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# Sound Synthesis Procedures as Texts: An Ontological Politics in Electroacoustic and Computer Music

**Abstract:** This article describes a set of "textual" technological practices that have been emerging over the past decade in the work of underground electroacoustic and computer music composers, focusing particularly on Florian Hecker and Russell Haswell. Guided by methodological insights from the field of software studies, the article zooms in on two computer programs, PulsarGenerator and GENDYN, presenting a genealogical analysis of them as cultural objects and outlining how these lines of descent are aestheticized in their works. In the hands of these artists, sound synthesis procedures carry an author function, and this transgresses both their legal status as technological "inventions" rather than texts, as well as their ontological status in the electroacoustic music genre. Combined with a compositional focus on "sounding" the materiality of these technologies—the particular affordances, limitations, and quirks of their operative functioning—this textual practice contributes to a new aesthetic, one that challenges the prevailing logic of secrecy, alchemy, and semblance in this music. Using the notion of "ontological politics" inherited from science and technology studies, I show how these practices highlight zones of contestation over electroacoustic music's ontology.

In 2008, a piece of code was shared on the online forum for users of the graphical programming environment Max that was purported to be the work of the British electronica duo Autechre. Autechre are a notoriously clandestine outfit, especially regarding their working methods, so this rare insight into their *téchne* naturally garnered some interest. The code itself is visually very messy and the only instruction on the screen is to "load a short .aif and then press spacebar." This action launches a sequencer that triggers polymetric patterns comprising short synthesizer sounds; they approximate kicks and snare drums, as well as "laser" sounds, so-called "gabber steps," and other sound effects. It sounds a bit like Autechre, at least close enough for the code to be debated in nearly 150 subsequent posts. The discussions it elicited ranged from the question of whether or not information "wants" to be free; to what constitutes an instrument and what a "trick" or "effect" in electronic music practice; to the role software environments play in creativity and whether they should be credited in CD publications; to questions of open and closed source software and the types of behaviors, secretive or pedagogical, that these engender in their online communities. Most of all, though, the discussions concerned the code's authenticity. Many of the messages had an anticlimactic tone, as though it ought to have been more interesting and complex if it were really by the artists themselves. After nearly 100 messages had been posted, a user called LOTA joined the conversation claiming to be Sean Booth, one half of Autechre. He shared some context on the artifact, calling it a "Sunday afternoon postcard" that he had composed to send to Rob Brown, his bandmate. Perhaps unsurprisingly, the question then shifted to the authenticity of LOTA himself. Was he really who he said he was, and if so, how could he prove it? "Security question: how grim is Rochdale?" somebody asks (Rochdale being Autechre's hometown).

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## Secrecy, Alchemy, Semblance

This event, simultaneously singular and commonplace, illustrates several key ontological constituents of electronic music as a cultural form. There is "secrecy," in the whispers and intrigue about what is normally unseen; "alchemy," in the determination to undermine the authenticity of the code and thereby retain Autechre's arcane mystique;

and "semblance," because it is electronic music's appearance—a performer standing behind a laptop screen, a concert with only loudspeakers, or an anonymous white label vinyl record—that brings about these qualities. The historical precedents for this are often traced back to Pierre Schaeffer and his notion of "reduced listening," a procedure that seeks to cultivate a kind of radical "presentness" wherein only the object of present perception is attended to, rather than its object-causes or semantic referents. What is left behind, following this intentional sensory bracketing, is what Schaeffer called the "acousmatic": the content of my perception rather than its cause. The word—itself derived from the Ancient Greek *acousmatikoi*—is a reference to the name given to Pythagoras' disciples, who would listen to the master's lectures from behind a curtain (Kane 2007). This occultation of the means of production has lent to electroacoustic music an enduring origin story, but it should be remembered that, for Schaeffer, the acousmatic situation was determined, first of all, by technology. He thought that sound reproduction, radio, and telecommunications technologies were essentially habituating us to circumstances that Pythagoras had to artificially construct; everyday auditory experience in the modern world meant listening to disembodied voices (Kane 2007). In the majority of electronic music of the past 15 years, this technologically determined acousmatic reduction has been imposed by the use of a personal computer, a black box with its own economy of visibility and invisibility, secrecy and transparency. Only rarely is it possible to produce knowledge about how a piece of electronic music was made via the traditional techniques of textual analysis (i.e., through sonograms), or by observing what a performer is doing. Instead it requires a specialist "technological" ear, ethnographic research and interviews, or doing as the aforementioned online electronic music community allegedly did, and stealing from the artists themselves.

There have been efforts to challenge this situation in recent years and promote a more transparent, even pedagogical, approach to electronic music. The ever-expanding live-coding scene represents perhaps the most well-documented and coherent example of this to date, an attempt to divest the concealed worlds of studio techniques, programming environments, and computer code of their mystique and reimagine them as essential visual signifiers of the scene. This article focuses on a related aspect of this new musical ontology. I describe a particular set of rhetorical, even curatorial, sound practices that have been emerging over the past few years in the work of a group of "underground" electroacoustic music composers, particularly Florian Hecker and Russell Haswell. Discursively, these artists situate themselves in relation to the artistic and technological developments of post-war modernity and the primarily academic traditions of electroacoustic art music, and yet the way they frame their work is quite different. Against the secrecy, alchemy, and semblance complex, their works strategically invoke the names of selected 20th century composers in ways that adhere to certain classic strategies of postmodernism (Haworth 2013). Most interestingly of all, this (what I will call) "textual" practice encompasses their uses of technology, a body of knowledge that electroacoustic music has historically tended to welcome with one hand while pushing it away with the other.

## Ontological Politics: The Status of Technology in Electroacoustic Music

Electroacoustic music is far from alone among art forms in casting its necessary relationship to technology in terms of a problem that needs to be dealt with. But in terms of the sheer quantity of intellectual effort that has been expended on smothering the technological support upon which it relies, it is distinctive. Denis Smalley's notion of *spectromorphology* has had a great influence on the contemporary discourse and practice of this music and, in a much-cited article of the same name, he simply and concisely articulates a position that continues to permeate the thinking on technology in the discipline. In a section called "Ignoring Technology," Smalley asserts that the listener must

> try to ignore the electroacoustic and computer technology used in the music's making. Surrendering the natural desire to uncover the

> mysteries of electroacoustic sound-making is a difficult but necessary and logical sacrifice (Smalley 1997, p. 108).

He argues further that the object of spectromorphology is formal analysis of content and structure, not processes and techniques; so figuring out the assorted technological procedures used by the composer is a false path towards "true musical meaning." In this, Smalley echoes Schaeffer—his censure of technological listening essentially amounts to the advocacy of reduced over-causal listening. But there is another aspect to this, which is disclosed when he argues that sound textures and events are "rarely the result of a single, quasi-instrumental, real-time, physical gesture . . . while in traditional music, sound-making and the perception of sound are interwoven, in electroacoustic music they are often not connected at all" (Smalley 1997, p. 109). The implication here is that the technologies at the electroacoustic music composer's disposal are not, properly speaking, musical instruments at all, as one's interaction with the individual parameters of a sound synthesis, signal processing tool, or software instrument does not carry salient information from the perspective of music perception. Smalley concludes that "ideally the technology should be transparent, or at least the music needs to be composed in such a way that the qualities of its invention override any tendency to listen primarily in a technological manner" (Smalley 1997, p. 109).

