Rhythmic Processes in Electronic Music

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ABSTRACT

Electronic technology has liberated musical time and changed musical aesthetics. In the past, musical time was considered as a linear medium that was subdivided according to ratios and intervals of a more-or-less steady meter. However, the possibilities of envelope control and the creation of liquid or cloud-like sound morphologies suggests a view of rhythm not as a fixed set of intervals on a time grid, but rather as a continuously flowing, undulating, and malleable temporal substrate upon which events can be scattered, sprinkled, sprayed, or stirred at will. In this view, composition is not a matter of filling or dividing time, but rather of generating time. The core of this paper introduces aspects of rhythmic discourse that appear in my electronic music. These include: the design of phrases and figures, exploring a particle-based rhythmic discourse, deploying polyrhythmic processes, the shaping of streams and clouds, using fields of attraction and repulsion, creating pulsation and pitched tones by particle replication, using reverberant space as a cadence, contrasting ostinato and intermittency, using echoes as rhythmic elements, and composing with tape echo feedback. The lecture is accompanied by sound examples. The text is derived from a chapter on rhythm in my forthcoming book *Composing Electronic Music: A New Aesthetic* [1].

1. RHYTHM IN ELECTRONIC MUSIC

Music is a dance of waves: vibrating the air, the ear drum, the bones of the inner ear, and the auditory nerve, with the ultimate goal of stimulating electrical storms in the brain. In much electronic music, including my own, rhythm often emerges as the dominant element in a flux of ever-changing parameter interactions. Indeed, rhythm is the sum total of all parameter interactions.

Today, rhythm can no longer be viewed merely as a pattern of notes on a page of score. We acknowledge the existence of a continuum from the pace of meso-structural boundaries (seconds and minutes), to infrasonic fluctuations (< 20 Hz) to events at all audio frequencies up to pulses at the sampling rate.

Microsonic processes introduce the possibility of evaporation, coalescence, and mutation of sound materials, analogous to the ever-changing pattern of clouds in the sky. As a result, the precise rhythmic pattern of certain sound phenomena is far from clear. As these microstructural processes unfold, they result in the phenomena of perceived pitch, duration, amplitude, space, and timbre, all of which function as articulators of rhythm. Thus rhythm occurs as an emergent quality of triggers, phasors, envelopes, and modulators on a micro time scale.

As Messiaen [2] pointed out, the perception of duration can be modulated by musical processes. We also know that human listeners construct rhythmic groups around events that are linked by Gestalt perception.

In the late 20th century, rhythmic notation evolved over time into hyper-complexity, testing the limits of readability and playability. At the same time, the technology of electronic music made the design of complex rhythms ever more accessible.

Indeed, technology has changed the paradigm of rhythmic theory and organization. The liberation of time from meter was enabled by the technologies of recording (with variable speed and backwards playback), editing, granulation, and programming. These capabilities have transformed the rhythmic playing field. Studio technology enables the exploration of polyrhythmic grids and fields. The new generation of sequencers and programmable clock sources lead into uncharted rhythmic territories. Ironically, the ability to stipulate rhythm precisely proved to be a barrier to naturally flowing rhythm in the early days of computer music, when the start time and duration of each event had to be typed in a long note list. The computer was an ideal vehicle for formally-oriented composers who wanted to distance themselves from habitual phrasing, but this same distance had to be overcome by composers and performers seeking more immediacy of expression.

Thus an aesthetic tension remains between machine-generated timings and the subtle body rhythms we naturally associate with virtuosic performance. The challenge in generative rhythm is to tame the urge to produce temporal minutiae that is fascinating only to the person who wrote the program that generated it.

Listeners organize rhythmic perceptions according to Gestalt expectations and tend to simplify or group events together into a limited range of rhythmic patterns. We are exquisitely sensitive to and compelled by pulsation. However, pulse is not only the ubiquitous beat of popular music, but any form of periodicity, however fleeting and temporary, like the repetition of slapback echo or the flutter of low-frequency amplitude modulation.

In the rest of this paper, I introduce aspects of rhythmic discourse that appear in my electronic music. The lecture is accompanied by sound examples.

