sans fin sans
(endlessness)

for guitar, seven wind instruments and double bass

by

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Abstract

*sans fin sans* (endlessness) is a fifteen-minute musical composition scored for solo guitar, seven wind instruments (flute, oboe, clarinet, bassoon, trumpet, horn, trombone) and double bass. Although the work is in one continuous movement, it consists of seven distinct sections, each constructed from fragmented pieces of a pre-composed originating structure. Influenced by the prose of Samuel Beckett, *sans fin sans* is an exploration of non-linear time and the Deleuzian notion of art as abstract machine.
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Chapter 1

Introduction

All sides endlessness earth sky as one no sound no stir.
—Samuel Beckett, Lessness

Sans fin sans (endlessness) is a fifteen-minute musical composition scored for solo guitar, seven wind instruments (flute, oboe, clarinet, bassoon, trumpet, horn, trombone) and double bass. Although the work is in one continuous movement, it consists of seven distinct sections, each constructed from fragmented pieces of a pre-composed originating structure. Influenced by the prose of Samuel Beckett, sans fin sans is an exploration of non-linear time and the Deleuzian notion of art as abstract machine.

The composition of sans fin sans represents my confrontations with a variety of musical and non-musical sources. At its core, it is my attempt to place my musical activities within a larger philosophico-aesthetic framework, as well as a continuation of my compositional interest in exploring unusual musical forms and non-traditional instrumental sound production techniques. It is also an attempt to utilise mathematical phenomena—including prime numbers, fractals and L-Systems—to generate compelling musical material.

The title of the work stems from a French translation of 'endlessness', fin sans fin, literally 'end without end'. These words were then inverted as both a play on the title of a prose work by Samuel Beckett, called Lessness, or Sans in its original French; and, as a reflection of the partly random construction technique which allows for any number of potential outcomes.
The unusual ensemble found in *sans fin sans* was chosen deliberately for its timbral potential, ability to produce wide dynamic contrasts and rare use. The choice of guitar for soloist also reflects my predilection for underused, non-orchestral instruments. Despite a limited presence in Western art-music—early examples include John Dowland’s lute works—the early 20th-century saw composers such as Manuel de Falla and Heitor Villa-Lobos bring a newfound legitimacy to the instrument. Notable contemporary works for solo guitar include Luciano Berio’s *Sequenza XI*, Tristan Murail’s *Tellur*, and Brian Ferneyhough’s *Kurze Schatten II*. Ferneyhough has also prominently featured the guitar in his recent opera, *Shadowtime*, based on the life of German philosopher Walter Benjamin. The second scene, *Les Froissemens d’Ailes de Gabriel*, is scored for solo guitar and large chamber ensemble, and Ferneyhough’s compositional focus on fragmentation and random ordering provided a strong influence on *sans fin sans*. Each of these works push the guitarist’s technique to new limits and introduce a variety of innovative methods for sound production, many of which are utilised in *sans fin sans*.

Following a brief discussion of the motivations behind *sans fin sans*, this dissertation spans four chapters: 1) Influences, Materials & Resources; 2) Pre-compositional Work; 3) Analysis: *sans fin sans*; and, 4) Conclusion. Supplemental materials, including computer source code, harmonic reference material and the full score of *sans fin sans*, can be found in the appendices.

1.1 Why this piece now?

Throughout my studies, I have been fascinated by the academic field of musical aesthetics. The question of compositional intent has motivated me to explore a variety of contemporary philosophical thought. Is my artistic goal simply to entertain, or to communicate an ideal, to express myself, some combination thereof, or something else entirely? I have certainly not fully answered any these questions, although my encounters with various thinkers—and of course, influential contemporary composers such as Helmut Lachenmann, Luciano Berio and Brian Ferneyhough—have led me to explore a variety of new compositional techniques and their affects.

Many of my past works can now best be viewed as contributing to experimentations with a particular theme or technique. For example, *Variations* and *...then burn*
me, both electroacoustic works for tape, are explorations of the sonic potential of a single sound source. Bent wallpaper is a string quartet that followed my initial encounters with the extended instrumental techniques present in Helmut Lachenmann’s works, and is also my first work that is heavily influenced by a non-musical source (a set of computer-generated ‘nonsense’ text). Happy pink music, for soprano saxophone and live electronics, is a virtuosic solo work combined with an electroacoustic component that utilises the saxophonist’s performance output to generate a real-time accompaniment. Sans fin sans represents a culmination and synthesis of these past works, and also provides me with a number of new directions for future pursuit.
Chapter 2

Influences, Materials & Resources

The composition of *sans fin sans* was inspired by a variety of musical and extra-musical sources: the prose of Samuel Beckett; philosophical concepts from Gilles Deleuze and Félix Guattari; the field of computer-assisted composition; spectralism; and, the theoretical writings of James Tenney and Brian Ferneyhough. The following chapter will provide some background and context for each of these influences.

2.1 Form & Conception

The initial inspiration that led to the composition of *sans fin sans* began through an encounter with a short work by Samuel Beckett, titled *Lessness*. Fascinated by its affect, I began to explore its underlying structure and resultant philosopho-aesthetic questions. This led me to examine a variety of contemporary aesthetic philosophies and conceptualise a means to reflect these influences in my own compositional work. Each of these extra-musical sources, their relationships to each other, and their impact on *sans fin sans* will be explored in this section.

2.1.1 Samuel Beckett

“Almost nothing happens” (Graver and Federman 1979). Quoted in Graver’s and Federman’s *Samuel Beckett*, this excerpt from a review of the play *Endgame* aptly summarises much of Beckett’s later work. During this period, Beckett’s prose embraces a dramatic minimalism—with ever shorter, more distilled writing—often only
amounting to a few pages of text. His drama and fiction dispense with conventional plot and the unities of time and place to become abstract narratives on the basis of experientiality.

2.1.1.1 Lessness

Beckett’s experimental prose piece *Lessness*—first published in French as *Sans* in 1969, and followed by Beckett’s own English translation in 1970—depicts a nameless protagonist within a barren world: “Grey face two pale blue little body.... Scattered ruins same grey as the sand ash grey true refuge.” (Beckett 1970)

The work consists of sixty sentences, structured into six groups (A-F) of ten sentences each (A1...A10, B1...B10, etc.) These six groups are differentiated by a particular thematic element that recurs in all ten sentences: decor, body, ruins, refuge forgotten, time past, and time future (Solomon 1980). These sentences were then ordered by means of a chance process: Beckett wrote each of the sixty sentences on a piece of paper, placed them in a box, and randomly selected them. The procedure was then repeated, resulting in 120 sentences (each of the original 60 restated once) which were subsequently ordered into paragraphs through a similar chance procedure. The numbers 3, 5 and 7 were written on four pieces of paper each, and the numbers 4 and 6 on six pieces of paper each, which were then also chosen randomly. This organised the final 120 sentences into 24 paragraphs, each consisting of a minimum of three, and a maximum of seven sentences (see Table 2.1) (Hulle 1980).

2.1.1.2 (end)Lessness

*Lessness* embodies a ‘Beckettian’ philosophy, a discourse with themes such as purgatory, despair and loneliness within an over-arching philosophy of the absurd. This absurdity is revealed at its most basic level as an engagement with nothing, and the repetition of nothing. This is not some nihilistic notion of emptiness, or lack-of-something, but rather a discourse with the dissolution of meaning. As Adorno remarks, “Beckett’s [works] are absurd not because of the absence of any meaning, for then they would be simply irrelevant, but because they put meaning on trial; they unfold its history.” (Adorno 1997, 153–4) This results in an art-form that cannot easily be explained through the constraints and conventions of a traditional narra-
Table 2.1: Ordering of Sentences in *Lessness*

<table>
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<tr>
<th>Paragraph</th>
<th>Part I</th>
<th>Part II</th>
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<td>C4, B6, A2</td>
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<td>A9, D3, E9, B8, E2</td>
<td>B8, B10, F2, F7</td>
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<tr>
<td>III</td>
<td>F10, C6, D8</td>
<td>E6, B2, F8, B4</td>
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<tr>
<td>IV</td>
<td>E6, D7, C1, F8, A5</td>
<td>D1, B3, A9, A5, E2, E9</td>
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<tr>
<td>V</td>
<td>B4, C4, B1</td>
<td>A1, F4, D6, C9, F6, B5, D7</td>
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<tr>
<td>VI</td>
<td>F3, E4, C7, B7, F2, B6</td>
<td>C3, C10, E5, F3, F5, E8</td>
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<td>VII</td>
<td>A4, C2, E3, C10, F5, E5</td>
<td>A7, E1, D5, E3, D3</td>
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<td>VIII</td>
<td>A1, C8, A6, B2, D5, A8</td>
<td>A10, D9, F9, B1, A8, E4, C6</td>
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<td>IX</td>
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<td>A4, B7, F1, C5, D10, B9</td>
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<td>D4, E7, D1, E1, C3, D2</td>
<td>C7, C1, C8, E10</td>
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tive structure. More specifically in the case of *Lessness*, there is an implicit reflection of the arbitrary structure that human beings have placed on time: twelve months in a year, twenty-four hours in a day, sixty minutes in an hour, etc. The impersonal and atemporal prose presents a confrontation with unending time and the futility of attempting to fix that which is always moving.

As a means of encouraging this challenge, Beckett offers the reader a series of sentences that have no immediately predictable relation or linear progression. It is a work of extreme concision, with a very small vocabulary employed alongside a high frequency of nominal constructions (Solomon 1980). Confronted with sameness and stasis, the reader must grasp for meaning by searching the seemingly chaotic text for any discernible pattern. Consequently, fragments are cognitively re-arranged in an attempt to create a suitable narrative structure, forcing the reader to truly interact with the work and ultimately become aware of their own interpretive strategies.

Further reflection on the affect of *Lessness* quickly engenders a need to situate any analysis within a larger philosophical framework. Beckett has been widely discussed by a variety of contemporary Western thinkers: Adorno, Bataille, Blanchot, Deleuze and Badiou have all written large-scale works devoted to Beckett, while many other authors have connected Beckett to various post-structuralist thinkers including Derrida and Foucault, as well as those already mentioned. An examination of the influ-
ence of Lessness and its connection to *sans fin sans* will be explored within this scope, specifically through the investigation of several ideas put forth by Gilles Deleuze and Félix Guattari.

### 2.1.2 Gilles Deleuze and Félix Guattari

Gilles Deleuze belongs to the predominantly French school of *post-structuralist* thought. Post-structuralism emerged in the late twentieth-century as a response to *phenomenology* and *structuralism*. Phenomenology developed early in the twentieth-century, with thinkers such as Edmund Husserl and Martin Heidegger building a means to objectively study the structures of consciousness. Structuralism is generally associated with the linguist Ferdinand de Saussure, and was an attempt to study linguistics—and later, culture and society—as a system where meaning is not inherent, but is instead derived from relationships with other components of its system. The post-structuralist movement responded to the perceived impossibility of both previous groups founding their knowledge on an objective, absolute 'Truth'.

Various thinkers took different approaches to this challenge: Michel Foucault disputed the view that certain social constraints can be considered 'natural' (e.g., sexuality), showing them to instead be historical; and, Jacques Derrida exposed how language constrains ideas with the privileging of particular terms over their complements (e.g., masculine over feminine). Deleuze also confronted generally accepted ways of thinking, preferring to view philosophy in terms of its possibility, rather than as a means to categorize and define. Deleuze's “great problem and contribution” (Colebrook 2002, 2) were the ideas of *difference* and *becoming*. These are both encounters with identity and ontology.

#### 2.1.2.1 Immanent Difference

For Deleuze and other continental thinkers, ontology is the study of being, or perhaps more to the point, it is the question: “what is it for something to *be*?” (May 2005, 13) Attempts to describe 'being' (or 'Being') most often lead to notions of transcendence, or 'out-of-world' existence (i.e., 'Truth', 'God', 'Beauty', etc.). Difference then becomes grounded upon identity (i.e., one object is different from another based

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1Generally mainland European philosophers outside the tradition of analytical philosophy.
upon what it is, or what it represents). Deleuze reverses this relationship with a ‘plane of immanence’, built upon a univocity of being. Instead of allowing for the existence of external matter, “the substance of being is one and indivisible.” (May 2005, 34) Identity results from the expression or actualisation of this Spinozian substance: identity becomes difference, or, difference is identity. In slightly more practical terms, this encourages new ways of thinking that are not attempts to represent pre-existing truths, but are instead immanent creations of difference that transform experience itself. Deleuze encourages a capacity to think differently.