Although Smalley does not define it in philosophical terms, spectromorphology is an ontology of music. Its object—electroacoustic art music—is not merely described but it is constructed, and prescriptively delimited, through the intricate conceptual and discursive framework it sets forth. (This is illustrated by the fact that, although ostensibly a technique for understanding and analysis, its influence has stretched much further, to production; cf. Blackburn 2009.) Now, in describing this as ontology, I draw on a social constructivist understanding of the term inherited from science and technology studies (STS; cf. Latour 2002), and recently carried over to music and the study of work concepts by Georgina Born (2013a, 2013b). Scholars of STS, such as Annemarie Mol, accept "that 'reality' does not precede the mundane practices in which we interact with it, but is rather shaped within these practices"; therefore, what a thing "is" is not closed and simply lying there waiting to be interpreted, but open, actively practiced, and under negotiation (Mol 1999, p. 75). So although the complex of secrecy, alchemy, and semblance in electroacoustic music may appear to be stable, given, and universal, as though a purely technological determination, a challenge to the dominant ontology can reveal the relational, historical, and immanently political nature of this "reality."

This detour into art's "ontological politics" (Mol 1999; Born 2013a, 2013b) illustrates both how an ontology can hold dominance, assuming the status of "truth" or "common sense," and how other, putative ontologies can arise to contest it. Conceived here as the dominant mode, spectromorphology's ontology hinges on a version of the so-called "neutrality thesis." This is the view that technology is value-neutral and exists merely as a means to some predetermined end (Feenberg 1995, p.23). Most famously critiqued by Martin Heidegger (1977), neutrality in art goes hand in hand with the idealist notion that the artist's tools are no more than a conduit of an unmediated and determinate vision. Of course, such Romantic humanism does not do full justice to Smalley's position; as noted earlier, spectromorphology is equally a discursive strategy for dealing with the types of instruments that computer technologies are assumed to be and the particular instrumentalities they are assumed to afford. Because the theoretical model of a sound-synthesis or signal-processing procedure and its material implementation in software are not bound by any necessary relationship, multiple instantiations arise—commercial, open source, self-authored custom software—each bearing different interaction paradigms. From the perspective of this seemingly endless difference, conceiving of technology as "just tools" represents a way of navigating the variegated terrain of electronic music techniques: it is to scrape away complexity to uncover the music's perceived "essence."

Recent approaches to electroacoustic music practice a very different ontology. By drawing the names of the authors of computer programs and the inventors of computer music techniques into

their works, while also sounding the materiality of these (primarily) digital instruments, this group of underground electroacoustic music composers initiate a set of technical, discursive, and aesthetic strategies for, channeling Born, "politicizing" the status of technology in electroacoustic music. Actively constructing a syntax of "tricks," "effects," and "techniques" around a restricted set of carefully chosen and niche sound-synthesis procedures, their music reflexively describes and produces an aesthetic of radical "medium specificity" around their curated software ecology. As I will demonstrate, this approach necessarily challenges some of the resounding notions about digital media in our cultural imaginary: namely, that they are immaterial, plural, and endlessly mutable and transferable across platforms. Many of the key practitioners move freely between analog and digital media, and this nonpartisan attitude inflects the emerging scene. But rather than follow scenes or composers especially, my focus in this article will be on some of the digital instruments they use: their materialities, histories, and how these are channeled in their works. Such a methodology recognizes that instruments have a "social life" that exceeds their mere "thingness," participating in aesthetics, genres, and the formation of individual–collective musical worlds (Dawe 2003). It may equally be seen to respond to the pressing call, made by Agostino Di Scipio (1995b) and Peter Manning (2006), to observe the centrality of *techné* in electroacoustic music. In this way, my methodology follows authors such as Volker Straebel (2008) and Manning and Clarke (2008), who have each devoted their attention to uncovering the subtle links between *techné* and aesthetics in composers' practices. Where I divert from these authors, however, is by considering how practitioners themselves actively perform technology's meaningfulness. Whether a composer deems technology to be "neutral," as in the case of Smalley; "substantive," as we will see in the work of Hecker and Haswell; or something else entirely, I proceed under the assumption that these positions have real effects: They are not merely supplementary. The practices I describe constitute material-discursive engagements with the question of what technological music "is." This is their ontological politics.

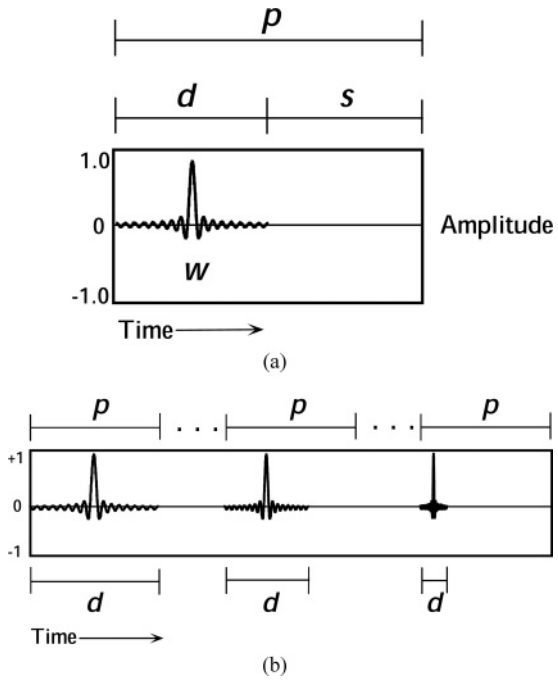
In what follows, I provide a close analysis of two computer programs that have played a key role in the aesthetics of glitch, microsound, and "extreme" computer music genres—Curtis Roads's PulsarGenerator and Iannis Xenakis's GENDYN—presenting a genealogy of them as cultural objects. What are they, both technically and discursively? What styles of music do they afford and discourage, and what musical genealogies do they participate in? What sort of author function do they carry? Finally, how and why are these non-sonic aspects formalized and objectified in recent works? My aim is to show how the aesthetics and genres of electronic music are changing in response to ubiquitous computing. Where electroacoustic music once denoted an indistinct haze of sourceless, nameless, abstract electronic sound to all but those with the *techné*, today a rhetorical practice is emerging—one that is selective, distinguishing, even curatorial in its use of audio technologies.

## PulsarGenerator

PulsarGenerator (PG) is an interactive sound synthesis software program that was implemented by Alberto de Campo in 1999 when he was working with Curtis Roads at the CREATE studio in Santa Barbara, California. Popularized by Roads's (2001) book, *Microsound*, as well as the freely accessible .microsound mailing list, it is notable for acting as a material point of contact linking practitioners inside and outside of research institutions (see Cascone 2000; Thomson 2004; Demers 2010). Referenced in genres such as glitch, microsound, and "extreme" computer music, it has also played an important role in the work of institutional electroacoustic music composers such as Agostino Di Scipio, Damien Keller, Horacio Vaggione, and others.