2. DESIGN OF PHRASES AND FIGURES

Rhythmic organization in my music often begins with a performance in studio using synthesis (e.g., pulsar synthesis, frequency modulation, etc.) or processing (e.g., granulation, tape echo feedback, pitch-shifted sample playback, etc.) and some kind of gestural interaction (using a musical keyboard, mouse, sliders, knobs, etc). Rhythmic behavior is already specific in this initial stage, as it is part of the conception. The result is a set of sound files of varying lengths. Following this initial, playful phase, I take a multiscale approach to organization. This involves detailed editing at the lowest levels of sound structure, but at any time I can intervene on higher levels of structure, rearranging meso structures or generating new sound material. The goal in the early stages is design of phrase organization. Many phrases are structured around *figures*–rhythmic patterns consisting of discrete events. The figures often have a distinct morphology of beginning, middle, and end lasting several seconds.

However, and this is important, I also sculpt meaningful phrases even in a continuous cloud, where there are no discrete events per se before I begin editing. (See the discussion of streams and clouds below)

For me, *Clang-tint* (1994) was a breakthrough in terms of phrase design. A commission from the Japanese Ministry of Culture and the Kunitachi College of Music, *Clang-tint* exists in three parts. The first part, *Purity,* opens with a slow and deliberate keyboard performance using the Bohlen-Pierce scale. This performance, which is not aligned to a regular pulse, was prepared by a long period of experimentation with the melodic and harmonic possibilities of this scale. After this performance, at 2:49 sustained undulating sine waves enter the scene. Certain sounds tremolo, fluttering at 7 Hz. At 4:47 echoing rhythms begin with repetitions at 400 ms. The finale features a long sustained tone with pitch bend, arching over 50 seconds. The second part, *Organic,* opens with a pulsar cloud, leading to an explosive crescendo with many different percussion timbres. Subsequent phrases feature sustained tones that build to a rapid-fire release followed by another sustained texture. Pulsations weave in and out. The pulsation slows at 1:28-1:41, breaking open a sustained ocean sound. Several pulsar pulsations begin again at different tempi. This is followed by a slow phrase with pulses every 4 seconds. Another sustained tone builds to the final explosive crescendo. The third part, *Filth,* opens with a high impact percussive tone. The rhythmic organization is again based on phrases, with long "straining" tones (like stretching a rubber band before it breaks) leading to crescendi with many clicking and snapping impulses, leading to a continuous noise texture punctuated by percussive hits. The textures fade to a low-intensity noise cloud lasting 20 seconds. A tone appears, punctuated by burning ember-like sounds. The finale consists of three widely-spaced percussive hits in reverberation, one 7.8 seconds after the first and the final hit 10.1 seconds after the second.

Meso structure is also the focus in *Volt air* (2003), a four-part exploration of a granular synthesis texture. Part 1, with its electronic woodblock-like sound palette, explores short-term pulsation as a means of forward motion. A rhythmic signature of the piece is the frequent double articulation of a single impulse. Another characteristic is the use of short flutters like 8 impulses in 300 ms, but also dozens of short pulse bursts (less than 10 pulses) in the 6-10 Hz range. Accelerations and decelerations of pulse trains are common. Silent intervals sometimes punctuate the phrases. Part 2 uses the same sound palette. This rhythmically complicated piece involves both pulsation but also continuous transformations such as in the middle section (1:10-1:48), which is based on continuous tape echo feedback. Part 3 opens with a long (55 seconds) sustained crescendo that builds toward an anticlimax. Following this, the form is designed as a set of six climaxes over the subsequent 1 minute and 20 seconds. I am most pleased with the irregular phrase between 1:57 and 2:03, which intermingles several pulsation frequencies. Part 4 features pulsations at different frequencies, interspersed with continuous tones. The climax of a phrase is often a breakup of a continuous texture into a sparse sprinkling of percussive impulses. Between 1:06 and 1:14 I invoke one of my most beloved clichés of electronic rhythm: the exponentially decelerating pulsation.