To achieve this transformation, there needs to be a creation of “new concepts (through philosophy) and new percepts and affects (through art).” (Colebrook 2002, 25) Through the concept of immanent difference, Deleuze advocates an artistic product which will “shock, shatter and provoke experience.” (Colebrook 2002, 1) This creation is not an act of variation on an already extant object (i.e., a communication of ‘Truth’ or ‘Beauty’), but is instead a pulling-apart of our existing opinions and ideas. There are no stable ‘beings’, only flows of ‘becoming’. In A Thousand Plateaus, Deleuze and his co-author, French psychoanalyst Félix Guattari, conceptualise the vehicle of this becoming as an abstract machine.

2.1.2.2 Abstract Machine

Deleuze and Guattari use the idea of an abstract machine—an object with no subjectivity or intent—to describe “a production that is immanent... production for the sake of production itself” (Colebrook 2002, 55). An abstract machine “is the vital mechanism of a world always emerging anew”, it “creates a new reality, constructs new ways of being” (Zepke 2005, 2). The abstract machine has no being itself, it only becomes, but as Zepke notes: “we should remind ourselves that we are [still] speaking of practical matters, of machines and their constructions.” (Zepke 2005, 2) An abstract machine is a dynamic process of deterritorialisation, or becoming something other.

In A Thousand Plateaus, Deleuze and Guattari present a model of a deterritorialising abstract machine with two distinct stages, called a double articulation (Deleuze and Guattari 1987, 40). Within it, a ‘first articulation’ collects similar units into potentialities: a ‘plane of consistency’; while a ‘second articulation’ establishes struc-
tures from actualisations of these possibilities: a ‘becoming’. Or, as James Bell writes: “[a] process involv[ing] both differentiation... and differenciation... consistent, homogeneous layers are transformed (or actualised, as Deleuze often says) into a new, identifiable entity.” (Bell 2006, 213) Through this process, possibilities become concrete.

2.1.2.3 Art and Philosophy

It is not difficult to view Lessness as a double-articulation abstract machine. The initial sentences and their themes constitute a consistent collection with a multiplicity of potential combinations via random ordering—a first articulation. The second articulation is the actualised ordering of the sentences by a specific outcome of the chance process. Freeing his original text from its fixed order and viewpoint, Beckett produces a new affect which encourages the reader to think differently about their own concepts of time and engagement with Beckett’s text (see Section 2.1.1.2). The result is Art as abstract machine.

2.2 Theoretical Foundations

What form does a (musical) abstract machine take? How can it be constructed? What does it do? The specific articulations (i.e., difference and becoming) of the sans fin sans abstract machine will be explored in the next chapters. First, there needs to be a discussion of the theoretical underpinnings of its assemblage.

2.2.1 Algorithmic (Computer-Assisted) Composition

Much of the subsequent discussion of sans fin sans presents the use of procedures and calculations that may be viewed as forms of algorithmic composition. While the field of algorithmic composition is usually associated with the use of mathematics, computers, and other electronic aids, it is at its base simply composition with formal sets of rules. Algorithmic procedures in music predate the computer era—Fuxian species counterpoint with its strict constraints is a prime example—with many composers employing mathematical systems to explore various compositional strategies (e.g.,
the ubiquitous Fibonacci series).

It would be seen as suspect, however, to suggest that Western art-music composers of the ‘classical’ era employed algorithmic composition techniques, despite the clear procedural rules surrounding common-practice tonal harmony and formal organisation. As Luke Dubois notes in his dissertation, “where an extreme break between a musical form and our prevailing musical perception has occurred... we are much more likely to construe that music as mathematically induced” (DuBois 2003, 2–3). The implicit artistic value-judgement of ‘mathematical’ music aside, it is clear that the term is most often applied to music from the mid-1950s onward.

Focusing on works composed in the last half-century, two distinct—but not necessarily mutually exclusive—applications of algorithmic music can be identified: 1) the use of algorithms to generate music via human-machine interaction (i.e. automatic music composition); and, 2) the use of algorithms to generate musical materials to be further manipulated, incorporated and refined by the composer (i.e. computer-assisted composition). Martin Supper further divides this latter description into “score synthesis (the computer-aided working out of a composition...)”, and “sound synthesis (the computer-aided working out of a synthetic sound...)” (Supper 2001, 48). The use of algorithmic composition in sans ďen sans is best categorised as score synthesis.

Important considerations for the selection or creation of a generative algorithm include: 1) which algorithms produce abstract structures or systems with qualities sufficiently interesting or useful enough to be applied to the compositional process?; and, 2) which means can be used to successfully map these abstract notions to musical parameters? For sans ďen sans, the answer to the first question lies within the extramusical disciplines of chaos theory, fractal geometry and automata theory.

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2 Examples of this sequence as applied to musical form—often through the use of the golden mean, or $\phi$—include Bartok's Music for Strings, Percussion and Celesta and 'Reflets dans l'eau', from Debussy's Images.

3 The specific computer-assistance tool utilised for sans ďen sans is Ircam's OpenMusic software, a graphical environment based upon the Common Lisp programming language (Agon et al. 2008; Bresson et al. 2005). This extensible environment allows users to visually interact with musical and non-musical data structures via various included and user-defined functions. OpenMusic provides composers a platform to practically represent, manipulate, and experiment with otherwise restrictively complex and time-consuming calculations and logical structures.
2.2.1.1 Fractals

Fractals and chaos provide a useful environment for mathematically modelling structures of natural phenomena. Music has long been associated with—and often justified by—relationships to the natural world (i.e., Pythagoras and his analysis of vibrating strings, the golden ratio, etc.). It is generally accepted that some form of consistent structural unity—be it Fuxian counterpoint, common-practice tonality, dodecaphony, total serialism, etc.—provides the basis for an aesthetically-pleasing musical work. Fractals supply a means to explore new and complex dynamic-systems for such use.

The defining characteristic—and source of interest—of a fractal is expressed through the concept of *self-similarity*, whereby the recursive repetition of a process results in the shape of the whole as composed of same- or similarly-shaped parts. A fractal has structure on multiple 'sizes', if considered visually. The Mandelbrot set is a popular example, named after the mathematician who first defined the term fractal in 1975 (see Figure 2.1). Each numbered area is self-similar to the others, at different size scales.

The production process for fractal structures introduces the idea of a *feedback machine* (Peitgen et al. 1992, 17): an abstract machine that processes an input into an output that is subsequently fed back into the system during the next discrete iteration (see Figure 2.2). It is important to note that while attention is most often focused on the final product of the machine, the intermediate stages are deserving of equal interest. These steps are more easily conceptualised via the application of a particular type of *automata*, a parallel string-substitution production system proposed by Dutch botanist Aristid Lindenmayer.

2.2.1.2 Lindenmayer Systems

Lindenmayer developed his theoretical framework—known as *L-systems*—as a means to study natural growth processes, beginning with simple multi-cellular organisms.

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4A an excellent starting point to survey the field of chaos theory and fractal geometry is Peitgen et al. (1992).

5It should be noted that the Mandelbrot set is not purely self-similar, as various scale versions differ slightly.

6Automata are theoretical state-machines that recognise formal languages, and are most often encountered in computer-science roles such as compiler design.
before formalising a description of plant growth (Lindenmayer 1968; Prusinkiewicz and Lindenmayer 1990). This framework consists of a feedback machine that transforms a given input according to a set of production (string-rewriting) rules. These production rules are applied concurrently to all symbols within the input string. The connection to fractal production is immediately apparent, and the recursive nature of L-systems make the process very suited to a computer implementation. L-systems are already beginning to find use amongst composers (DuBois 2003; Manousakis 2006; Supper 2001), and when combined with fractals they provide an excellent means to explore 'natural' developmental processes.
L-systems are formally defined by an alphabet, or set of symbols containing elements that can be replaced (variables, represented by $V$); an initial system state, or axiom (represented by $\omega$); and, a set of production rules defining the way variables are to be rewritten with new sets of symbols. The actual symbols used are irrelevant to the functioning of the system, but will take on a significance during subsequent interpretation (see Section 2.2.1.3). A sample L-system can be represented:

**Alphabet:** $V : AB$

**Production rules:**
- $A \rightarrow AB$
- $B \rightarrow A$

**Axiom** $\omega : B$

which produces for each step $n$:

- $n = 0$: $B$
- $n = 1$: $A$
- $n = 2$: $AB$
- $n = 3$: $ABA$
- $n = 4$: $ABABA$
- $n = 5$: $ABAABABA$
- etc...

This particular example, taken from Prusinkiewicz and Lindenmayer (1990), is known as a context-free L-system as its productions are in the form predecessor $\rightarrow$ successor. It is also considered to be deterministic, as each symbol appears only once at the left of a production rule (i.e., there is no ambiguity about how to replace the successor). Various other categories of L-systems are possible; a comprehensive summary may be found in Manousakis (2006, 21–31).

The resulting sequences of strings from an L-system evaluation provide a wealth of self-similar data, but without context. A simple and commonly-accepted means of representing these L-system output strings was selected by Prusinkiewicz (Prusinkiewicz 1986), which produces a visual interpretation through the use of *turtle graphics*. 

13
Table 2.2: Available Turtle Graphics Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F$</td>
<td>move forward by a fixed step length $l$ and draw a line</td>
</tr>
<tr>
<td>$f$</td>
<td>move forward as above for $F$ but do not draw the line</td>
</tr>
<tr>
<td>$+$</td>
<td>turn left (counterclockwise) by a fixed angle $\delta$</td>
</tr>
<tr>
<td>$-$</td>
<td>turn right (clockwise) by a fixed angle $\delta$</td>
</tr>
</tbody>
</table>

2.2.1.3 Turtle Graphics

Developed by Seymour Papert at MIT for inclusion with the LOGO programming language, turtle graphics is now a common term for a method of drawing vector graphics. The ‘turtle’ is defined as a two-dimensional—although multiple dimensions are possible—automaton whose state consists of a current position $(x, y)$, and a current heading $(\alpha)$. This is written as a triple $(x, y, \alpha)$. The turtle is able to move forward and turn by sequentially interpreting a series of instructions, drawn from Table 2.2. By substituting these new symbols into an L-system definition, it becomes very easy to visually construct fractals.

As an example, consider a Koch curve. Named after the Swedish mathematician who introduced it in 1904, it is often regarded as a ‘classical’ fractal. It can be constructed by beginning with a straight line, which is then divided into three equal parts. Next, the middle portion of this division is replaced by an equilateral triangle with no base. This step is then repeated multiple times for each of the resulting line segments (see Figure 2.3). The process can be represented with the following L-system:

Alphabet: $V : F + -$

Production rules:
- $F \rightarrow F + F - F + F$
- $+ \rightarrow +$
- $- \rightarrow -$  

Axiom $\omega : F$

Parameter $\delta = 60$ degrees

which produces for each step $n$:
Figure 2.3: First Stages of a Koch Curve

\[ n = 0: \quad F \]
\[ n = 1: \quad F + F - F + F \]
\[ n = 2: \quad F + F - F + F + F + F - F + F - F + F + F + F - F + F + F \]

etc...

By interpreting these strings with the commands from Table 2.2, the visual output is nearly identical to Figure 2.3, although issues of scale are ignored (i.e., to accurately reproduce the shown graphic, the fixed length \( F \) would need to reduce proportionally after each iteration). It also useful to note that the resultant strings quickly become very large, and the use of a computer is essential for the efficient exploration of this and other fractals.

2.2.1.4 Musical Interpretation

The final stage in this process is a musical interpretation of these generated symbols. To be successful, this step requires an effective spatial mapping strategy. Initial attempts were simple connections between the graphical output and musical pa-
rameters such as pitch and duration (Prusinkiewicz 1986), while subsequent systems increase in complexity to address timbre, polyphony and ultimately, real-time generative routines (Chapel 2003; DuBois 2003; Manousakis 2006). Dubois suggests discarding the visual stage completely, advocating the mapping of an expanded symbol-vocabulary directly to discrete musical events (DuBois 2003, 28–32). This approach is an extension of the system whereby multiple—if not all—musical parameters are controlled by a single L-system. For sans fin sans, I limit my use of L-systems to an exploration of harmonic spectra, and as such, require a means by which the two-dimensional turtle graphics output can be mapped to musical pitch classes. This mapping strategy is best explained within the context of a compositional approach known as spectralism.