PulsarGenerator produces a form of synthesis called pulsar synthesis (PS), a technique Roads himself invented. The procedure is sometimes considered a form of granular or particle synthesis because it works with short grains of sound, typically between 1 and 100 msec long. The grain in PS is, however, called a "pulsar," and a single pulsar consists of a short burst of energy, called the

*Figure 1. Anatomy of a pulsar (Roads 2001). A single pulsar (a) consists of a short burst of energy* w*, called a "pulsaret," with a duration* d *and followed by a period of silence* s*. The period of the pulsar is denoted by* p *and its total duration is given by* d + s*. Pulsars are emitted continuously in "pulsar trains" (b). The pulsar period* p *remains constant, while the pulsaret duration decreases. The ellipses denote the passage of time between each pulsar displayed.*



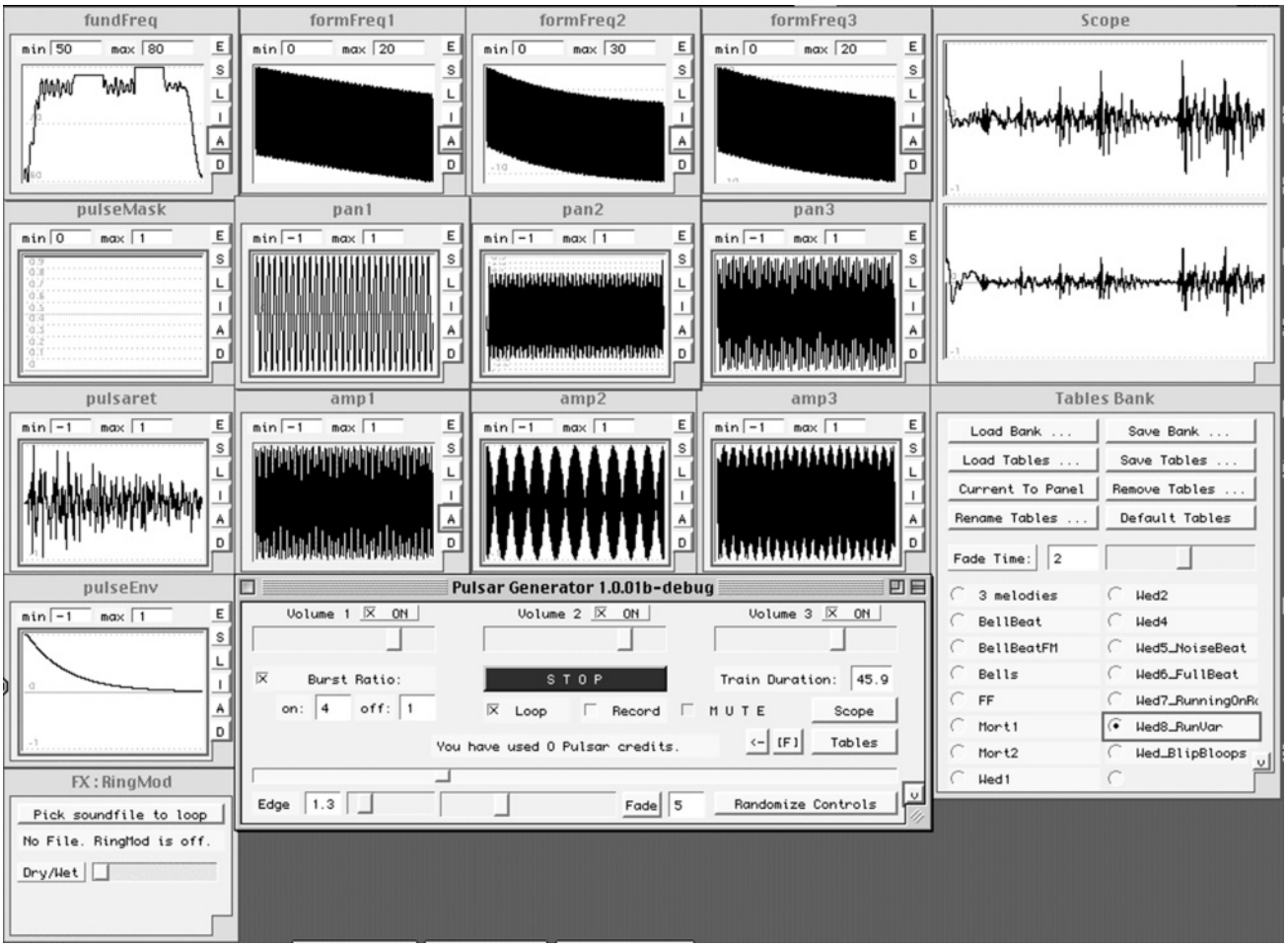

"pulsaret waveform," followed by a period of silence (see Figure 1). When the program runs, these pulsars are emitted continuously in what are known as "pulsar trains." The frequency of the pulsar train is independent of the duration of the pulsaret, which causes the latter to act rather like a vocal formant. Changing the duration of the pulsaret waveform while keeping the fundamental frequency constant creates a digital version of the effect one would achieve were one to sweep the center frequency of a band-pass filter connected to the output of an impulse generator. Karlheinz Stockhausen used the classic analog technique abundantly in *Kontakte*, and the signature sound of PS does emulate some of the material we know from this composition in its focus on the perceptual threshold between rhythm and tone. The potential control that PS affords is, however, only possible digitally (Roads 2001, p. 329).

Every aspect of the relatively simple circuit described here is a variable in PulsarGenerator. The pulsaret waveform, pulsaret envelope, spatial path, pulsar train duration, as well as the fundamental frequency, formant frequency, and amplitude envelopes: All are available for precise user control (see Figure 2). Drawing directly into graphs, which are essentially short time lines, can control three aspects of the pulsar train. The *x* dimensions of these graphs correspond to a global time and, when this is elapsed, the sound repeats. The time is given in seconds, which means that one does incredibly detailed work on a very small timescale to compose what is essentially a short loop of sound, usually not more than ten seconds in length. The graphs can be saved as presets and as many as three simultaneous sets of them can be morphed between over a variable duration. The morphing feature creates more time, taking us from durations of 1 to 10 sec up to durations of about 30 sec, but in order to avoid loops one would have to continually load pre-composed preset graphs, or else export the sound files and work on them in an offline audio editor.

Perhaps more than most categories of synthesis, granular synthesis (which includes PS) is endowed with an abundance of terminology, and many of its terms refer to the same underlying concept. Individual procedures like PS can seem more akin to compositional systems than they are to instruments. There is an aesthetic unity to them: Each founds a discourse. Taken as a system, we would say that PG privileges composition. Although edits can be auditioned while you work, the user typically works outside time to produce results to be utilized later; it would be incredibly difficult to play PG as a live instrument with any degree of satisfaction. Further, of the seven complex variables there are to control, only one incorporates randomness. This choice can be seen as an outward manifestation of the authors' preference for what could be called "absolute composition," a philosophy of electronic music descended from the Cologne studios, and ultimately from serialism. In its most radical guise, this approach entails using no material that is "given" from outside. No musical instruments, no recorded samples: Every feature right down to the microlevel is the outcome of a choice. (It was with respect to this that Herbert Eimert [1957] spoke of a "real musical control of nature.")