3. PARTICLE-BASED RHYTHM

Most of my works, with the exception of *Clang-tint* (1994), explore a particle-based rhythmic discourse. Microsonic processes can unfold as a more-or-less continuous granulation, a sparse pulsation, or by means of a manual practice of detailed assembly of micro-rhythmic figures or *micro-montage.* One characteristic figure is a high density spray or "avalanche" of particles, which creates a rattling or hissing sound, depending on the spectrum of the particles. As a cadential gesture at the end of a phrase, such an avalanche has the function of releasing accumulated energy, like letting off steam. (See the description of *Sonal atoms* below.)

4. POLYRHYTHMIC PROCESSES

I am interested in Varèse-inspired rhythmic processes in which independent strands align at critical mesostructural boundaries. An example is *Always* (2013), which features polyrhythmic processes on multiple time scales. Due to this work's initial construction, as a real-time combination of six stereo sound files played simultaneously from a sampler on ten keys (with pitch-shifting according to each key, totaling 120 tracks), *Always* is especially complicated from the standpoint of rhythm. The work is divided in two sections. The first section is dissipative. The second section is fast-paced and scintillating, characterized by thousands of clicks and hissing grains underpinned by a lively melodic/bass line.

Pacing is critical. Much of my music consists of rapid-fire rhythmic processes on multiple time scales–a high rate of information density. This is also why many of my works tend to be short and concentrated. This rate of information density becomes tiresome if it is extended for too long without a break. Thus in high-velocity works like *Touche pas* (2009) the second half of the composition process consisted of slowing down an initial granulation. This meant selecting phrases and transposing them down in pitch (by an octave, for example) and speed, then inserting reverberation cadences and pauses to make the work breath in between the fireworks.

5. SHAPING STREAMS AND CLOUDS

Exploring the new musical resource of streams and clouds of grains is central to my practice. At the core of these processes is an engine for grain emission. The valves that regulate the rate of granular flow are central. These control the number of streams and the granular density of the streams. In effect, they control the micro-rhythm of the granular emission as it is being generated in real time.

Once these textures have been recorded as sound files, as a rhythmic tactic, I seek to articulate meso-structural highlights within the granular flow. Through micro-editing I create internal fluctuations and accents of individual grains that sometimes sound like the crackling of a wood fire, except that the crackles are composed precisely to articulate the unfolding of meso-structural processes. I shape the continuous clouds with pitch bending curves to obtain an effect of speeding up or slowing down. I also vary the grain durations over time, which has the effect of moving back and forth between pitch and noise. I often apply envelopes that lead to forceful accents. Indeed, I seek clear articulation of accents. However, accents are not always important structural boundaries; there can be a strong accent within a phrase merely as a point of articulation, not just at the beginning and end of a meso-structural boundary.

In terms of finally understanding how to organize granular materials, *Half-life* (1999) was a breakthrough composition [3]. This is when I began to learn how to compose with stream and cloud morphologies. For example, the second part of *Half-life*, called *Granules* was spawned by a single real-time granulation of a file created by pulsar synthesis. I extensively edited and rearranged this texture over a period of months with a goal of maintaining the illusion that the end result could have somehow been generated in real time, with no pauses. The macro structure of *Granules* is a slow dissipation of energy, bubbling down to the depths, proceeding inexorably to a sputtering end.

Like *Half-life, Tenth vortex* (2001) was originally a real-time granulation of a pulsar synthesis file. It unfolds as a continuous cloud texture, characterized rhythmically by expressive undulations, spectral fluctuations, and accents rather than a series of discrete events. Meso structure is often articulated by spectral processes that unfold over several seconds, such as a bandwidth widening induced by shrinking the grain durations (Roads 2001b). This has the effect of dissolving a pitched texture into a noise texture. Since this unfolds over several seconds it articulates a phrase.

Eleventh vortex (2001) opens with a 4 Hz pulse that eventually dissolves into an irregular granulation. Rhythmically, the *Eleventh vortex* is a play of oppositions between continuous granulation and pulsating sequences. These pulsations often appear at the end of phrase boundaries or as a penultimate gesture before an ending fadeout as in the finale.