2.2.2 Spectralism

Julian Anderson’s article, A Provisional History of Spectralism, begins by noting the disparate background of the various ‘spectral’ composers, their lack of conscious participation as a coherent group, and the tendency to somewhat simplistically reduce their common connections to the obvious use and manipulation of sound spectra: “There is no real school of spectral composers; rather, certain fundamental problems associated with the state of contemporary music, since at least 1965, have repeatedly provoked composers... into searching out some common solutions.” (Anderson 2000, 7) Attempts have been made to outline these ‘common solutions’ as a variety of concepts and techniques central to the spectral movement (Fineberg 2000; Mosovich 1997; Wannamaker 2008)—those most directly applicable to sans fin sans are: 1) the basic notion of deriving pitch aggregates from spectral models; 2) the investigation of continuous state transformations; and, 3) the exploration of sonic experience beyond semantic meaning.

The latter two items fall within the previous theoretical discussion of the Deleuzian concept of art as abstract machine (see Section 2.1.2), equating to ideas of becoming and difference, respectively. The remainder of this section will investigate the final item: sound spectra as a harmonic resource and a domain rich for potential use in L-system interpretation.
2.2.2.1 Spectral Harmonic Structures

For the European-centric spectral regime—most commonly associated with composers such as Grisey, Murail, and Harvey; and attached to the ongoing research at the Institut de Recherche et Coordination Acoustique/Musique (Ircam)—harmonic and timbral structures are built upon musical frequencies. Pitches result from conversions of sets of frequencies that have been derived via spectral analysis of a particular sound sample and possible manipulation through various synthesis techniques (e.g., frequency modulation, additive synthesis, subtractive synthesis, etc.), techniques adopted from use in electroacoustic music.

Parallel to these developments in Europe, American composer and theorist James Tenney was also intensely occupied with utilising harmonic spectra as a structural resource. Of prime importance to Tenney’s compositional procedures is the exploration of the harmonic (or overtone) series, defined as a set of simple periodic waves (partials) that are whole number multiples of some fundamental frequency. His efforts resulted in a means to generate ‘pitch crystals’ in a lattice-like multi-dimensional harmonic space.

2.2.2.2 Harmonic Space

Tenney’s concept of harmonic space—which is extrapolated from Cage’s writings on harmony—is designed to express perceptions of pitch relationships beyond a single-dimensional continuum running from low to high. Tenney uses the phenomenon of octave equivalence to illustrate a frequency relationship that cannot be easily explained by simply applying ‘higher’ or ‘lower’ descriptions (Tenney 1983, 21). Within this multi-dimensional space of pitch perception, pitches are “represented by points... and each is labelled according to its frequency ratio with respect to some reference pitch” (Tenney 1983, 22). Materially and conceptually related to the overtone series, these whole-number frequency ratios represent musical intervals (i.e., a pitch one octave above a reference has the frequency ratio 2/1, a pitch a perfect fifth above a reference has the frequency ration 3/2, etc.). In order to transform a ratio into a co-ordinate or ‘point’ within harmonic space, Tenney makes use of a fundamental mathematical theorem: any integer can be represented by a unique product of prime numbers. This

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7For more on Tenney’s ‘spectralist’ works, see Wannamaker (2008).
product is called its \emph{prime factorization}.

Each musical interval can thus be represented within harmonic space by the prime number factor exponents of its frequency ratio. For example, the interval of a fifth, with its ratio of $3/2$, would be encoded as a pitch-point of $(-1, 1)$, a co-ordinate obtained by multiplying $2^{-1}$ and $3^1$. Harmonic space can be expanded into multiple dimensions corresponding to the number of prime number factors (i.e., 2, 3, 5, 7, 11, 13, etc.) required to specify particular frequency ratios. Each additional dimension allows for the representation of a larger collection of ratios. For example, using only the 'Pythagorean' intervals of unisons, perfect fifths, perfect fourths and octaves (ratios $1/1$, $3/2$, $4/3$ and $2/1$, respectively), a two-dimensional harmonic space is sufficient to define its members (see Table 2.3). Adding the remaining Riemann just-intervals of thirds and sixths requires a new dimension, corresponding to the next prime number in the series, which is five. This new construct can be referred to as 5-limit harmonic space, referencing the highest utilised prime factor. Similarly, the earlier Pythagorean intervals exist within a 3-limit harmonic space. More complex integer ratios can be added, and further dimensions explored, resulting in an extended just-intonation area of 7-, 11- and 13-limit harmonic space (Hasegawa 2006), and beyond, to 23- and even 31-limit harmonic space (Sabat 2008a,b). Tenney does note that the concept of a \emph{tolerance range} does constrain the extension into unlimited dimensions of harmonic space. As such, “at some level of scale-complexity, intervals whose frequency ratios involve a higher-order prime factor will be indistinguishable from similar intervals characterized by simpler frequency ratios, and the prime factors in these simpler ratios will define the dimensionality of harmonic space in the most general sense” (Tenney 1983, 23).

Tenney and Sabat outline a last refinement to harmonic space: \emph{pitch-height constrained harmonic space} (Sabat 2008b, 61), or \emph{pitch-class projection space} (Tenney 1983, 25). This space ‘collapses’ the 2-dimension by using an octave-equivalence principle. That is, as 2-limit harmonic space is only capable of representing octaves or unisons, the 2-dimension is not required to uniquely identify intervals less than one octave. It is therefore sufficient to write any octave-related ratio in its simplest form. For example, a just major third (ratio $5/4$) is encoded with the pitch-point \footnote{This co-ordinate is obtained by multiplying $2^{-2}$, $3^0$ and $5^1$} of $(-2, 0, 1)^8$ in 5-limit harmonic space, while a just major tenth (ratio $5/2$) would...
Table 2.3: Pythagorean Intervals in 2-limit Harmonic Space

<table>
<thead>
<tr>
<th>Interval Name</th>
<th>Co-ordinates</th>
<th>Limit</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>unison</td>
<td>(0,0)</td>
<td>2-1/1</td>
<td>1/1</td>
</tr>
<tr>
<td>fifth</td>
<td>(-1,1)</td>
<td>2-3/2</td>
<td>3/2</td>
</tr>
<tr>
<td>fourth</td>
<td>(2,-1)</td>
<td>2-4/3</td>
<td>4/3</td>
</tr>
<tr>
<td>octave</td>
<td>(1,0)</td>
<td>2-2/1</td>
<td>2/1</td>
</tr>
</tbody>
</table>

be encoded with the pitch-point of $(-1,0,1)_F$. However, in pitch-class projection space, the 2-dimension can be ignored and both of these intervals—in addition to any other octave-related distance—can simply be referred to by the pitch-point $(0, 1)$. This principle effectively allows a representation of the primary ratios of triadic/tonal music (5-limit harmonic space) within a two-dimensional co-ordinate system.

As noted earlier, the concept of harmonic space was developed to explore extended pitch relationships. Tenney's specific use of this theory stems from his desire to achieve harmonic coherence via the “use of relatively compact, connected sets of points... [where] every element is adjacent to at least one other element in the set.” (Tenney 2008, 47) The connection between any two points in harmonic space is conceptually quantified as harmonic distance. Tenney defines this measurement to be “proportional to the sum of the distances traversed on a shortest path connecting [the two points]”, and is calculated using a logarithmic function: $\log(a) + \log(b) = \log(ab)$, where $f_a$ and $f_b$ are the fundamental frequencies of the two tones, $a = f_a/gcd(f_a, f_b)$, $b = f_b/gcd(f_a, f_b)$, and $a \geq b$ (Tenney 1983, 24). Consequently, his ‘crystal growth’ algorithm chooses sets of points “in some n-dimensional harmonic space, under the condition that each new point must have the smallest possible sum of harmonic distances to all points already in the set.” (Tenney 2008, 47) This algorithm has subsequently been refined and expanded by Marc Sabat (Sabat 2008b).

While Tenney’s algorithm and its output are certainly of interest, it is the larger framework of harmonic space that holds the most appeal for my use with sans fin sans. Mapping graphical L-system output to this theoretical model appears to provide a wealth of compositional potential. The specific application of this connection to sans

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*This co-ordinate is obtained by multiplying $2^{-1}$, $3^0$ and $5^1$.
fin sans will be discussed in the next chapter. The next and final section will explore a few relevant ideas of musical time.

2.2.3 Musical Time

The relationship between time and music is a fascinating one. Being a temporally perceived art-form, discussions often privilege music and its ability to represent time. This type of thinking quickly leads to “the realisation that certain fundamental methods for understanding musical phenomena can be formulated—if at all—only in philosophico-aesthetic terms” (Klein 2004, 133), and that “without doubt, the question of time is one of these [phenomena]” (Klein 2004, 134). Klein’s essay provides an excellent introduction to various philosophical thoughts on musical time.

For sans fin sans, a large-scale dialogue with musical time can best be viewed in terms of Jonathan Kramer’s definitions of multiply-directed linear time, and, to a lesser degree, moment time/form (Kramer 1988); while more localised rhythmic explorations have been inspired by composer Brian Ferneyhough (Ferneyhough 1995a,b). Each of these categories will be explored in turn.

2.2.3.1 Non-linear Musical Form

Traditional musical time can be seen to be linear: there are beginnings, endings and middles, and the progress of works reflecting this type of time demonstrate a “temporal continuum created by a succession [of] events in which earlier events imply later ones and later ones are consequences of earlier ones.” (Kramer 1988, 20) The fragmentation, re-ordering and de-construction of linear time results in what Kramer calls multiply-directed linear time: a multi-dimensional work where “some processes... move towards one or more goals yet the goals are placed elsewhere than at the ends of the processes.” (Kramer 1988, 46) Finally, moment time/form represents a complete discontinuity in the musical process and a destruction of the beginning-middle-end logic of the dramatic curve.

Initially formulated by Stockhausen in the early 1960s, the abstract aesthetic concept of moment time is clearly exhibited in Beckett’s Lessness. The prose inhabits a world of timelessness, describing only fleeting moments; while the chance construction techniques employed by Beckett bring further fragmentation and disorder to
the work. Nevertheless, this resulting arbitrary ordering cannot fully disguise the relations which exist between the sentences (discussed earlier in Section 2.1.1.1 see Table 2.1). It is within these relationships that moment time and multiply-directed linear time meet. Many of the construction techniques and linkages between the generative structure of Chapter 3 and the resulting piece described in Chapter 4 are attempts to explore the consequences of these two theories of musical time. However, in order for these formal relationships to exist there was a need to apply some level of a directed connection to localised rhythms.

2.2.3.2 Duration and Rhythm

Ferneyhough’s work is notable for his complex confrontation with contemporary compositional problems related to the musical demarcation of time. His scores are precisely notated examples of extreme virtuosity. A prolific writer as well, Ferneyhough notes: “the issue of rhythmic structuring in contemporary music has long remained vexed” (Ferneyhough 1995a, 51). Further, “there is arguably little point in retaining regular iterative rhythmic structures in a stylistic context devoid of tonal (or tonal-type) harmonic patterns.” (Ferneyhough 1995a, 51) Or, as Gérard Grisey notes in his article on musical time: “Without a reference pulse we are no longer talking of rhythm but of durations... perceived quantitatively by [their] relationship to preceding and successive durations.” (Grisey 1987, 240)

Ferneyhough’s solution is to create rhythmic and metric structures based on ratio relationships. A straight-forward example, taken from Ferneyhough (1995b, 54), is to build two simple numerical sequences: $A = (3, 4, 5)$; and, $B = (4, 5, 6, 7)$. Combining them to form simple ratios results in a new sequence: $C = (3 : 4, 4 : 5, 5 : 6, 3 : 7, 4 : 4, 5 : 5$, etc.). The unequal lengths of both sequences provides a further potential point of interest. Figure 2.4 demonstrates a possible musical representation. For sans fin sans, a connection with the ratios expressed in harmonic space suggest a parallel extension of pitch-relationships into the rhythmic realm. Together, these relationships provide a level of goal-direction to the musical material, and support a future reorganisation of these linear lines into the realm of multiply-directed linear time.

This procedure can be further combined with a process Ferneyhough refers to
as a *random funnel*: a cyclic, linear random procedure whereby “a fixed, unordered number series is randomly permuted until it reaches a contextually pre-determined, final destination” with the caveat that “if a number arrives at its destination before the last stage it simply repeats, or remains in place.” (Feller 2004, 179) Again, a simple example can be used to illustrate the procedure. Given a sequence: $A : (1, 2, 3, 4, 5)$, a possible random funnel process output can be found in Figure 2.5 (emphasised numbers indicate those which have reached their final destination). More elaborate versions of these procedures will govern much of the surface-level metric activity of *sans fin sans* (see Section 3.2).