Now, many of the utopian claims that were made in the name of this new realm of control have come to be complicated by research on the perception of timbre, among other areas. Recent music theory

*Figure 2. Control panel of PulsarGenerator by Alberto de Campo and Curtis Roads (Roads 2001).*




has tended to view the relationship between microlevel organization and the ensuing percept as a "phenomenon of emergence, of nonlinear causality" (Di Scipio 1997, p. 166), and this calls into question the appropriateness of visually editing parameters at a grain of less than 100 msec (see also the discussion on "timbral transition" in Born 1995). All the same, this is the history we interface with when we use PG: The compositional imaginations of Stockhausen, Eimert, and Xenakis inform its architecture. Starting from "nothing," we proceed up through the various levels of musical time: from the microlevel of timbre, to the minilevel of note, to the mesolevel of polyrhythm, to the macrolevel of form (Xenakis 1992, p. 266). Pulsar synthesis operates between the microlevel and the mesolevel, which is something I will come to shortly.

### *PulsarGenerator in Practice*

PulsarGenerator was implemented in SuperCollider 2 and released as freeware in 2001. At the time of this writing, the link to the software on Road's site has expired, so in order to use it one has to acquire it via the authors themselves. Because it has not been updated, it requires a Macintosh computer running OS 9 to run. And although a couple of re-implementations have been attempted in recent years, these either extend upon the original design (Wilmering, Rehaag, and Dupke 2012) or are not

publicly available. (For example, Tommi Keränen rewrote the software in SuperCollider 3 and distributed it to friends.) PulsarGenerator is therefore an elite, idiosyncratic, and specialist tool, and its eccentricity and inaccessibility certainly feeds into the attraction for many artists (Blonk and Van Peer 2005). It may also explain the strange tendency for artists to actually cite the software in their work, either via liner notes or in track titles. This is a relatively new development, and one that runs counter to the prevailing logic of secrecy, alchemy, and semblance in electronic music. The earliest example of this paratextual practice is on Kim Cascone's (2004) *Pulsar Studies*, which was released as a download-only album by the Falsch label. Each of the 20 tracks is approximately one minute in length, which situates it somewhere between high-concept minimalism and a technical demonstration CD that might accompany an instructional textbook. The rhythm–tone threshold is a central formal device that serves to identify the software instrument in some tracks, but a great deal of postproduction signal manipulation is also used. Cascone writes:

> What the raw data is isn't probably very interesting by itself, but when you use it with other data, when you convolve it with other data, or do ring modulation, so on and so forth, it can create very interesting textures that evolve other time. So I just basically worked up a whole palette of files and then incorporated them into a final piece as I went (Cascone 2000).

On tracks such as *Stratified Rhizomes*, the frequency domain processing is so strong that the source is rendered mostly unrecognizable; an approach that echoes extreme sample-manipulation practices, where some of the enjoyment in listening derives from how far the result differs from the original source. But Cascone's methodology in *Pulsar Studies* is most clearly informed by Curtis Roads's own compositional work. It is a brand of microformalism where, through potentially endless processes of granulation, filtration, pitch shifting, reverberation, and so on, one short sound sample may derive the material for a whole piece (Roads 2001, p. 156).

What Cascone describes disparagingly as "raw data" in the earlier quote becomes the site of a somewhat stranger genre of formalism in more recent uses of PG. This approach, which I would call "medium specific," has come to be a reasonably common way of working with the software in underground computer music genres. It is interesting because it actually goes against the implicit purpose of the program, which was always for Roads a tool for experimenting with sonic ideas to be mixed with other material at a later stage in a composition (Roads 2001, p. 156). In Hecker's *Pulsar Wg'lett*, the nagging, repetitive quality of PG is undisguised despite the fact that this could easily be viewed as a limitation of the software from the perspective of real-time performance. The track features on the album *Recordings for Rephlex* (Hecker 2006), a collection of eight computer music compositions that are each accompanied by a short technical description in the liner notes detailing the audio software used and the events for which the pieces were commissioned. Most of the acoustic detail is achieved by careful editing of the graphs and slow morphing between saved settings inside the program in real time. Offline treatment of the material is used to exaggerate the microtemporal and timbral detail of the pulsar trains, but no transformation of the sounds is employed, nor is there any attempt to mix them with other sounds. Instead, the output of the program—what Cascone had termed the "data"—is presented bare and unadorned. The piece explores a space between the comic and the grotesque. Frantic "zipping" sounds are microtemporally sequenced such that they resemble the temporal structure of speech patterns, and this results in sounds that appear to mimic or even mock human speech. Though there is a single unified "voice" that maintains for the majority of the piece, the spatial imagery changes in depth and positioning continually, at times becoming diffuse as the audio signal is decorrelated. This detailed microsonic organization is intercut with material that operates at the timescale of individual pulses: rhythmic accelerandi and ritardandi that recall classic analog instruments based on filtered pulse trains (Roads 2001). The fact that this flat juxtaposition between sounds that code as "speech-like" and sounds that

code as "music-like" appears to emanate from the same instrument, rather than different sources, is an accomplishment of the composition, but some work is done by paratextual elements of the CD such as the liner notes and titling. This framing strategy influences our listening, cementing the sense that we are hearing a single unified voice morph, distort, break apart, and come back together again, rather than several discrete sound objects mixed together.

Hecker's brutalist "truth to materials" approach is echoed by two works from Russell Haswell's (2011) album *ACID nO!se Synthesis,* entitled *nO!se Pulsar* and *Pulsar Anthem*. Emulating friction sounds like sawing, scraping, twisting, and tearing, these pieces obtain a similar "hyperrealness," as though a performer with two hands could have created them, physically. The album as a whole is the product of an intriguing recording process: Haswell monitored the audio both aurally and visually, connecting the stereo outputs of the computer or analogue synthesizer to the $x - y$ inputs of an oscilloscope and accepting only those pieces that produced interesting Lissajous images when "scoped" (electronic mail correspondence, 29 September 2014). Because the results were issued as an audio CD rather than a multimedia release, however, what the listener encounters is effectively half of the information; to experience the full audiovisual experience one has to source a software oscilloscope independently.

This strange compositional process is evident *nO!se Pulsar*, which is built around a ramping motif that changes in rhythm, timbre, and duration with each permutation. In technical terms, the fundamental frequency contour is kept more or less intact while the other parameters—formant frequency, amplitude curve, spatial trajectory and so on—are altered. This is exaggerated either by convolving the source with other noise sources inside PG, or taking the signal and feeding it into an analog effects chain. (In the liner notes, Haswell pledges there were "no overdub[s], no MIDI" used on the recordings.) The pulsar train lasts in the region of four seconds, but each repetition is met with slight alterations to the pulse-train duration, which is the same as modulating a loop point. This aperiodicity is coupled with abrupt jumps and drops in intensity, which contribute to a strong sense of tension and unpredictability in the piece. The proximity of the "sound source" to the listener is dramatically choreographed with an emphasis on thrill and excitement. In this way, Haswell uses the facility for precise parameter definitions of PG against itself, to create the dynamism and unpredictability of noise music.

The works *Pulsar Wg'lett, nO!se Pulsar,* and *Pulsar Anthem* emphasize the propensity of PS for the "ecologically valid" reproduction of sound, a methodology that entails the emulation of behaviors of certain classes of sound rather than their precise imitation (Keller and Truax 1998). The pieces methodically explore the uncanny effect that transpires when these behaviors are stretched just beyond familiarity: when the threshold between named and nameless sound is "played" as a parameter.