Sculptor (2001) derives from a driving percussion track sent to me by Tortoise drummer John McEntire. I granulated this track into a continuous cloud, turning it into a flow of undulations, spectral fluctuations, and accents. The individual grains reveal themselves only in the end when they form a rapid rhythmic pattern.

Fluxon (2002) is a continuous granulation of a sample of rolling marbles marked by undulations, spectral fluctuations, and accents, combined with fluttering amplitude modulations in the 14-18 Hz range. The jittering cloud form articulates the central theme of pitch bending towards local climaxes.

The three movements of *Never* (2010) are similarly outcomes of continuous granulation, marked by undulations, spectral fluctuations, and accents. The granulation is regularly broken up into high-velocity particle figures. A bass line serves as a rhythmic counterpoint to the granular figures.

6. FIELDS OF ATTRACTION AND REPULSION

In several works, including *Half-life, part 1* (1998), and Part 2 of *Clang*-tint (1994) I set up gravitational fields of attraction and repulsion. An attractive field serves as a magnet for a dense avalanche, that is, a micromontage of dozens of discrete events. A repulsive field disperses events to create a rhythmically sparse texture.

7. CREATING PULSATION AND PITCHED TONES BY PARTICLE REPLICATION

In this music, both pulsation (at infrasonic frequencies) and tone formation (at audio frequencies) are emergent qualities of particle repetition. Thus, although the compositions as a whole are rarely aligned to a meter, within a piece I create metric figures on multiple time scales including the audio time scale. For example, in the first part of *Half-life* (1999) called *Sonal atoms,* the pitched phrase at 2:18 was created by replicating grains at audio rates to form tones. Most of this piece contrasts long clouds of more-or-less continuous granular noise, punctuated by discrete rhythmic figures (using individual grains), such as bursts of grain repetitions in the 7-14 Hz range. The work makes explicit use of individual pinpoints grains as accents. Silent gaps of up to 1.65 seconds appear in the middle, gradually increasing granular density beginning at 1:45. A first avalanche of short grains is centered at 2:02, followed by low-level pulsation interrupted by sharp isolated impulses and a return to noisy granulation. The pitched phrase at 2:18 was created by replicating grains at audio rates to form tones. In the final minute of the piece, phrases often conclude with grain avalanches that fade away with pulsation. The finale consists of an accelerando with a phrase repeated five times speeding up that ends in an explosive granular avalanche. The finishing gesture is a decaying pulse train at 10 Hz.

8. REVERBERATION AS A CADENCE

A phrase that ends with a long reverberation pause is typical in several recent works, including *Epicurus.* The tripartite form of *Epicurus* determined its rhythmic structure. The opening section is high velocity and animated. This is followed by a slow section, succeeded by a grand finale. All three sections transpire in the space of just 3 minutes and 6 seconds. The 18-second opening introduces all the elements of the piece: sharp impulses, low-amplitude granulation, replicated particle patterns, and long (10-second) reverberation cadences. The next 20 seconds form a continuous granulation that is finally broken up at a pattern of particle replications (37.5 to 40 seconds). The second, slow section starts at 1:22.5. The finale, starting at 2:03 deals with long reverberated decays ranging from 5.7 seconds to a long 16.8 seconds.

The reverberations are often compound sounds, what I *call reverberation chords* consisting of several pitch-shifted copies of the same reverberation cloud. Reverberation is usually noisy and has no pitch, but it can be induced to have *latent pitch*. As Natasha Barrett [4] observed, latent pitch can be articulated by sequential contrast:

> *Pitch content becomes perceptually evident when a composer applies methods of "sequencing"…When articulating a single [sound object], the sound may appear to contain little in the way of pitch. When articulating a series of [sound objects] in succession, one compares discrete articulations and detects differences of pitch or tessitura…In* Earth Haze, *water droplets have been sequenced in this manner to expose a pitch contour.*

In a similar manner, my piece *Touche pas* (2009), features sequences of unpitched impulsive sounds in which each successive sound is pitch-shifted by a perfect fifth. Shifting unpitched noise sounds like cymbals can bring out an impression of pitch as the intervals between certain resonances become apparent.