A final theoretical concept of Ferneyhough’s that will be evidenced in *sans fin sans* is *interruptive polyphony*, or *interference form* (Feller 2002; Ferneyhough 1995b). Clearly related to multiply-directed linear time, it involves the convergence of two or more independent rhythmic processes (usually notated on separate staves) into a single stream. Employed explicitly in Ferneyhough’s solo instrument works—although also evident in ‘soloistic’ works such as *Terrain*—the “monophonic capability of the instrument comes into continual conflict with the highly polyphonic nature of the superincumbent materials” (Ferneyhough 1995b, 48). In practical terms, materials or events from one process are continually being interrupted by those from the others, resulting in subverted durations and ‘broken’ gestures. Figure 2.6 demonstrates a two-part interruptive polyphony for solo violin active during the first few measures.
Figure 2.6: Measures 1–4 of Ferneyhough’s Terrain

of Terrain (Ferneyhough 1993). Its use in sans fin sans can be observed at the formal level (see Section 4.1.1).

2.3 Summary

This chapter has covered a diverse array of material. By extrapolating several Deleuzian philosophico-aesthetic ideals from Beckett’s Lessness, and exploring various algorithmic functions (i.e., pitch and rhythmic derivations from harmonic space) as production means, the theoretical pieces for sans fin sans have been arranged.
Chapter 3

Pre-compositional Work

Various pre-compositional decisions were made prior to writing *sans fin sans*. As is usual for my work, this stage exhaustively details many musical parameters, including rhythmic and harmonic resources as well as large-scale form. For *sans fin sans*, this work constituted a concrete implementation of the various theories and philosophico-aesthetic concerns outlined in Chapter 2, building a collection of pitch, form and durational materials. These components then guided the composition of a generative structure.

3.1 Pitch Material

The harmonic resources of *sans fin sans* are akin to the Deleuzian plane-of-consistency: a homogeneous collection of materials resulting from a filtration-system which actualises pitch-fields from a common source, analogous to the process of sedimentation described in Deleuze and Guattari (1987, 41). Overlooking the extra-musical influence, this approach is similar to one employed by Ferneyhough. He has described his use of serialism for pitch selection “as being something like a sieve, a set of filter systems, which I forcibly impose on the basic mass of initially unformed or unarticulated [elements].” (Boros and Toop 1995, 227)

For *sans fin sans*, a pitch sequence was generated via the mapping of an L-system output to 5-limit harmonic space (i.e., interval ratios which require the prime exponents of 2, 3 and 5). This output was then delimited into chords through a process of circular range-‘wrapping.’ In order to accomplish this production, a custom Open-
Music library was authored.

3.1.1 omlsystem: An OpenMusic library

As discussed in Section 2.2.1, the various calculations and products of an L-system quickly become cumbersome to employ without the assistance of a computer. The OpenMusic system (Agon et al. 2008; Bresson et al. 2005) provides an excellent working environment for this task, and it has the additional feature of providing tools to translate abstract output to musical entities. However, as OpenMusic does not provide higher-level functions to work directly with L-system concepts, it was necessary to create a custom user-library. Called omlsystem, this library provides an implementation of the mathematical theories discussed in Section 2.2.1.2: 1) a turtle graphics interpretive module; 2) a processing engine that will evaluate a given L-system; and, 3) a mapping system to translate the turtle graphics output to pitch values via harmonic space co-ordinates. See Appendix A for a full source code listing of the library.

3.1.1.1 Turtle Graphics Interpretation

The basic data-object of the omlsystem library is the turtle (see Section 2.2.1.3 for a definition). It keeps track of its own position, and responds to functions that correlate to the instructions given in Table 2.2. The turtle’s subsequent state after evaluating a function $F$, $+$, or $-$ is calculated with simple trigonometric functions (see Table 3.1). Here, $l$ represents the value the turtle moves forward by (the default is 1.0), and $\delta$ is the angle by which the turtle turns left or right (the default is 90°). A polar coordinate system is used (i.e., 0° is facing right, or the 3 o’clock position), and the initial starting point of the turtle is the state $(0, 0, 0)$.

The turtle graphics module was designed to be of general-purpose use, and is not strictly tied to the evaluation of L-systems. However, one particular requirement became apparent during the mapping phase: for any meaningful location in harmonic space, the $(x, y)$ co-ordinates must remain integers. This resulted in a specific mode of evaluation for the turtle, where the real number co-ordinates are rounded to integer values by a function that essentially ‘locks’ the turtle’s rotation angle to multiples

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1The omlsystem library did not implement $f$, as it was not utilised for sans fin sans.
Table 3.1: Turtle Graphic State Evaluation

<table>
<thead>
<tr>
<th>Command</th>
<th>State ((x, y, \alpha)) Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(F)</td>
<td>((x + l \cos \alpha, y + l \sin \alpha, \alpha))</td>
</tr>
<tr>
<td>+</td>
<td>((x, y, \alpha + \delta))</td>
</tr>
<tr>
<td>-</td>
<td>((x, y, \alpha - \delta))</td>
</tr>
</tbody>
</table>

of 45°. As well, this function modifies the length \(l\) that the turtle moves forward when its heading is not parallel to either the x- or y-axis such that its final location can be represented by integer values.

The remaining elements of the turtle graphics module include implementations of two comparison functions: one that performs a standard ‘equals’ evaluation, and a second that determines if two turtle objects occupy the same \((x, y)\) position (regardless of heading). As well, helper functions exist to read the \((x, y)\) position of a turtle object or list of turtle objects.

3.1.1.2 L-system Processing Engine

Rather than implementing a specific L-system as a single procedure (as is most common), omlsystem provides a graphical means to evaluate a variety of possible L-systems. A single end-user function takes as input an axiom and a paired-list of production rules, each made up of references to the turtle command functions described in Table 3.1. There are two outputs from this function: a turtle object corresponding to the final position of the evaluation, and a list of turtle objects that equate to the positions the turtle has passed through during evaluation (i.e., each position of the turtle after processing an \(F\) function). The result is an environment that is easily correlatable to the form of L-system definitions encountered in Section 2.2.1.2.

Formally, the L-system processing engine performs two procedures: 1) given a list \(L\) of functions, and a list \(P\) of paired-production rules (i.e., string replacements), apply the substitutions in \(P\) to \(L\); and, 2) given a list \(L\) of functions (i.e., \(F, +\) or \(-\)), and a turtle-object \(X\), apply the functions in \(L\) to \(X\). These functions can be considered a substitution phase and an evaluation phase, respectively. The engine functions by recursively performing these phases in sequence for \(n\) number of stages, beginning
with a substitution\footnote{By starting with a substitution, the axiom is not included in the evaluation phase, and is therefore not part of the engine’s output.}

As an example, let’s return to the Koch curve from Figure 2.3. The corresponding omlsystem representation can be seen in Figure 3.1. The L-system evaluation engine takes three inputs: 1) an integer detailing the recursion depth; 2) the axiom (represented as a list of turtle objects); and, 3) a paired-list of production rules composed of a turtle object signifying the string to be replaced and a list of turtle objects representing the actual substitution string. The output is a list of turtle objects, which are then ready to be translated into a list of specific pitches.

3.1.1.3 Harmonic Space Mapping

This translation process makes up the final component of the omlsystem library, and maps a turtle’s position onto harmonic space. Since the turtle module operates within a relatively simple two-dimensional space, it may seem that the omlsystem library is constrained to a 3-limit harmonic space (i.e., a harmonic space that requires only two prime factors to specify its location). However, by employing pitch-class projection space and its removal of the 2-dimension (see Section 2.2.2.2), the intervallic possibilities of the system are expanded into 5-limit harmonic space—albeit normalised to include only intervals less than one octave—while still allowing for a two-dimensional representation. Table 3.2 provides all available intervals and their corresponding location in 5-limit harmonic space. Both the ordering and naming of these intervals are taken from Sabat (2008b, 58–61). By mapping these values to two-dimensional space (see Figure 3.2), another interesting quality is made apparent: the resulting structure is not square, but rather lattice-like, the ‘crystal’ end-product of Tenney’s growth algorithm.

A lookup-table provides the translation between a turtle’s co-ordinates and an interval value in cents (i.e., a unit of pitch measurement where an octave is divided into 1200 equal segments). This level of granularity allows for a representation of the micro-tonal intervals involved in multi-dimensional harmonic space. However, while the system is capable of producing a higher degree of accuracy, a quarter-tone resolution was chosen for sans fin sans due to practical performance considerations.

To demonstrate this translation process, the omlsystem version of a Koch curve
Figure 3.1: An omlsystem Koch Curve
Table 3.2: Available Intervals in 5-limit Harmonic Space

<table>
<thead>
<tr>
<th>Interval Name</th>
<th>Co-ordinates</th>
<th>Limit</th>
<th>Ratio</th>
<th>Cents</th>
</tr>
</thead>
<tbody>
<tr>
<td>unison</td>
<td>(0,0)</td>
<td>2-</td>
<td>1/1</td>
<td>0</td>
</tr>
<tr>
<td>pythagorean fifth</td>
<td>(1,0)</td>
<td>3-</td>
<td>3/2</td>
<td>702</td>
</tr>
<tr>
<td>pythagorean fourth</td>
<td>(-1,0)</td>
<td>3-</td>
<td>4/3</td>
<td>498</td>
</tr>
<tr>
<td>major whole tone</td>
<td>(2,0)</td>
<td>3-</td>
<td>9/8</td>
<td>204</td>
</tr>
<tr>
<td>ptolemaic major third</td>
<td>(0,1)</td>
<td>5-</td>
<td>5/4</td>
<td>386</td>
</tr>
<tr>
<td>ptolemaic major seventh</td>
<td>(1,1)</td>
<td>5-</td>
<td>15/8</td>
<td>1088</td>
</tr>
<tr>
<td>ptolemaic major sixth</td>
<td>(-1,1)</td>
<td>5-</td>
<td>5/3</td>
<td>884</td>
</tr>
<tr>
<td>ptolemaic tritone</td>
<td>(2,1)</td>
<td>5-</td>
<td>45/32</td>
<td>590</td>
</tr>
<tr>
<td>ptolemaic minor third</td>
<td>(1,-1)</td>
<td>5-</td>
<td>6/5</td>
<td>316</td>
</tr>
<tr>
<td>ptolemaic minor sixth</td>
<td>(0,-1)</td>
<td>5-</td>
<td>8/5</td>
<td>814</td>
</tr>
<tr>
<td>ptolemaic minor seventh</td>
<td>(2,-1)</td>
<td>5-</td>
<td>9/5</td>
<td>1018</td>
</tr>
<tr>
<td>major diatonic semitone</td>
<td>(-1,-1)</td>
<td>5-</td>
<td>16/15</td>
<td>112</td>
</tr>
<tr>
<td>pythagorean minor seventh</td>
<td>(-2,0)</td>
<td>3-</td>
<td>16/9</td>
<td>996</td>
</tr>
<tr>
<td>minor whole tone</td>
<td>(-2,1)</td>
<td>5-</td>
<td>10/9</td>
<td>182</td>
</tr>
<tr>
<td>ptolemaic diminished fifth</td>
<td>(-2,-1)</td>
<td>5-</td>
<td>64/45</td>
<td>610</td>
</tr>
<tr>
<td>pythagorean minor third</td>
<td>(-3,0)</td>
<td>5-</td>
<td>32/27</td>
<td>294</td>
</tr>
<tr>
<td>ptolemaic augmented fifth</td>
<td>(0,2)</td>
<td>5-</td>
<td>25/16</td>
<td>773</td>
</tr>
<tr>
<td>ptolemaic diminished fourth</td>
<td>(0,-2)</td>
<td>5-</td>
<td>32/25</td>
<td>427</td>
</tr>
<tr>
<td>minor chromatic semitone</td>
<td>(-1,2)</td>
<td>5-</td>
<td>25/24</td>
<td>71</td>
</tr>
<tr>
<td>ptolemaic augmented second</td>
<td>(1,2)</td>
<td>5-</td>
<td>75/64</td>
<td>275</td>
</tr>
<tr>
<td>large diminished octave</td>
<td>(1,-2)</td>
<td>5-</td>
<td>48/25</td>
<td>1129</td>
</tr>
<tr>
<td>ptolemaic diminished seventh</td>
<td>(-1,-2)</td>
<td>5-</td>
<td>128/75</td>
<td>925</td>
</tr>
<tr>
<td>ptolemaic wide fourth</td>
<td>(3,-1)</td>
<td>5-</td>
<td>27/20</td>
<td>520</td>
</tr>
<tr>
<td>major limma</td>
<td>(3,1)</td>
<td>5-</td>
<td>135/128</td>
<td>92</td>
</tr>
<tr>
<td>ptolemaic narrow fifth</td>
<td>(-3,1)</td>
<td>5-</td>
<td>40/27</td>
<td>680</td>
</tr>
<tr>
<td>pythagorean major third</td>
<td>(-3,-1)</td>
<td>5-</td>
<td>256/135</td>
<td>1108</td>
</tr>
<tr>
<td>comma-diminished octave</td>
<td>(-4,0)</td>
<td>3-</td>
<td>128/81</td>
<td>792</td>
</tr>
<tr>
<td>Rameau's tritone</td>
<td>(-2,2)</td>
<td>5-</td>
<td>25/18</td>
<td>569</td>
</tr>
<tr>
<td>ptolemaic augmented sixth</td>
<td>(2,2)</td>
<td>5-</td>
<td>225/128</td>
<td>976</td>
</tr>
<tr>
<td>Rameau's false fifth</td>
<td>(2,-2)</td>
<td>5-</td>
<td>36/25</td>
<td>631</td>
</tr>
<tr>
<td>ptolemaic diminished third</td>
<td>(-2,-2)</td>
<td>5-</td>
<td>256/225</td>
<td>223</td>
</tr>
</tbody>
</table>
in [Figure 3.1] will produce a first-stage output of \(((1, 0), (1, 1), (1, 0), (2, 0))\) in harmonic space co-ordinates with a starting point of \((0, 0)\), corresponding to the instructions \(F + F - F + F\). Only four co-ordinates are output as the non-movement instructions (i.e., +, −) are not recorded. The translated intervals are \((702, 1088, 702, 204)\), or by name, \((\text{pythagorean fifth, ptolemaic major seventh, pythagorean fifth, major whole tone})\). The musical mapping, with middle-C as the base tone and rounding to the nearest quarter-tone, is shown in Figure 3.3.