## Dynamic Stochastic Synthesis

*Dynamic stochastic synthesis* (DSS) has come to assume a significant role as a sound generating method in contemporary noise and underground computer music (Hoffmann 2013). Though much recent scholarship has focused on the synthesis method itself (Luque 2009) and the sonic concepts it enfolds (Döbereiner 2011), what has yet to be considered in great detail is the work this sound does in forging connections between the high modernism of its creator, Iannis Xenakis, and the contemporary noise underground. (Two notable exceptions to this are Ikeshiro [2011], where links between Merzbow and Xenakis are described, and Haworth [2013].) This involves constructing a special kind of author function for DSS that, again, challenges the prevailing logic of secrecy, alchemy, and semblance in electroacoustic music. What follows is an attempt to address some of the myriad questions raised by DSS's latter-day appropriation. First, however, a brief primer on the technique is needed before going further.

Although not named until much later, DSS was an ongoing experiment in microsound synthesis that intermittently occupied Xenakis from the late 1960s until the end of his life in 2001 (Luque

2009). Its computer program counterpart was called GENDYN (general dynamic stochastic synthesis), but unlike PulsarGenerator, GENDYN was never intended for distribution outside of Xenakis's studio. It was the author's own system for creating automated computer music works using stochastic principles (music "out of nothing," see Xenakis 1992). As well as synthesizing sound directly (the DSS part), GENDYN implemented macrocompositional procedures that would "select the number of 'voices' (waveforms) activated at any one time, their points of entry in the time-line of the piece, and the duration of each of these segments for each voice" (Harley 2002, p. 54). Both the DSS technique and the GENDYN program itself have been implemented in other forms since 1996, but it is necessary to insist on the distinction between the two. GENDYN was an algorithmic composition system devised specifically for the creation of *Gendy301* (1991), *Gendy3* (1991, see Xenakis 1995 for a recording), and for *S709* (1994), whereas the technique that Xenakis described in *Formalized Music*, DSS, is a general procedure for generating a sound signal that varies in time and amplitude stochastically. Though the name GENDYN is often referenced in the title of various implementations of DSS (for instance iGENDYN by Nick Collins and GENDYN Choir by Alberto de Campo), only Peter Hoffmann's New GENDYN Program is an attempt at a recreation of the actual program Xenakis devised to create his late electroacoustic works (Hoffmann 2000). Moreover, GENDYN was mutable and redesigned for different pieces. Hoffmann's GENDYN recreates the program that produced *Gendy3* and the later withdrawn *Gendy301*, which is why his PhD thesis omits analysis of the later *S709* (Hoffmann 2009). For this latter piece, Xenakis redesigned the program to add time-varying parameters. This is reflected in the very different sonic territory it explores (cf. Xenakis 1997 for a recording).

Dynamic stochastic synthesis is classed as one of a family of "nonstandard" synthesis techniques, so called because they are based on nonimitative abstract or intuitive models for producing pressure waves. The moniker was coined to distinguish the paradigm from the "standard" synthesis approach whereby sound is simulated "given a description in terms of some acoustic model" (Holtzman 1979, p. 1). The technical implementation of DSS is closely tied to Xenakis's own aesthetic philosophy, and one of the outcomes of this is that the resulting sound tends to bear the stamp of its author: DSS is "Xenakian" in a way that other, more utilitarian, techniques perhaps are not. (Consider granular synthesis, the invention of which is also sometimes credited to Xenakis.) On the other hand, it could equally be the case that later adopters have chosen to stick within the aesthetic frame set by the works in which DSS featured. This is one of the things I hope to establish in what follows.

In DSS, the sound signal is constructed using probabilities. Specifically, with each repetition of a simple wave, the instantaneous time and amplitude positions of a set of breakpoints are calculated anew according to an independent random deviation, or "random walk," from the previous values. The samples between breakpoints are calculated via linear interpolation, which produces a waveform that is continually in flux from one cycle to the next. No naturally occurring acoustic vibration behaves in this way, but the common observation that DSS represents an arbitrary mathematical function transformed into sound pressure is not entirely true (cf. the critique of Xenakis in Schaeffer 1971, and also Haworth 2012). The model is surprisingly well suited to generating nonrepeating, quasiperiodic waveforms. Each repetition being a variable deformation of previous one, the relative periodicity or aperiodicity of the wave depends upon the step size of the random walk. Large moment-to-moment time and amplitude deviations will result in something close to white noise, whereas very small ones approach a simple wave. The bounded space between these extremes produces a "living" waveform with continuous flux in amplitude and pitch, not dissimilar in certain characteristics to what can be achieved with pulse-width modulation.

Dynamic stochastic synthesis was the outcome of Xenakis's critique of Fourier analysis and the attempt to use electronic means to replicate musical sounds by attending only to their harmonic structure and not their microtemporal variations in amplitude and frequency. It is grounded in dissatisfaction with then-current strands of computer music research,

which Xenakis deemed to be inattentive to the complexities of musical sounds, as well as the "demands" of the human hearing system (Xenakis 1992, p. 244). In this latter sense, DSS can loosely be considered an early attempt to implement a perceptually based synthesis procedure, albeit a somewhat idiosyncratic one. It is derived from the principle that a sound's spectrum must change over time for it to "please the ear," something Jean-Claude Risset is credited with having discovered while working on the synthesis of brass instruments (Risset 1964; Verplank, Mathews, and Shaw 2000).

### The Legal Ontology of Sound Synthesis

In referring to DSS as a sound-synthesis technique, we implicitly place it among a family of methods that are freely available for anyone with a computer and a basic grasp of some music software program to use in whatever way he or she chooses. Sound-synthesis techniques do not have authors, they have inventors, and this important distinction between copyright and patent law defines the type of "work" these techniques do in electroacoustic and computer music. When they are used in a composition, it is almost always without direct permission or attribution. If an acknowledgement of the inventors is made at all, it generally takes place before any work is done, through the purchase of music software, or a synthesizer, or a VST plug-in, etc. The absence of an author function that would afford some form of textual practice for this music contributes to the status of technology in its discourse and aesthetics. Ignored, resisted, or treated as though it were a natural resource rather than the product of human labor, the paradigm for the ethics of use for a sound-synthesis or signal-processing procedure is the musical instrument. More or less anonymous to all intents and purposes, the instrument is the "always already" of musical practice (Waksman 2003, p. 252)—what a sound is rather than what it does (Fales 2002, p. 58). Considered in this context, it seems reasonable to surmise that what we perceive as "timbre" cannot be authored, but this is not entirely true. When a waveform is sampled from a recording that is protected by copyright, then timbre has an author. Contrary to conventional wisdom, there is no concession made for sampling such brief durations as would qualify as timbre in copyright law; no "two-second" or "four-note" rule exists (Challis 2009). Even if a sample is literally a sample, and so brief as to be perceived as a broadband click, in theory, permission from the copyright holder must be granted before using it. Alongside such considerations as the part of the song being sampled (is it a hook or a background element?), the stature of the artist one is sampling from, and the role the sample plays in the resulting music (is it essential to the composition or merely atmospheric?), the actual duration of the sample being used is a factor in determining how much one is likely to pay for a license to include it (Bergman 2005). Given that in the USA and UK, infringement on a person's copyright is judged according to the nebulous requirement of "substantial similarity" in the opinion of a judge or jury (McKenna 2000), it is, however, safe to conclude that the question of timbral plagiarism is unlikely to be a practical issue for artists producing works. (On the other hand, for an interesting discussion highlighting the complex legal issues entailed in synthesizing novel timbres from a corpus of copyright-protected work using concatenative synthesis, see Sturm 2006.)