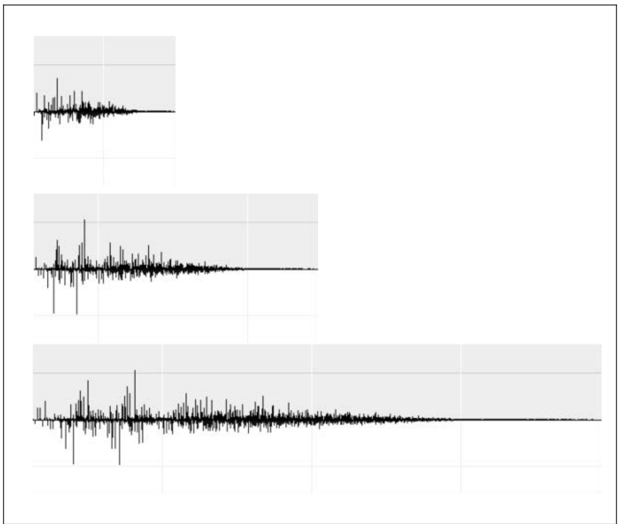

Figure 1. Superimposition of pitch-shifted reverberation tails form a *reverberation chord.* The middle graph is shifted down an octave, so it lasts twice as long as the top graph. The bottom graph is pitch shifted two octaves down, so it is four times as long.

Another means of articulating latent pitch is by additive superposition of pitch-shifted noises to articulate "noise-chords." For example, in my composition *Modulude* (2013) I superposed multiple pitch-shifted reverberation tails (which individually sound like colored noises) to create tuned reverberation chords (see Figure 1).

The ambiguous zone of latent pitch is deeply fertile ground for experimentation. It shows again how a sound's perceived structural function depends on its musical context. For certain sounds, whether the sound is perceived as a noise or a pitch depends on its setting.

A related technique that appears in *Epicurus* is the explicit introduction of pitched tones to imbue a harmonic shimmer to a reverberant cadence.

9. OSTINATO AND INTERMITTANCY

I am interested in the tension between repetition and interruption, between ostinato and intermittency. For example, *Pictor alpha* (2003) is a loop-based composition, a repeating theme-and-variations form with a repeating pulsar at 8 Hz as a central rhythmic figure, around which many other pulsations speed up and slow down. The loops are rarely perfect; rather, they are slightly "off" in timing or directly spliced into to break the regularity of the ostinato. Another rhythmic motif is a 13 Hz pulsation. A pivotal point around 2:14 sees the 8 Hz pulses sustain and then explode. At 2:42 the rhythm splits into two contrapuntal streams. The finish is a fadeout of pulses at 4 Hz.

By contrast, in *Half-life* (1999), I wanted to shift the musical discourse away from continuous, stationary, and homogenous signals (such as pitched tones) to intermittent, nonstationary and heterogeneous emissions (pulses, grains, and noise bands). Thus the sound universe of *Sonal atoms* is a concentrate of punctiform transients, fluttering tones, and broadband noise textures. Only a few stable pitches appear as the epiphenomena of particle replications.

10. ECHOES AS RHYTHMIC ELEMENTS

To craft the rhythms of the sonic surface structure in detail requires many editing interventions. A common motive in some of my works is the echoed repetition of impulses at key transition points. While the underlying texture shifts abruptly, these echoes continue the past into the future. This is a signature of *Now* (2003)–a continuous granulation marked by undulations, spectral fluctuations, and accents. This work is the product of an asynchronous granulation with overlapping large grains, which created a 400 ms echo effect in many parts of the work. The piece is further characterized by sharp drum-like collisions of sound in the opening section (e.g., at 0:07, 0:12.6, 0:17.9, 0:33.1, etc.). I constructed these collisions by cutting off the swell of a granulation cloud (creating a sharp wave edge at the peak of the swell) and splicing it with a sound occurring several seconds before the swell. Over this junction I layered particle streams to create hysteresis-like effects (Figure 2), as if the previous sound was ricocheting or rebounding from the collision.

The final part of *Now* devolves into continuous granulation textures and a long quickly pulsating fadeout with a 24 Hz mean frequency, capped by a final echoed burst.