One final component of the omlsystem library is a customisable constraint function to keep the output co-ordinates within 5-limit harmonic space. Once a co-ordinate extends beyond the lattice, for example \((5, 0)\), the out-of-bounds value is ‘wrapped’ as though the lattice were placed on the surface of a sphere (i.e., in a manner similar to a two-dimensional representation of a map of Earth). This allows for complex and cumulative explorations of 5-limit harmonic space.

3.1.2 endlessness

After experimenting with a variety of classical fractals and their musical mappings, I selected a randomised quadratic Koch curve to serve as the basis for the pitch-generation model of sans fin sans. A more advanced version of the Koch curve discussed earlier (see Figure 2.3), it provides a suitably varied and non-trivial exploration of 5-limit
harmonic space without excessive computational complexity. The curve can be represented with the following L-system:

**Alphabet:**

\[ V : F + - \]

**Production rules:**

\[ F \xrightarrow{50\%} F + F - F - FF + F - F \]
\[ F \xrightarrow{50\%} F - F + F + FF - F - F + F \]
\[ + \rightarrow + \]
\[ - \rightarrow - \]

**Axiom**

\[ \omega : F \]

**Parameter**

\[ \delta = 90 \text{ degrees} \]

While still context-free, this L-system is *non-deterministic*, as it has an element of random choice. The decision of which string substitution for \( F \) to apply at each point in the process is determined by a stochastic process, with a 50% probability that the first choice will be selected and a 50% probability that the second choice will be selected. As a result, the output from this system will be different each time it is run. The *omlsystem* patch for this system is shown in Figure 3.4. Owing to its larger string substitution length, the size of the output of this system grows very quickly. After the first stage only eight intervals are generated, however, by the completion of the fourth stage there are over four-thousand. The ‘endless’ nature of this sequence is clearly evident.

In order to aggregate these intervals into usable pitch-fields, an algorithm was created that ‘wraps’ chords built on these intervals at an upper- and lower-limit based upon the traditional guitar range (i.e., low open string E2 to 12\(^{th}\)-fret top string E5, without the scordatura discussed in Section 3.3). Once a pitch exceeds the upper limit, it is transposed down the necessary octaves to ‘fit’ into the lower register of the guitar. It is also at this point that a new chord begins.

After applying this procedure—and beginning with E2 raised by a quarter-tone—the intervals of the fourth-stage are accumulated into 577 chords. It is from this collection that I withdrew the harmonic material for *sans fin sans*. Once the various rhythmic and formal decisions of the next two sections were implemented, the harmonic language of *sans fin sans* constituted the first 152 chords of this selection. See Appendix B for the complete chord sequence.
Figure 3.4: An omlysystem Randomised Quadratic Koch Curve
Beyond common pitch relationships, the generative materials of sans fin sans also employ homogeneous treatments of duration. Metrical consistency of the originating structure is maintained by way of a cyclic repetition of a durational sequence derived from the ratio-relationships of harmonic space. Following the order provided by Tenney’s algorithm (see Table 3.2), a basic sequence is assembled (see Figure 3.5). Then, a base rhythmic value of an eighth-note is applied to this sequence, creating a fourteen-bar unit: (1/8, 1/8, 3/8, 2/8, 4/8, 3/8, 9/8, 4/4, 5/8, 2/4, 7 + 8/8, 5/8, 3/8). The end result is a structure for potential musical ‘sentences’, each made up of exactly 71 eighth-note pulses.

In addition to the rhythmic flow of each line, the main surface-level activity of sans fin sans is also governed by a variant of this durational sequence. By splitting the ratios of Table 3.2, two sequences are defined. A random funnel algorithm (see Section 2.2.3.2) is then applied until the original ordering is obtained.

The resulting sequences, shown in Table 3.3, are combined with the rhythmic ‘sentence’ structure to create a grid of various rhythmic polyphonies. As an example, Figure 3.6(a) displays the rhythmic pulses of the first four measures of iteration I. Each measure is subdivided via an application of the (sometimes simplified) random funnel sequence. Comparable rhythmic-skeletons were created for each of the remaining groups. These were then further processed by accumulating beats either within or across measures based upon a further numerical sequence. For example, Figure 3.6(b) shows an accumulation process where the subdivisions of Figure 3.6(a) are grouped into longer rhythmic pulses starting from the third position of the original ordering of the basic durational sequence (i.e., 3, 2, 4, 3, etc.). Figure 3.6(c) shows the same procedure applied within individual measures only.

These various means of partitioning the initial subdivided structure using similar numerical sequences creates a sense of ‘textural time’, to use Ferneyhough’s terminology. “Just as pitch-partitioning operations allow pitch-space to be traversed in many subtly nuanced ways, so different ‘textural-times’ can be evoked by distributing

\[(1, 1, 3, 2, 4, 3, 9, 8, 5, 4, 15, 8, 5, 3)\]

Figure 3.5: Basic Durational Sequence in sans fin sans

3.2 Duration
Table 3.3: Random Funnel Sequence in *sans fin sans*

<table>
<thead>
<tr>
<th>Iteration</th>
<th>Random Funnel Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>8 16 5 3 4 6 9 27 1 15 3 16 5 45</td>
</tr>
<tr>
<td></td>
<td>8 3 8 3 5 5 5 2 32 5 16 8 1 4 9</td>
</tr>
<tr>
<td>II</td>
<td>1 15 8 9 5 6 1 27 9 3 45 16 4 16</td>
</tr>
<tr>
<td></td>
<td>3 8 3 8 4 5 1 32 5 2 1 1 1 9</td>
</tr>
<tr>
<td>III</td>
<td>1 8 8 9 5 15 1 27 9 3 4 16 9 6</td>
</tr>
<tr>
<td></td>
<td>1 1 3 8 4 16 3 32 1 5 9 3 8 5</td>
</tr>
<tr>
<td>IV</td>
<td>1 3 16 9 5 15 5 9 3 8 4 16 9 27</td>
</tr>
<tr>
<td></td>
<td>1 1 3 8 4 16 3 32 5 5 9 15 1 8</td>
</tr>
<tr>
<td>V</td>
<td>1 9 1 9 5 3 5 45 6 8 1 16 4 27</td>
</tr>
<tr>
<td></td>
<td>1 2 1 8 4 1 3 32 5 5 1 15 9 8</td>
</tr>
<tr>
<td>VI</td>
<td>1 3 4 9 5 3 5 45 6 8 1 16 1 27</td>
</tr>
<tr>
<td></td>
<td>1 2 3 8 4 1 3 32 5 5 2 15 1 16</td>
</tr>
<tr>
<td>VII</td>
<td>1 3 4 9 5 15 5 45 6 8 9 16 16 27</td>
</tr>
<tr>
<td></td>
<td>1 2 3 8 4 8 3 32 5 5 5 15 9 16</td>
</tr>
</tbody>
</table>

available impulses according to hierarchically-preferential schemata” (Ferneyhough 1995a, 58). In *sans fin sans*, I have attempted to build an internal consistency by expressing the ratios of harmonic space within a rhythmic context.

### 3.3 Form

To this point, it may appear that *sans fin sans* is the product of a particularly strict, sterile computational system. How does creativity factor into the compositional process, beyond the selection of particular algorithms or mapping strategies? Admittedly, there has been little evidence yet for such concerns; nevertheless, musicality and intuition *do* play a vital role. At this stage, the various skeletal structures of pitch and duration will be intuitively assembled into an originating structure consisting of seven musical groups.

This overall generative form of *sans fin sans* mimics Beckett’s *Lessness* (see Section 2.1.1.1), with a few minor alterations. The seven groups of musical lines are each composed of focused, short phrases from one to five measures in length—analagous
to the paragraphs and sentences of Beckett’s prose—all related by a particular thematic element. Like elaborate studies, these phrases explore their particular musical ‘topic’ (See Table 3.4), various technical means of producing its expressions on the guitar, and distinct manifestations of an overall pre-occupation with resonance. Additionally, an exploration of levels of ‘tension’ within three other themes occur: attack density, texture, and contrast (see Table 3.5). Musical parameters such as phrasing, dynamics, articulation and gesture—as well as the duration of specific pitch-fields—are all intuitively composed to best express each line’s particular thematic characteristics.

All of the generative material composed for sans fin sans was written for the solo guitar only. As will be seen in Chapter 4, the ensemble’s main function is to help
delimit the actualisation of the originating structure, and as such, it has no role in
this first stage. This approach reinforces the guitar's position as the work's conceptual
focus.

Since the source pitch sequence produced microtonal sonorities, it was necessary
to employ a scordatura tuning to allow for the production of all the quarter- and three-
quarter-tone pitches present. Four alternately-tuned strings are arranged around two
strings with normal tuning: the low E string is raised by a quarter-tone, the second A
string is also tuned up by a quarter-tone, the D and G strings remain at their normal
pitches, the B string is tuned down to an A, and the upper E string is tuned down a
quarter-tone to D (see Figure 3.7).

This system provides access to all the necessary quarter- and three-quarter-tone
pitches of the harmonic sequence (with octave equivalency in effect), while still maintaining the traditional limit of adjacent semi-tones on each string. Nevertheless, the instrument's usual resonance has been distinctly altered. This change, along with the cyclic rhythmic patterns discussed in Section 3.2, evoke a strong sense of non-Western musics (e.g., Hindustanic and Carnatic music). And, the use of guitar techniques originating from Toque, or the guitar playing form of Spanish Flamenco—which are discussed in the next section—further connect sans fin sans to a broad musical aesthetic.

3.3.1 Musical Material

Group I of the generative structure begins with an exploration of two separate means of plucked resonance: natural harmonics, and tremolo. These two levels of polyphony focus on the first three strings plus the low sixth string, and the remaining fourth and fifth string, respectively (see Figure 3.8). The contrast is very high between the singly articulated harmonics and the repeated-attacks of the tremolo. Once each harmonic is plucked, the player’s left-hand returns to the sounding tremolo. These micro-interruptions are expected, but the performer is challenged to make these transitions as smooth as possible, as well as to avoid dampening any sounding string. Despite the near-constant tremolo, the overall character of this group is one of stasis.

Group II explores the use of percussive attacks on the guitar's sounding board (golpe), as well as striking the strings with the right-hand palm while the left-hand fingers the indicated chord (tamburo). The use of golpe includes both single-attacks with the ring finger on the lower-body of the guitar, and ‘rolls’ between the thumb on the upper-body and the ring finger. These resonances extend or alternatively articulate normally-played material, and are techniques drawn from Flamenco music.
Groups III and IV also utilise Flamenco techniques, and are related through the varied use of right-hand articulation patterns. Techniques include extending from relatively simple repeated index finger strikes to more complex rasgueado strumming, as well as employing 'pulling' (tirando) and 'resting' (apoyando) strokes.

The first four groups share a more homogeneous approach to their thematic areas, with generally low textural variation. The last three collections, however, are more dramatic and virtuosic with a wider variety of accompanying material beyond their particular themes. Group V alternates between scalar-runs in one voice and chordal progressions in the second, while Groups VI and VII approach 'fantasia'-like units with denser textural layers and sudden alterations between contrasting materials. By the end of Group VII, the guitar has engaged with many diverse playing techniques and dramatic forces.