Nevertheless, this legal framework ensures an author function for certain types of sample, like music. To channel Michel Foucault (1970), it is the "guarantee" that restores danger to art, issuing forth the entire body of transgressive practices that we are familiar with from the postwar period forward. Because it is situated within the discourse and legal frameworks of communications technology, the hazards and playfulness of sampling do not bear upon our usage of a sound-synthesis procedure. But that does not mean that sound synthesis is not composition. The multiple off-the-shelf sound-synthesis techniques available to the studio composer can be seen as standardized instances of what Di Scipio has called, in reference to computer music, "micro-structural time modeling of sound" (Di Scipio 1995a). The "extreme" computer music duo of Roc Jiménez de Cisneros and Stephen Sharp, performing under the name Evol, drew attention to the creativity and politics of standardized timbre design unambiguously when they included an interview with Eric Persing in the sleeve of their

*Wormhole Shubz* album (Evol 2011). Persing is the inventor of the factory patches that shipped with the 1985 Roland Alpha Juno synthesizer, one of which, entitled "What The?," quickly became iconic in late 80s dance music under the colloquial name of "the Hoover sound." This gesture of recognizing an anonymous inventor conceals a strong and provocative suggestion: that his sound was instrumental in the birth of hardcore, the subgenre of rave music that made use of this sound. Alongside Joey Beltram, whose *Mentasm* track popularized the sound, Evol challenge us to see Persing as one of as one of hardcore's authors, a gesture that is symptomatic of the ontological politics over technical agency and labor in underground electronic music. Practicing a strenuous ethics of technological mediation, it drives the various versions of the neutrality thesis of technology into the position of supporting a "great men" theory of electronic music composition, wherein the creativity of multiple individuals is retroactively channeled under the agency of one: the composer.

It is somewhat ironic that it takes a composer like Xenakis to bring these ideas forward, but so be it: By extending agency "down" to the level of individual samples, so that what is called composition includes the construction of the sound signal itself, hitherto entrenched distinctions between the music and the material, process and forms, art and technics emerge as discursive rather than material. This discourse forecloses on the possibility of what would be a timbral authorship in computer music despite the fact that DSS is recognizably Xenakian. It is in this specific way that DSS can be considered transgressive, as exceeding the restricted set of normative categories and creative practices currently recognized by music's copyright laws. Now, from a certain perspective, Xenakis's thinking on microsound composition can seem to be in alliance with the structuralist and poststructuralist thinking on authorship referenced above. In *Formalized Music,* he posits stochastic synthesis as an important step towards an entirely automated music, one with potentially grand implications for authorship:

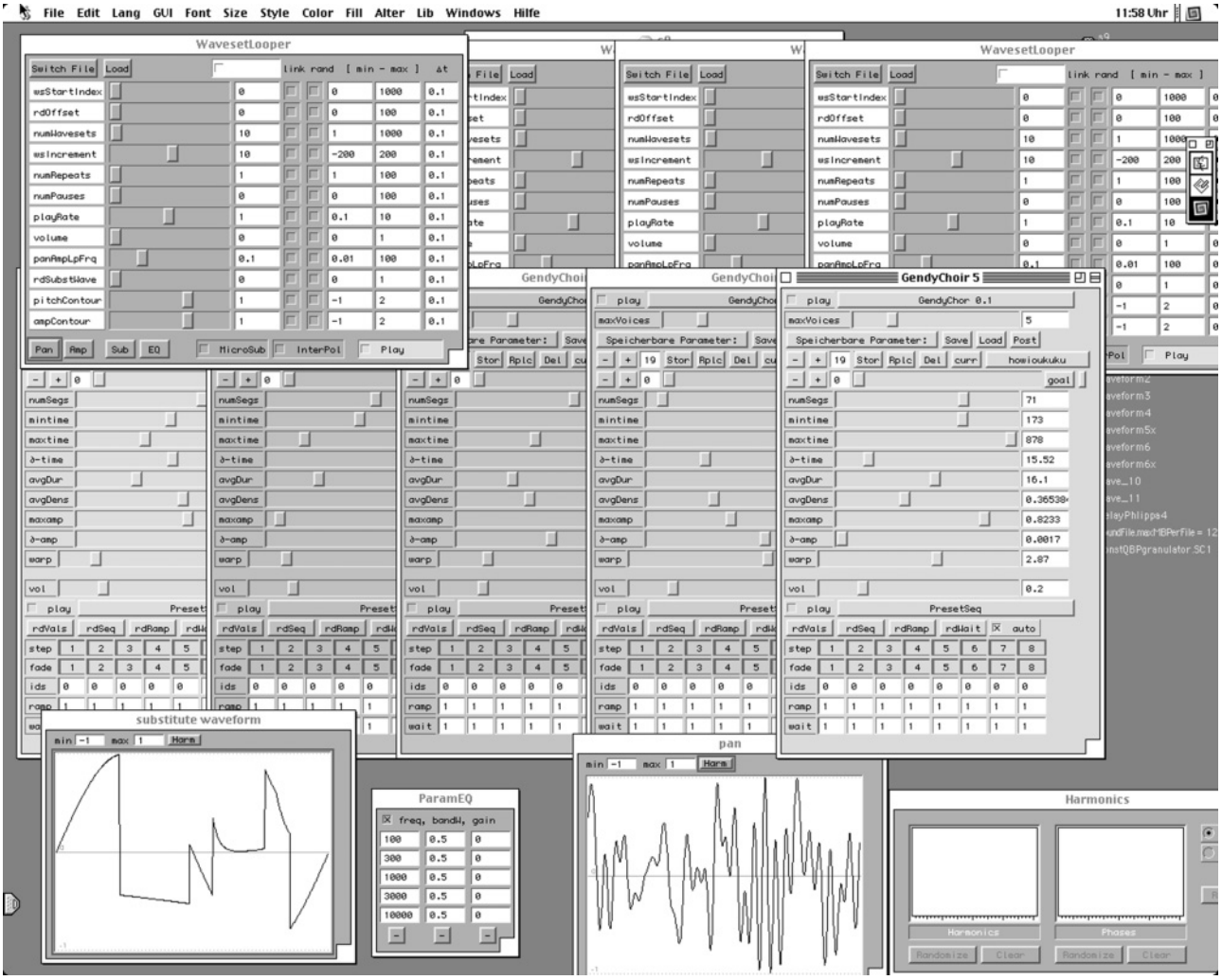
> We find ourselves in front of an attempt, as objective as possible, of creating an automated art, without any human interference except at the start, only in order to give the initial impulse and a few premises, like in the case of the Demiourgos in Plato's Politicos, or of Yahweh in the Old Testament, or even of Nothingness in the Big Bang Theory (Xenakis 1992, p. 295).