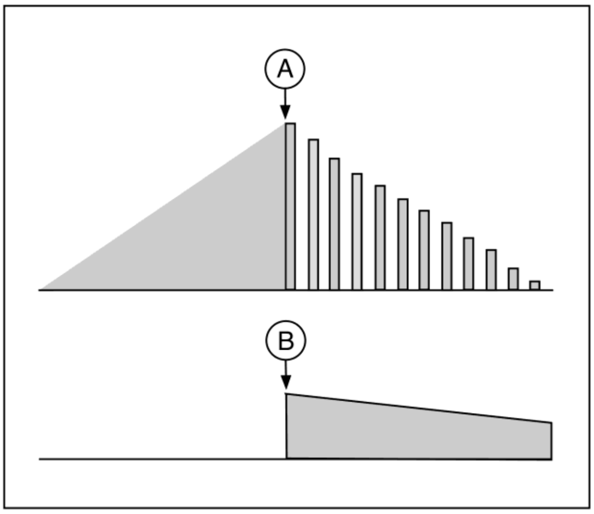

Figure 2. The initial sound crescendos to a peak at which point its last particle A echoes into the future as a kind of hysteresis effect over a new sound B.

Nanomorphosis (2003) is a continuous granulation marked by undulations, spectral fluctuations, and accents. The granulation sometimes breaks up into rapid-fire rhythmic figures with a typical density of 10-20 grains per second. In this piece I sometimes mark transitions by inserting a *barrier particle* as a kind of punctuation mark into the flow. At the junction of a barrier particle, particles ricochet or rebound, while simultaneously the ongoing stream changes character. The behavior is similar to Figure 2, but without an initial crescendo. This ricochet technique appears throughout *Nanomorphosis.*

Touche pas (2009) marked the beginning of a new rhythmic style, with "bouncing" particle figures, in which a particle echoes several times. This behavior reminded me of Subotnick's *Touch* (1969) hence the title. The phrases end on a strong accent that is sustained by tag that is either (a) reverberation, (b) pitches alone or in chords, (c) a sound that is pitch bending. This phrase-ending tag creating a breathing space in between phrases and serves as a cadence. The tags last anywhere from 2.6 seconds to 9.2 seconds. Part 1 also introduces a bass line consisting several deep sustained pedal points. Part 2 continues the rhythmic strategies of part 1, with the addition of a more animated bass melody that serves as a rhythmic counterpoint to the granular figures. Brief particle pulsations overlay the central granulation theme. Also I introduce the extensive deployment of brief (1 ms) and sharp impulse clicks scattered over the granulation like grains of salt and pepper. At 1:47 the central granulation texture is transposed down an octave, suddenly slowing the rhythmic pace for the rest of the piece. The unusual ending consists of seven iterations of a 3.4-second loop.

11. TAPE ECHO FEEDBACK

An important characteristic of my music is the deployment of analog tape echo feedback, with its unique palette of effects. (My current work-in-progress, *Then,* is based entirely on sound material generated tape echo feedback.) These include pulsating echos (as described in the previous section) whose period is determined by tape speed, to self-sustaining feedback with continuous pitch shifting and narrow filtered resonances. Feedback can last for several seconds or several minutes. The rhythmic component is a function of the fluctuations introduced by manual control of knobs and faders involved in regulating the echo-feedback process. A prime example appears in *Volt air,* part 2, from 1:08 to 1:48.

12. CONCLUSIONS

Electronic technology has liberated musical time and changed musical aesthetics. In the past, musical time was considered as a linear medium that was subdivided according to ratios and intervals of a more-or-less steady meter. However, the possibilities of envelope control and the creation of liquid or cloud-like sound morphologies suggests a view of rhythm not as a fixed set of intervals on a time grid, but rather as a continuously flowing, undulating, and malleable temporal substrate upon which events can be scattered, sprinkled, sprayed, or stirred at will. In this view, composition is not a matter of filling or dividing time, but rather of generating time.

Acknowledgments

I would like to thank my colleagues and students in the Media Arts and Technology Program at UCSB for providing such an open and stimulating environment in which to explore these threads of research.

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