3.4 Summary

This chapter has been concerned with the construction of pre-compositional or generative material—the first articulation of a double-articulation abstract machine—for
sans fin sans. The end result of applying the theories and ideals of Chapter 2, this originating structure contains the work’s harmonic, melodic and rhythmic resources; all built from explorations of the ratio-relationships of harmonic space coupled with an over-arching theme of resonance.
Chapter 4

Analysis: sans fin sans

As discussed in Section 2.1.1.2, Beckett’s *Lessness* challenges the reader to confront their own interpretation of a non-linear prose. *Sans fin sans* also confronts the listener with a splintering of the generative structure outlined in Chapter 3. Moreover, I was presented with a compositional challenge: how was I to fashion a successful musical work from these fragmented raw materials? In essence, my personal musical ideas and tastes were overlaid onto a reordering of the originating elements during a process of actualisation, or *becoming-music* (in Deleuzian terms).

Of particular note in this process are the connections between the solo guitar-only generative structure, and the full ensemble actualisation. It is analogous to the compositional procedures of Luciano Berio and his series of *Sequenzas* and *Chemins*. These works present a virtuosic composition for a solo instrument (the Sequenza), and a related composition where the original solo material is transformed into a concerto-like work for soloist and instrumental group (the Chemins). It is an additive process that develops the musical potential of existing materials. In the case of *sans fin sans*, this expansion is particularly focused on the possibility for timbral development.

4.1 Becoming-music

The resultant form of *sans fin sans* again follows Beckett’s construction method for *Lessness*. The order of the originating musical ‘sentences’ of Section 3.3—71 in total—was determined via a simple randomisation process where each fragment was
allowed to appear twice in a variable location. However, unlike Beckett’s plan, the end-work is not divided into two parts, and each sentence is free to appear in any position. See Figure 4.1 for the complete listing.

This specific ordering is only one of multiple possibilities or other lines-of-becoming. Like *Lessness*, it is not a progression to an end, but instead is an active transformation and production of itself. It is a Deleuzian deterritorialisation of the relationships of the generative structure that encourage new perception. Patterns do emerge, and I emphasise these through an application of Ferneyhough’s concept of interruptive polyphony (see Section 2.2.3.2).

### 4.1.1 Interruptive Polyphony

The reordered musical fragments of *sans fin sans* are combined in two distinct ways: stratification and interlock[^1]. Stratification is characterised by materials which “continuously recombine and are subject to interruptions” (Feller 1999), while interlocking—or ‘slippage’, to use Ross Feller’s terminology—involves sequential orderings which rarely recombine. While no pre-determined plan existed (i.e., combinations occurred in an intuitive manner), stratification procedures were most often applied to the multi-textural fragments of Groups V–VII of the originating structure, whereas

[^1]: These terms are taken from a discussion of Stravinsky’s methods in Cone (1962, 19)
Table 4.1: Location of Group I Fragments

<table>
<thead>
<tr>
<th>Fragment</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>mm. 19–23</td>
</tr>
<tr>
<td>3,2</td>
<td>mm. 36–40</td>
</tr>
<tr>
<td>4</td>
<td>mm. 63–66</td>
</tr>
<tr>
<td>3</td>
<td>mm. 74–77</td>
</tr>
<tr>
<td>2</td>
<td>mm. 94–95</td>
</tr>
<tr>
<td>4</td>
<td>mm. 118–121</td>
</tr>
<tr>
<td>1</td>
<td>mm. 161–165</td>
</tr>
</tbody>
</table>

interlocking was generally used on the mono-textural materials of Groups I–IV. The result is a formal series of phrases with contrasting levels of tension.

The most pronounced effect of the selected ordering of these phrases is a periodic occurrence of the fragmented harmonics/tremolo-themed Group I (see Table 4.1, 4.2(a) and 4.2(b)). Interlocked with surrounding fragments, these recurring and
timbrally-distinct sentences form thematically recognisable areas of relatively low tension. This music becomes a refrain—functioning as sectional beginnings—that delimits and binds together the non-linear flow of musical sentences. While maintaining a common texture, these repetitions are varied via length, pitch use and orchestration. As a result, the actualised large-scale form of *sans fin sans* consists of seven sections (reflecting the seven Group I fragments). This form is outlined in Table 4.2. Each section opens with a Group I phrase, with the exception of Section I, which instead begins with an introductory guitar solo. The overall sectional delineation is further articulated by the accompanying octet.

### 4.1.2 The Ensemble

The ensemble of *sans fin sans* utilises the same instrumentation as Edgar Varèse’s *Octandre*. This selection was deliberately made to reflect both my past exposure and high regard for the 1923 work, as well as its potential as a rich timbral vehicle. Offering a large palette of instrumental sounds and combinations as well as the ability to produce wide dynamic contrasts, its timbral resources are elevated to the same level of importance as the more traditional musical parameters of pitch, rhythm and dynamics. In *sans fin sans*, the instrumental ensemble and its potential combinations and sonorities both reinforce and help create the overall musical form.

The composition of the ensemble portion of *sans fin sans* was performed in a

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**Table 4.2: Large-Scale Form of *sans fin sans***

<table>
<thead>
<tr>
<th>Section</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>mm. 1–35</td>
</tr>
<tr>
<td>II</td>
<td>mm. 36–62</td>
</tr>
<tr>
<td>III</td>
<td>mm. 63–73</td>
</tr>
<tr>
<td>IV</td>
<td>mm. 74–93</td>
</tr>
<tr>
<td>V</td>
<td>mm. 94–117</td>
</tr>
<tr>
<td>VI</td>
<td>mm. 118–160</td>
</tr>
<tr>
<td>VII</td>
<td>mm. 161–181</td>
</tr>
</tbody>
</table>

---

2This raising of the significance of instrumental timbre is also a characteristic shared by many spectralist composers.
far less structured and controlled manner than the solo guitar part. Nevertheless, algorithmic routines were still utilised to generate pitch and rhythmic materials.

4.1.2.1 Rhythm

The rhythms of the ensemble instruments were selected from a pool of potential choices created by a variant of the process discussed in Section 3.2. The random funnel permutation for each particular group (from Table 3.3) was used to create a list of durations and a list of rhythmic pulses. Each duration was subdivided by its corresponding number of pulses, and the end result was mapped onto the basic repeating durational cycle (see Figure 3.5). Finally, two variants of this result were created by injecting periodic rests and ties into the sequence, and by inverting the rhythms of that result such that every note became a rest and every rest became a note. A visual representation of the patch is shown in Figure 4.3. As with the process of assigning pitch-fields to the musical fragments, rhythmic selection from these variants was done intuitively.

4.1.2.2 Pitch

The pitch material for the ensemble was drawn from the same harmonic-fields activated by the guitar (see Appendix B). While the guitar constantly unfolds these pitches into melody, the ensemble explores the available pitches in a more harmonic or chordal sense. Pitches existing in the field but not articulated by the guitar are often used, or particular pitches sounded by the guitar are chosen and emphasised. As with the rhythmic selection of the previous section, these choices are made instinctually in an effort to reveal patterns within the randomised form.

4.1.3 Timbre and Form

sans fin sans begins with 18 measures of guitar solo, clearly presenting the guitar as the centre-piece of the work. This soloistic role remains in place throughout the piece (with the exception of four measures at the start of section IV). However, the ensemble does not respond with simple accompaniment. Instead, it functions on an almost-equal level, activating fundamental, shared or even missing pitches from the operative harmonic-field.
Figure 4.3: OpenMusic Rhythm Patch
Figure 4.4: *sans fin* *sans*, mm. 32–35
Two examples of this resonance expansion can be found in Figure 4.4 and Figure 4.5. The former demonstrates a quasi-chordal diffusion of the pitch-field articulated by the guitar; while the latter is a more active, contrapuntal stretching of the harmonic space.

The ensemble is never employed as a single, homogeneous unit, with preference instead given to partitioning it into various combinations. It is composed of duets plus single instruments in section I; duets, trios and quartets plus single instruments in section II; solos and duets in section III; paired duets in section IV; varied ensembles in sections V & VI; and, remains mainly absent in the final section. A full listing of the ensemble combinations can be found in Table 4.3. Notably, at various points throughout the latter portion of the work each woodwind instrument, as well as the double bass, is given a solo line marked *espressivo*.

### Table 4.3: Ensemble Combinations

<table>
<thead>
<tr>
<th>Section</th>
<th>Location</th>
<th>Ensemble</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>mm. 1–18</td>
<td>guitar solo</td>
</tr>
<tr>
<td></td>
<td>mm. 19–23</td>
<td>guitar + (ob., cl.) + dbl.</td>
</tr>
<tr>
<td></td>
<td>mm. 24–27</td>
<td>guitar + (fl., bsn.) + tbn.</td>
</tr>
<tr>
<td></td>
<td>mm. 28–31</td>
<td>guitar solo</td>
</tr>
<tr>
<td></td>
<td>mm. 32–35</td>
<td>guitar + (tpt., tbn.) + dbl.</td>
</tr>
<tr>
<td>II</td>
<td>mm. 36–42</td>
<td>guitar + (fl., bsn., hn.) + (hn. + tpt.) + dbl.</td>
</tr>
<tr>
<td></td>
<td>mm. 43–46</td>
<td>guitar + (ob., cl.) + dbl.</td>
</tr>
<tr>
<td></td>
<td>mm. 47–49</td>
<td>guitar + (hn., tpt., tbn.)</td>
</tr>
<tr>
<td></td>
<td>mm. 50–53</td>
<td>guitar + (hn., tbn.) + dbl.</td>
</tr>
<tr>
<td></td>
<td>mm. 54–58</td>
<td>guitar + (fl., ob., cl., bsn.) + dbl.</td>
</tr>
<tr>
<td></td>
<td>mm. 59–62</td>
<td>guitar + (fl., ob., cl., bsn.) + dbl.</td>
</tr>
<tr>
<td>III</td>
<td>mm. 63–66</td>
<td>guitar + ob.</td>
</tr>
<tr>
<td></td>
<td>mm. 67–69</td>
<td>guitar + (cl., bsn.)</td>
</tr>
<tr>
<td></td>
<td>mm. 70–73</td>
<td>guitar solo</td>
</tr>
<tr>
<td>IV</td>
<td>mm. 74–77</td>
<td>(bsn., hn., tpt., tbn., dbl)</td>
</tr>
<tr>
<td></td>
<td>mm. 78–81</td>
<td>guitar + (cl., bsn.) + (hn., tpt.)</td>
</tr>
</tbody>
</table>

Continued on the next page
Table 4.3 – continued from the previous page

<table>
<thead>
<tr>
<th>Section</th>
<th>Location</th>
<th>Ensemble</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm. 82–85</td>
<td>guitar + (fl., bs.,) + hn.</td>
</tr>
<tr>
<td></td>
<td>mm. 86–87</td>
<td>guitar + (fl., cl.) + (tbn., dbl)</td>
</tr>
<tr>
<td></td>
<td>mm. 88–93</td>
<td>guitar + cl.</td>
</tr>
<tr>
<td>V</td>
<td>mm. 94–99</td>
<td>guitar solo</td>
</tr>
<tr>
<td></td>
<td>mm. 100–106</td>
<td>guitar + (fl., cl., hn., tbn., dbl.) + (bsn., tpt.) + (ob., tbn.)</td>
</tr>
<tr>
<td></td>
<td>mm. 107–109</td>
<td>guitar + (hn., tpt., dbl.)</td>
</tr>
<tr>
<td></td>
<td>mm. 110–114</td>
<td>guitar + (picc., dbl.)</td>
</tr>
<tr>
<td></td>
<td>mm. 115–117</td>
<td>guitar + (ob., cl.)</td>
</tr>
<tr>
<td>VI</td>
<td>mm. 118–121</td>
<td>guitar solo</td>
</tr>
<tr>
<td></td>
<td>mm. 122–127</td>
<td>guitar + (fl., ob., hn., dbl.)</td>
</tr>
<tr>
<td></td>
<td>mm. 128–129</td>
<td>guitar + (cl., bs., tbn., dbl.)</td>
</tr>
<tr>
<td></td>
<td>mm. 130–134</td>
<td>guitar + (picc., tbn., dbl.) + (ob., cl., bs.)</td>
</tr>
<tr>
<td></td>
<td>mm. 135–137</td>
<td>guitar + (ob., cl., bs.) + tbn.</td>
</tr>
<tr>
<td></td>
<td>mm. 138–140</td>
<td>guitar + dbl.</td>
</tr>
<tr>
<td></td>
<td>mm. 140–144</td>
<td>guitar + picc.</td>
</tr>
<tr>
<td></td>
<td>mm. 145–147</td>
<td>guitar + (fl., hn., tpt.) + (hn., tpt., tbn.) + dbl.</td>
</tr>
<tr>
<td></td>
<td>mm. 148–151</td>
<td>guitar + (hn., tpt., tbn.) + (bsn., hn.) + dbl.</td>
</tr>
<tr>
<td></td>
<td>mm. 152–155</td>
<td>guitar + (bsn., hn., tbn., dbl.)</td>
</tr>
<tr>
<td></td>
<td>mm. 156–160</td>
<td>guitar + (fl., ob., tpt.)</td>
</tr>
<tr>
<td>VII</td>
<td>mm. 161–166</td>
<td>guitar solo</td>
</tr>
<tr>
<td></td>
<td>mm. 167–170</td>
<td>guitar + bs., + (fl., cl., hn., tbn., dbl.)</td>
</tr>
<tr>
<td></td>
<td>mm. 171–175</td>
<td>guitar solo</td>
</tr>
<tr>
<td></td>
<td>mm. 176–178</td>
<td>guitar solo</td>
</tr>
<tr>
<td></td>
<td>mm. 179–181</td>
<td>guitar solo</td>
</tr>
</tbody>
</table>
Figure 4.5: *sans fin sans*, mm. 83–85
4.1.3.1 Musical Material

The creative challenge of *sans fin sans* was to shape the raw materials of Chapter 3 into a viable, unified musical work. Although pitch and rhythm were to some degree predetermined via algorithmic procedures, the next step was not simply to ‘plug in’ these values for a final result. Both aesthetic and playability concerns affected the choice of specific elements from the pre-compositional structure, and these issues also dictated that these selections were sometimes necessarily modified. As well, all of the remaining undetermined musical parameters (i.e., orchestration, timbre, dynamics, phrasing, etc.) were created through traditional compositional practices.