But there exists a gap between the speculative ideal presented here—what Peter Hoffmann calls the composer's "lifelong dream of an Automated Art" (Hoffmann 2009, p. 92)—and what GENDYN was in practice. To compose *Gendy3*, "Xenakis constantly rewrote the program, executed (parts of) it, listened to the results, and rewrote the program further" (Hoffmann 2009, p. 86). The final piece was made up of two sound files edited together, which were the 402nd and 403rd files GENDYN had produced (Xenakis 1992, p. 86). *S709* required that the program be rewritten once again, and the final sound file had to have the silences edited out of it before it was ready to be performed (Sharon Kanach, electronic mail message to author, 28 January 2013). Listening to the pieces themselves, we do find important musical decisions seemingly handed over to the calculation of a machine—an example being the crude endings to *Gendy3* and *S709* that are noted in Pape (2002, p.19). But the editing process Xenakis underwent for these pieces makes it difficult (and certainly irrelevant) to identify what is a selection and what was "handed down" to him. If the iteration of GENDYN that produced *S709* did indeed "stop" midway through the last voice's descent, as we notice at the end of the recording, then preserving that determination as opposed to editing it is still a choice. For this and other reasons, GENDYN bears the strong authorial voice of its creator, and it is this very recognizability—stochastic synthesis's author function—that is channeled and instrumentalized by later adopters.

## Post-Xenakian DSS

Of the "post-Xenakian" (Hoffmann 2013) composers to take up stochastic synthesis as a dedicated sound strategy, Florian Hecker is particularly worthy of note. The first recorded document of this is

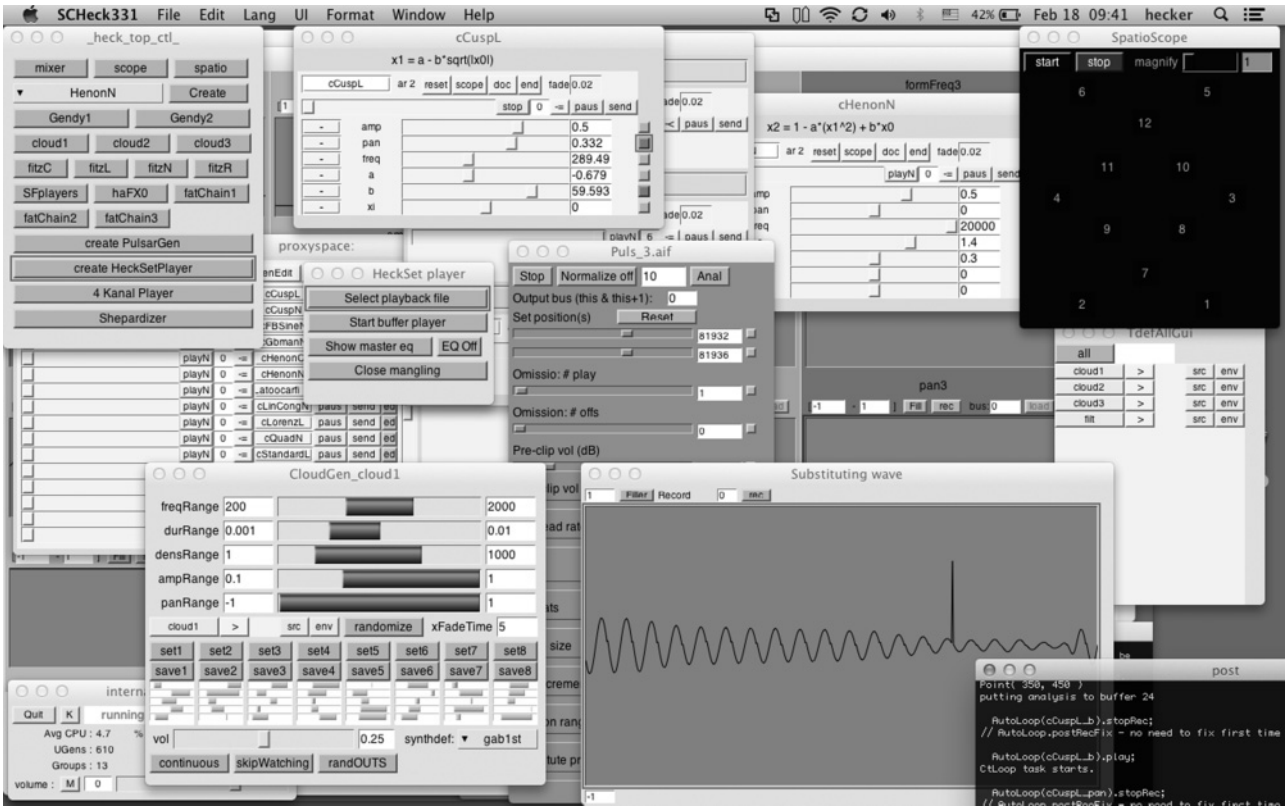
*Figure 3. Screen shot of Hecker's OS 9 computer showing programs designed by Alberto de Campo (Image courtesy of Florian Hecker).*




on *Stocha Acid Vlook,* a piece that was first released on a CD accompanying the *Ausgeträumt* exhibition in 2001 (Asfour, Bondy, and Rhomberg 2002), and was popularized by its inclusion on the *Sun Pandämonium* album released on the Mego label (Hecker 2003). Since then, his exploration of DSS as an instrument has continued to develop, culminating (as of this writing) with the *Kanal GENDYN* project, released as a multimedia DVD and as an LP in 2011. Produced in collaboration with Russell Haswell, this latter record documents the pair's live accompaniment to a film of the Zurich sewer system by the artists Peter Fischli and David Weiss, entitled *Kanal Video* (1992). Each artist used separate instances of a software program based upon Xenakis's original GENDYN program, resulting in a 63-min celebration of the "ever changing and meandering waveforms" of stochastic synthesis (Haswell and Hecker 2011).

This new GENDYN implementation was authored by Alberto de Campo and implemented in SuperCollider 2 (see Figure 3). Hecker and de Campo have worked together closely since 2000, de Campo designing custom software instruments for Hecker to use, which are then modified and improved through dialog. The dynamic resembles the

*Figure 4. Screen shot of Hecker's OS X computer (Image courtesy of Florian Hecker).*




emerging paradigm of the "instrument builder / performer" relationship in new musical instrument design more than it does the "composer / technician dynamic" that Xenakis would have recognized. As we will see, this important factor distinguishes Hecker's real-time instrumental use of DSS from Xenakis's rule-driven compositional approach.

The first thing to note is that, although the original GENDYN was provisional and in flux, never reaching a "definitive" version and transforming greatly between *Gendy3* and *S709*, in listening to Hecker's work with the program, we sense that we are hearing a "fixed" instrument with a strongly defined and confident identity. The reasons for this can be broken down into technological, performative, and discursive constituents. Technologically, Hecker and de Campo's collaborative work on the software differs from other related projects in that it has proceeded according to a logic of, quoting Hecker, "improvement" rather than "advancement" or direct replication (from an electronic mail to the author, 2 May 2013). This is important. Whereas some have attempted to extend upon DSS conceptually or sonically (e.g., Luque 2009), or take its basic principles in entirely different directions (Di Scipio 2002), in Hecker's work with miniGENDYN and GENDYNchoir (two of de Campo's names for the software) the original program's diverse sound palette is "curated," with aspects selected, enhanced, and discarded according to the composer's aesthetic preferences. This choice means that the sustained pitches and consonant intervals of *Gendy3* are entirely absent in the derivative versions; the focus instead is always on the chaotic, unstable quality of DSS most familiar from *S709* and the earlier *La Légende d'Er* (1977), noisy sonorities that Xenakis famously likened to "wild horses" (Robindoré and Xenakis 1996, p. 13). The second, perhaps less provocative technological "improvement" is real-time interaction, a dimension that

was unavailable to Xenakis working in the late 1980s and early 1990s (the original GENDYN had no visual interface). This of course radically changes what GENDYN is as a tool, affording Hecker a vector of physical instrumentality.

