle, F. Musique acousmatique: propositions … positions. Paris: Buchet/Chastel. 1993.

Berg, Paul, Robert Rowe, and David Theriault. "SSP and Sound Description." Computer Music Journal 4, No. 1 (Spring 1980): 25-35.

Brün, Herbert. A Manual for SAWDUST. Edited by Arun Chandra. Web. http://academic.evergreen.edu/a/arunc/brun/sawdust/sawdust.htm (accessed May 2, 2017).

Brün, Herbert. SAWDUST Computer Music Project. EMF CD 00644. CD. 1998.

Cook, Perry R. "Sound Synthesis for Auditory Display." In The Sonification Handbook edited by Thomas Hermann, Andy Hunt, and John G. Neuhoff, 197-235. Berlin: Logos Verlag, 2011.

Demers, Joanna. Listening Through The Noise: The Aesthetics of Experimental Electronic Music. New York: Oxford University Press, 2010.

Di Scipio, Agostino. "Compositional Models in Xenakis's Electroacoustic Music. Perspectives of New Music 36, No. 2 (1998): 201-243.

Döbereiner, Luc. "Models of Constructed Sound: Nonstandard Synthesis as an Aesthetic Perspective." Computer Music Journal 35, No. 3 (2011): 28-39.

Floridi, Luciano. Information: A Very Short Introduction. New York: Oxford University Press, 2010.

Fujinaga, Ichiro. "Adaptive Optical Music Recognition." Ph.D. Dissertation, McGill University. 1997.

Hayles, N. Katherine. "How We Became Posthuman: Ten Years On An Interview with N. Katherine Hayles." Paragraph 33, No. 3 (November 2010): 318-330.

Hayles, N. Katherine. How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics. Chicago: University of Chicago Press, 1999.

Hoffmann, Peter. “Something Rich and Strange: Exploring the Pitch Structure of GENDY3.” Journal of New Music Research 33, No. 2 (2004): 137-144.

Holtzman, S.R. “An Automated Digital Sound Synthesis Instrument.” Computer Music Journal 3, No. 2 (1979): 53-61.

Koenig, G.M. “Composition Processes.” 1978. http://www.koenigproject.nl/indexe.htm (accessed September 21, 2017).

Leman, Marc. Embodied Music Cognition and Mediation Technology. Cambridge: MIT Press, 2008.

Luque, Sergio. “The Stochastic Synthesis of Iannis Xenakis.” Leonardo Music Journal 19 (2009): 77-84.

Mead, Andrew. “Bodily Hearing: Physiological Metaphors and Musical Understanding.” Journal of Music Theory 43, No. 1 (Spring, 1999): 1-19.

Moore, F. Richard. Elements of Computer Music. Englewood Cliffs, NJ: Prentice-Hall, 1990.

Norman, Katherine. “Concrete Tales and Touching Times.” In Sounding Art: Eight Literary Eight Literary Excursion through Electronic Music, 1-22. Aldershot: Ashgate, 2004.

Ostertag, Bob. “Human Bodies, Computer Music.” Leonardo Music Journal 12 (2002): 11-14.

Roads, Curtis. Microsound. Cambridge, MA: MIT Press, 2001.

Serra, Marie-Hélène. “Stochastic Composition and Stochastic Timbre: GENDY3 by Iannis Xenakis.” Perspectives of New Music 31, No. 1 (1993): 236-257.

Shannon, C.E. “A Mathematical Theory of Communication.” Reprinted from Bell System Technical Journal, 1948 in Mobile Computing and Communications Review 5, No. 1 (January 2001): 3-55.

Smalley, Denis. “Spectromorphology: Explaining Sound Shapes.” Organised Sound 2, No. 2 (1997): 107-126.

Tone, Yasunao. “John Cage and Recording.” Leonardo Music Journal 13 (2003): 11-15.

Tone, Yasunao. Musica Iconologos. Lovely Music, Ltd. LCD 3041. CD. 1993.

Xenakis, Iannis. Formalized Music: Thought and Mathematics in Composition. Revised Edition. Stuyvesant, New York: Pendragon Press, 1992.