*Sans fin sans* opens with a number of very quiet, repeated-note guitar figures. These gestures are quickly juxtaposed with increasingly dramatic chordal, percussive and scalar outbursts lasting until m. 18. (See Figure 4.6). The resulting contrasts between relative stasis and interruptive attacks foreshadow much of the ensuing dramatic form of the piece. At m. 19, an ensemble duet comprised of the oboe and clarinet enters for the first time. They accompany the first fragment of the harmonics/tremolo-themed Group I as played by the guitar and double-bass (see Figure 4.7). Together, these events mark the beginning proper of Section I. The subsequent music continues to develop the alternation between moments of calm and more active discharges. An extended period of tremolo-like figures in the guitar, with timbral accompaniment provided by muted trumpet and trombone, bring this section to a close.

Section II begins with another Group I fragment, this time accompanied by flute, bassoon and horn. From m. 41, a chordal attack in the guitar is expanded to include brass figures against a woodwind tremolo (see Figure 4.8). As this section pro-
Figure 4.7: sans fin sans, mm. 19–23
Figure 4.8: *sans fin* *sans*, mm. 40–43
gresses, the static elements dominant in Section I appear less frequently. This section concludes in mm. 60–62 with a dynamic climax involving woodwind multiphonics, scratch tones in the double-bass, and open-string chords with Bartok-style pizzicato strikes in the guitar.

A static exploration of alternate fingerings marks the start of the third section. It functions as an echo or refrain of the vigorous material from Section II. At only eleven measures, it is the shortest of the seven sections. The beginning of the next region, Section IV, is unique within the piece as the only point in which the guitar is not the main melodic and harmonic focus. Instead, it is silent, replaced by the double-bass in its upper register and an accompanying bassoon/brass chorale-like progression (see Figure 4.9). The guitar returns in m. 78, and begins a series of broken, staccato figures contrasted with legato scalar runs. Following another climax in mm. 83–84, a clarinet duet with the guitar from mm. 88–90 transitions to a quiet sectional end in m. 93.

Echoing the distinction between the more homogenous materials of the first four groups of the generative structure and the ‘fantasia’-like last three groups (see Section 3.3.1), Sections V & VI move away from the distinct juxtapositions of earlier sections, and instead function as larger-scale refrains and developments of previous sections, respectively. Section V opens with a short fragment and initial thematic material in the guitar, before being interrupted by an ensemble quintet (flute, clarinet, horn and double-bass) in m. 100 (see Figure 4.10). After this intrusion, fragmented and accented figures motivically related to the staccato lines of Section IV are realised before an espressivo-solo in the oboe closes this passage.

Section VI is the longest of the piece, lasting 43 measures. After beginning with a straight-forward presentation of a Group I fragment, the musical discourse of the remainder of the section can be best viewed in a developmental context as previous materials are transformed alongside the introduction of new thematic material. For example, in mm. 131–133, repeated staccato figures in the oboe, clarinet and bassoon combined with the more legato melodic material of the flute and double-bass accompany new material in the guitar (see Figure 4.11).

The final section of the piece forms a coda-like ending, with the solo guitar interrupted only once by the ensemble in m. 170. Functionally, this refrain is meant to balance the varied instrumental combinations and developmental materials of the
Figure 4.9: sans fin sans, mm. 74–78
Figure 4.10: sans fin sans, mm. 98–101
Figure 4.11: *sans fin sans*, mm. 132–133
previous sections. The work ends very quietly, with the open-string guitar chords invoking the full harmonic-space of _sans fin sans_.

### 4.1.4 Tempo

As a last means of providing structural emphasis and musical unity, the sectional units of Table 4.3 are reinforced via a series of variable tempos (see Table 4.4). These reflect the constantly changing stratification of the instrumental combinations. Each distinct tempo is based upon a sometimes simplified ratio-relationship of harmonic-space applied to a base tempo of 71 eighth-note beats per minute (e.g., \(71 \times \frac{3}{2} = 53\)). However, unlike the similar relationships evident in both the pitch and rhythmic constructions of _sans fin sans_, these tempo fluctuations are not applied in a systematic manner. Notable, however, is the assigning of a constant tempo (53 eighth-note BPM) to the recurring Group I fragments that signal the start of each new section.

**Table 4.4: Tempo Map of _sans fin sans_**

<table>
<thead>
<tr>
<th>Section</th>
<th>Location</th>
<th>Tempo (eighth-note BPM)</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>mm. 1–23</td>
<td>53</td>
<td>3/2</td>
</tr>
<tr>
<td></td>
<td>mm. 24–27</td>
<td>71</td>
<td>1/1</td>
</tr>
<tr>
<td></td>
<td>mm. 28–35</td>
<td>53</td>
<td>3/2</td>
</tr>
<tr>
<td>II</td>
<td>mm. 36–53</td>
<td>53</td>
<td>3/2</td>
</tr>
<tr>
<td></td>
<td>mm. 54–58</td>
<td>64</td>
<td>9/5</td>
</tr>
<tr>
<td></td>
<td>mm. 59–62</td>
<td>71</td>
<td>1/1</td>
</tr>
<tr>
<td>III</td>
<td>mm. 63–73</td>
<td>53</td>
<td>3/2</td>
</tr>
<tr>
<td>IV</td>
<td>mm. 74–77</td>
<td>53</td>
<td>3/2</td>
</tr>
<tr>
<td></td>
<td>mm. 78–85</td>
<td>64</td>
<td>9/5</td>
</tr>
<tr>
<td></td>
<td>mm. 86–90</td>
<td>53</td>
<td>3/2</td>
</tr>
<tr>
<td></td>
<td>mm. 91–93</td>
<td>64</td>
<td>9/5</td>
</tr>
<tr>
<td>V</td>
<td>mm. 94–106</td>
<td>53</td>
<td>3/2</td>
</tr>
<tr>
<td></td>
<td>mm. 107–109</td>
<td>79</td>
<td>9/8</td>
</tr>
<tr>
<td></td>
<td>mm. 110–114</td>
<td>64</td>
<td>9/5</td>
</tr>
<tr>
<td></td>
<td>mm. 115–117</td>
<td>71</td>
<td>1/1</td>
</tr>
</tbody>
</table>

Continued on the next page
Table 4.4 – continued from the previous page

<table>
<thead>
<tr>
<th>Section</th>
<th>Location</th>
<th>Tempo (eighth-note BPM)</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>VI</td>
<td>mm. 118–160</td>
<td>53</td>
<td>3/2</td>
</tr>
<tr>
<td>VII</td>
<td>mm. 161–181</td>
<td>53</td>
<td>3/2</td>
</tr>
</tbody>
</table>

4.2 Summary

This chapter has outlined the actualisation of one of the many potentialities inherent in the generative structure of Chapter 3. A process of 'becoming', raw musical materials were shaped to express their inherent connections and possibilities. These relationships were also emphasised by particular ensemble orchestrations and a corresponding map of tempo alterations. The end result is *sans fin sans*. 
Chapter 5

Conclusion

_Sans fin sans_ is my attempt to create a musical work that expresses itself. Philosophy, according to Deleuze, creates concepts that are creative rather than representational. These concepts encourage people to push thought to its limits, pull it apart and see what our thinking can do. My response to this challenge is a musical work that does not attempt to communicate a specific meaning, or represent a particular image or feeling, but instead conveys what it does. The result of an engagement with Samuel Beckett’s _Lessness_, _sans fin sans_ is constructed from a series of algorithmically-derived pitches and rhythms which are assembled, fragmented and transformed via a machinic process of ‘becoming.’ This process is purely creative, combining customary compositional techniques with parameters generated through an exploration of fractal geometry and mathematical automata. The end result is a piece that—like Beckett’s—challenges the listener to become aware of how it works, what it does, and through these questions, what it is.

Future possibilities for development of the compositional techniques presented in this dissertation include the expansion of the pitch-generation algorithms of Chapter 3 into higher dimensions of harmonic space and the investigation of more complex fractal patterns, as well as the exploration of a more subtle means of structural fragmentation beyond simple randomisation (i.e., constraints-based). Additionally, a cognitive evaluation of how listeners react to non-linear musical discourse would undoubtedly prove fascinating.
Bibliography


Bell, Jeffrey A. 2006. *Philosophy at the Edge of Chaos: Gilles Deleuze and the Philosophy of Difference*. University of Toronto Press. → pages 9


Appendix A

omlsystem Source Code

A.1 turtle.lisp

1 ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
2 ;;
3 ;; OML-System
4 ;; author: J. Scott Amor
5 ;;
6 ;; An OpenMusic library developed to facilitate experiments
7 ;; with Lindenmayer systems, including the interpretation
8 ;; of strings (lists) as turtle graphics commands.
9 ;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
10
11 (in-package :lsystem)
12
13 ;;--------------------------------------------------
14 ;; constants
15 ;;--------------------------------------------------
16
17 (defparameter *rotate-by-integer* t) ; will use integer instead of real value for rotations
18 (defparameter *initial-heading* 0.0) ; initial heading value for turtle
19 (defparameter *standard-rotation* 90.0) ; default rotation value
20 (defparameter *standard-length* 1.0) ; default length to move turtle forward
21 (defparameter *turtle-icon* 801)
22
23 ;;--------------------------------------------------
24 ;; A turtle graphic object
25 ;;--------------------------------------------------
26
27 (om::defclass! turtle ()
28  (x
29   :initarg :x
30   :initform 0.0
31   :type float
32   :accessor x
33   :allocation :instance
34   :documentation "x-coordinate")
35  (y
36   :initarg :y
(defmethod initialize-instance :after ((self turtle) &key)
  (with-accessors ((heading heading)) self
    (setf heading (mod heading 360))))

;; Operators
;;--------------------------------------------------
;; default constraint function performs no constraint (can be customized by other libraries/patches)
(defparameter *constraint-function* #'(lambda (coordinates) (cons (cdr (car coordinates)) (cdr (cdr coordinates)))))

(defun f ((turtle turtle))
  :indoc '("a turtle instance")
  :icon *turtle-icon*
  :doc "move turtle object forward"
  (with-accessors ((x x) (y y) (heading heading)) turtle
    (let ((newx (+ x (* *standard-length* (cosine heading))))
           (newy (+ y (* *standard-length* (sine heading))))
           (constrained (funcall *constraint-function* (cons (cons x newx) (cons y newy))))
           (x (car constrained))
           (y (cdr constrained)))
      turtle))

(defun plus ((turtle turtle))
  :indoc '("a turtle instance")
  :icon *turtle-icon*
  :doc "rotates a turtle instance counter-clockwise"
  (with-accessors ((heading heading)) turtle
    (let ((new-heading (mod (+ heading *standard-rotation*) 360)))
      (setf heading (if *rotate-by-integer* (round new-heading) new-heading))))