Turning now to how instrumentality is performed, the first thing one notes on hearing Hecker's work is a peculiarly virtuosic use of DSS, as though a potential that the canonical works hint at is harnessed and exaggerated to the point of grotesquery. This is a product, first, of the reflexive construction of "the GENDYN sound" as a discrete genre signifier. Through the mediations of Hecker and other computer noise artists, this whining, buzzing, unstable timbre has come to act as a sounding touchpoint between "academic computer music" and "noise," and this historical re-enactment affords the emergence of a rhetorical, playful dialog with the "fixed" original. (It also raises the question of what an alternative protension of GENDYN would sound like, one that focused not on the noisy components but on, say, the consonant organ-like tones of *Gendy3*.) That this connection can be made is certainly facilitated by the fact that the derivative GENDYNs can be performed in real time on laptop computers. Hecker's DSS work is always explored heuristically, through listening and improvising, then editing, arranging, and combining the recorded sound files with other sources in an offline audio editor. And with the exception of *Kanal GENDYN*, in which GENDYNchoir is the only instrument, DSS generally represents just one of a number of analog and digital synthesis tools he uses in this process rather than a holistic composition environment (illustrated in Figures 3 and 4).

Finally, I want to turn to a discursive construction of the GENDYN instrument. Hecker's real-time instrumental use of DSS is augmented by a style similar to the aforementioned references to pulsar synthesis, where the name of the program and author is directly cited. *Stocha Acid Vlook's* title contains a cryptic nod to DSS, the style commensurate with the obscure titling conventions of popular electronica in the early 2000s. However, a practice of direct and unmistakable quotation develops in later works. Following *Blackest Ever Black*, Haswell and Hecker's (2007) album derived entirely from material produced with Xenakis's *Unité Polyagogique Informatique CEMAMu* (UPIC) system, there is a clear attempt to contextualize their work with technical, social, and autobiographical detail about the composer and the instrument. Coupled with the enforced stylistic restriction to only the sounds of GENDYNchoir, *Kanal GENDYN* (Haswell and Hecker 2011) also comes packaged with an extended essay by Peter Hoffmann on the reverse sleeve, where we learn about "explicit computer music" and abstract synthesis, the history of GENDYN, current academic research on stochastic synthesis, and Haswell and Hecker's ongoing work with Xenakis's computer music instruments. This is where the attempt to circumvent the technologically determined acousmatic reduction typically imposed by the computer, as well as the structural listening strategies inherited from Schaeffer and spectromorphology, comes across most forcefully. Constructing a discursive and sonic lexicon of techniques and software instruments, while at the same time practicing an aesthetic of radical medium specificity, has the accumulated effect of linking sounds to sources and technologies to creators. Similarly to live coding, but via very different means, a syntax is built around what is normally unseen: the composer's hidden software ecology.

**Inside and Outside Academia**

The wider social and institutional influences upon the medium-specific software practices described here can be seen to correspond broadly to the tendency that Kim Cascone, at the turn of the new century, identified as "post-digital" (Cascone 2000). Cascone described how, in opening up new modes of circulation and distribution, the Internet brought about such great changes in knowledge practices that

> a non-academic composer can search the Internet for tutorials and papers on any given aspect of computer music to obtain a good, basic understanding of it. University computer music centers breed developers whose tools are shuttled around the Internet and used to develop new music outside the university (Cascone 2000, p. 12).

But Cascone lamented that this was a one-way communication channel: Although knowledge was shuttling freely around the Internet, the new practices that were developing were not making it back to the ivory towers. The focus on noise and improvisation I have noted in GENDYN, and the particular ways that PG's complex interface is sounded, affirm Cascone's feeling that new sounds, aesthetics, and techniques have developed around tools that were previously unavailable outside the academy. The present article, however, has highlighted changes to the nature of this "inside/outside" relationship, suggesting that more than just new sounds are being incorporated and aestheticized. As I have shown, this nonacademic electroacoustic and computer music increasingly comes accompanied with extensive liner notes detailing the technologies used, as well as academic essays that historicize the emerging practices. Provided by Peter Hoffmann (on the history of DSS for *Kanal GENDYN)*, Curtis Roads (on graphical synthesis and the UPIC for *Blackest Ever Black)*, and Tony Myatt (on the MP3 deviation software used on *Convulsive Threshold* by Russell Haswell and Yasunao Tone [2013]), these writings perform an important framing function, providing listeners with intimate technical knowledge about the procedures used, their authors, and their historical contexts. This mode of address produces a particular style of interaction with the material; we listen, not necessarily for form and structure, but for understanding: to verify that we correctly hear the object that is being presented, whether it be auditory, acoustic, or technological. In this, these publications go so far as to flirt with the resolutely anti-aesthetic genre of the "demonstration CD," the media accompaniments that come with specialist technical journals and psychoacoustics textbooks.

Another effect of this scholarly endorsement is, of course, legitimation. The words of Curtis Roads and others bestow the established cultural authority of the institution upon these "outsiders," while also installing them within the esteemed biographies of the composers whose names they invoke. Although I have argued that these framing strategies should be seen within the context of a struggle against the fetishization of sound itself and the formal concerns with surface, structure, and form that characterize electroacoustic art music, aspects of the attempt to puncture this and promote an ethics of technology risk a converse type of fetishization, where those attributes that the new forms of circulation are presumed to undermine—inaccessibility, prestige, and hierarchies of knowledge—are themselves aestheticized. With the boundaries between inside and outside institution practices being re-inscribed by these "postdigital" practitioners, the two-way cultural exchange Cascone hoped for still awaits.

## Conclusion

This article has analyzed a set of what I have called "textual" technological practices that have been emerging over the past decade, paying particular attention to the various ways that technology's meaningfulness is "performed" in underground electroacoustic music, and considering what the implications of this are for the genre as a whole. I have argued that this can be conceived in terms of an ontological politics, where electroacoustic music's "natural" mode of secrecy, alchemy, and semblance becomes a conceptual zone of contestation over what this music "is." Zooming in on two niche computer music programs that have played a central role in glitch, noise, and "extreme" computer music genres—PulsarGenerator and GENDYN—I have presented a technical and discursive analysis of them as cultural objects: showing what they are as instruments, what aesthetic biases they implement, who their authors are, and how these factors are directly channeled and instrumentalized in recent works. Challenging the legal ontology of technology, as well as notions that digital instruments are immaterial, plural, and endlessly transferable across platforms, I have argued that these practices represent a new strain of "medium specificity" in digital music. Whether a particular sound was created via amplitude modulation, filtered pulse trains, pulsar synthesis, or sampling may not matter to electroacoustic music conceived as semblance. But for medium-specific practices, such as I have described in this article, these previously anonymous sound sources become richly imbued with meaning.

Finally, this article has discussed the implications for authorship and for the possibility of two-way cultural exchange between academic and nonacademic practices inside and outside institutions.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