(defun minus ((turtle turtle))
  :indoc '("a turtle instance")
  :icon *turtle-icon*
  :doc "rotates a turtle instance clockwise"
  (with-accessors ((heading heading))
    (let ((new-heading (if (< (- heading (mod *standard-rotation* 360)) 0)
                          (+ 360 (- heading (mod *standard-rotation* 360)))
                          (- heading (mod *standard-rotation* 360))))
                          (round new-heading)
                          new-heading)))

;;--------------------------------------------------
(defmethod! is-same? ((turtle1 turtle) (turtle2 turtle))
  :indoc '("a turtle instance" "a turtle instance")
  :icon *turtle-icon*
  :doc "determines if two turtle instances are the same"
  (with-accessors ((x1 x) (y1 y) (heading1 heading)) turtle1
    (with-accessors ((x2 x) (y2 y) (heading2 heading)) turtle2
      (and (= x1 x2) (= y1 y2) (= heading1 heading2)))))

(defun! is-same-pos? ((turtle1 turtle) (turtle2 turtle))
  :indoc '("a turtle instance" "a turtle instance")
  :icon *turtle-icon*
  :doc "determines if two turtle instances are at the same position (ignores heading)"
  (with-accessors ((x1 x) (y1 y)) turtle1
    (with-accessors ((x2 x) (y2 y)) turtle2
      (and (= x1 x2) (= y1 y2)))))

(defun! copy-turtle ((turtle turtle))
  :indoc '("a turtle instance")
  :icon *turtle-icon*
  :doc "makes a copy of a turtle instance"
  (with-accessors ((x x) (y y) (heading heading)) turtle
    (make-instance 'turtle :x x :y y :heading heading)))

(defun! turtle->coord ((turtle turtle))
  :indoc '("a turtle instance")
  :icon *turtle-icon*
  :doc "converts a turtle instance to an x,y coordinate cons"
  (with-accessors ((x x) (y y)) turtle
    (cons x y)))

(defun! turtle->coord ((tlist list))
  :indoc '("a list of turtle instances")
  :icon *turtle-icon*
  :doc "converts a list of turtle instances to a list of x,y coordinate cons"
  (loop for turtle in tlist
    collect (turtle->coord turtle)))
(defun is-f? (func)
  "determines if a function performs the same operation as f"
  (is-same? (funcall func (make-instance 'turtle)) (f (make-instance 'turtle))))

(defun is-plus? (func)
  "determines if a function performs the same operation as plus"
  (is-same? (funcall func (make-instance 'turtle)) (plus (make-instance 'turtle))))

(defun is-minus? (func)
  "determines if a function performs the same operation as minus"
  (is-same? (funcall func (make-instance 'turtle)) (minus (make-instance 'turtle))))

;;; Helper methods

(om::defmethod ! remove-rotations ((slist list))
  :indoc '("a list of interpreted stages")
  :icon *turtle-icon*
  :doc "removes rotation-only turtles from a list of interpreted stages"
  (loop for stage in slist counting stage into size
        collect (let ((egats (reverse stage)))
                  (loop for i from 1 to (length egats)
                        for slist = (nthcdr (- i 1) egats)
                        collect (cond ((= (length slist) 1) (first slist))
                                      (t (if (is-same-pos? (first slist) (second slist)) nil (first slist))))
                                  into tlist)
                  do (format t "turtles remaining for stage ~a: ~a~%
                               size (length slist))
                  finally (return (remove nil (reverse tlist))))))

(defun introspect-func (func)
  "return function name of input func"
  (cond ((is-f? func) #'f)
        ((is-plus? func) #'plus)
        ((is-minus? func) #'minus)))

;;; Interpretation

(om::defmethod ! perf-subst ((stage list) (production-rules list))
  :indoc '("list of symbols" "association list of production rules")
  :icon *turtle-icon*
  :doc "performs (string) substitutions on stage according to production rules"
  (om::flat (loop for symbol in stage
d                   collect (let ((subst (cdr (assoc (introspect-func symbol) production-rules))))
                              (cond ((eq subst nil) symbol)
                                    (t subst))))))

(om::defmethod ! eval-stage ((stage list) (turtle turtle))
  :indoc '("list of symbols" "a turtle instance")
  :icon *turtle-icon*
  :doc "evaluates the symbols within stage starting from turtle"
  (om::flat (loop for symbol in stage
d                   collect (let ((subst (cdr (assoc (introspect-func symbol) production-rules))))
                                 (cond ((eq subst nil) symbol)
                                       (t subst))))))
(loop for symbol in stage
  collect (if (= (length elist) 0)
    ; always copy first turtle
    (funcall symbol (copy-turtle turtle))
    (cond
      ; only copy subsequent turtles if moving turtle forward
      (not (is-f? symbol))
        (funcall symbol (copy-turtle (car (last elist))))))
  finally (return (delete-duplicates elist)))

(defun interpret-lsystem ((num-stages integer) (axiom list) (production-rules list) &rest alternates)
  :indoc '("number of stages to interpret" "list of symbols" "association list of production rules")
  :icon *turtle-icon*
  :doc "interpret a given l-system"
  (let
    ((prules (if (= (length alternates) 0)
      production-rules
      (append list production-rules alternates))))
    (loop for i from 1 to num-stages
      collect (if (= i 1)
        (perf-subst axiom (if (= (length alternates) 0)
          prules
          (nth (random (length prules)) prules)))
        (perf-subst (car (last stages)) (if (= (length alternates) 0)
          prules
          (nth (random (length prules)) prules)))) into stages
      collect (if (= (length slist) 0)
        (eval-stage (car (last stages)) (make-instance 'turtle :heading *initial-heading*))
        (eval-stage (car (last stages)) (car (last (car (last slist)))))) into slist
    do
      (format t "processing stage ~a:~% ~a" i (car (last stages)))
    finally
      return slist))

A.3 pitchspace.lisp

;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
; pitchspace
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
; author: J. Scott Amort
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
; An OpenMusic library developed to facilitate experiments
; with James Tenney's concept of harmonic space, where each pitch is represented
; by coordinates which are exponents of the prime factors of their frequency ratio.
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;

12 (in-package :pitch-space)
13
14 ;;--------------------------------------------------
15 ;; 5-limit harmonic space
16 ;;--------------------------------------------------
17
18 ; coordinates | prime limit | ratio | cents | interval name
19 ; (0,0,0) | 2- | 1/1 | 0 | unison
20 ; (-2,1,0) | 3- | 3/2 | 702 | fifth
21 ; (2,-1,0) | 3- | 4/3 | 498 | fourth
22 ; (-3,2,0) | 3- | 9/8 | 204 | major wholetone (dominant wholetone)
23 ; (-2,0,1) | 5- | 5/4 | 386 | ptolemaic major third
24 ; (-3,1,1) | 5- | 25/8 | 1088 | ptolemaic major seventh
25 ; (0,-1,1) | 5- | 5/3 | 884 | ptolemaic major sixth

68
26 ; (-5,2,1) | 5- | 45/32 | 590 | ptolemaic tritone
27 ; (1,1,-1) | 5- | 6/5 | 316 | ptolemaic minor third
28 ; (3,0,-1) | 5- | 8/5 | 316 | ptolemaic minor sixth
29 ; (0,2,-1) | 5- | 10/9 | 1018 | ptolemaic minor seventh
30 ; (4,-1,-2) | 5- | 26/25 | 212 | major diatonic semitone
31 ; (4,-2,0) | 5- | 26/19 | 996 | ptolemaic minor seventh
32 ; (-4,3,0) | 5- | 26/19 | 996 | ptolemaic major sixth
33 ; (1,-2,1) | 5- | 64/45 | 610 | ptolemaic diminished fifth
34 ; (3,0,-1) | 5- | 8/5 | 814 | ptolemaic minor sixth
35 ; (0,2,-1) | 5- | 9/5 | 1018 | ptolemaic minor seventh
36 ; (4,-1,-1) | 5- | 16/15 | 112 | major diatonic semitone
37 ; (4,-2,0) | 3- | 16/9 | 996 | pythagorean minor seventh
38 ; (-4,3,0) | 3- | 27/16 | 906 | pythagorean major sixth
39 ; (6,-2,-1) | 5- | 64/45 | 610 | ptolemaic diminished fifth
40 ; (5,-3,0) | 5- | 32/27 | 294 | pythagorean minor third
41 ; (-4,0,2) | 5- | 25/16 | 773 | ptolemaic augmented fifth
42 ; (5,-1,-1) | 5- | 10/9 | 182 | minor wholetone (subdominant wholetone)
43 ; (-6,1,2) | 5- | 10/9 | 182 | ptolemaic diminished seventh
44 ; (-2,3,-1) | 5- | 27/20 | 520 | ptolemaic wide fourth
45 ; (-7,2,2) | 5- | 225/128 | 976 | ptolemaic augmented sixth
46 ; (2,2,-2) | 5- | 36/25 | 631 | Rameau's false fifth
47 ; (8,-3,-1) | 5- | 128/75 | 925 | ptolemaic diminished seventh
48 ; (-2,3,-1) | 5- | 27/20 | 520 | ptolemaic wide fourth
49 ; (-7,3,2) | 5- | 235/228 | 92 | major limma
50 ; (7,-4,0) | 3- | 81/64 | 408 | pythagorean major third
51 ; (7,-4,0) | 3- | 128/81 | 792 | comma-diminished octave
52 ; (-1,-2,2) | 5- | 25/18 | 569 | Rameau's tritone
53 ; (2,2,-2) | 5- | 36/25 | 631 | Rameau's false fifth
54 ; (8,-3,-1) | 5- | 256/225 | 223 | ptolemaic diminished third
55 ; ;;--------------------------------------------------
56 ; ;; Constants
57 ; ;;--------------------------------------------------
58 (defparameter *5limit-prime-form* (make-array 33
59 :initial-contents
60 "(0 702 498 204 386 1088 884 590 316 814 1018 112 996 906 182 610 294 906 408 792 569 976 631 223)))
61 (defparameter *5limit-lookup-table* (make-array '(5 9)
62 :initial-contents
63 '((nil nil 569 71 773 275 976 nil nil)
64 (nil 680 182 884 386 1088 590 nil)
65 (906 408 792 294 1018 520 nil) 408
66 (nil 256 225 1108 610 976 316 nil)
67 (nil nil 223 925 427 1129 631 nil)))
68 ;;;--------------------------------------------------
69 ;;; Utilities
70 ;;;--------------------------------------------------
71 (om::defmethod ! coords->cents ((clist
72 :indoc "a list of x,y cons co-ordinates")
73 :icon 178
74 :doc "converts a list of x,y co-ordinates to interval values (in cents)"
75 (let ((lookup *5limit-lookup-table*))
76 (loop for coord in clist
77 ; array indexes are offset (x by 2, y by 4) to account for negative coordinate values
78 collect (aref lookup (+ (round (cdr coord)) 2) (+ (round (car coord)) 4))))
79 ;;;--------------------------------------------------
80 ;;; Customizations for use with omlsystem library
81 ;;;--------------------------------------------------
82 (defun constrain (co-ordinates)
"constrains the maximum of a set of orig/new co-ordinates"
;; this function keeps co-ordinates within 5-limit pitch space
;; by 'wrapping' at the edges of the crystal
;; constrains f for use with the pitch-space library
(let ((origx (car (car co-ordinates)))
  (newx (cdr (car co-ordinates)))
  (origy (car (cdr co-ordinates)))
  (newy (cdr (cdr co-ordinates))))
  (cond
;; evaluate special cases (as crystal is not square)
  ;((and (= (abs newx) 3) (< (abs newy) 1)) (cons newx newy))
  ;((and (= (abs newx) 4) (= newy 0)) (cons newx newy))
  ;((and (= (abs newx) 3) (= (abs newy) 2)) (cond
  ;; ((= (abs origx) 3) (cons origx (* origy -1.0)))
  ;; (t (cons (* origx -1.0) (* origy -1.0))))
  (t (cond
  ;((and (= origx newx) (= origy newy)) (cons newx newy))
  (t (cons (if (> (abs newx) 2.0)
  (* origx -1.0)
  newx)
  (if (> (abs newy) 2.0)
  (* origy -1.0)
  newy))))))))
))
(defparameter lsystem::*constraint-function* #'pitch-space::constrain)
Appendix B

Pitch-Fields in *sans fin sans*
Appendix C

Musical Score of *sans fin sans*
sans fin sans
( endlessness )

j. scott amort
Scoring

solo guitar, slightly amplified (for balance only)

1 flute, doubling piccolo
   1 oboe
   1 clarinet in A
   1 bassoon

1 trumpet in C
   1 horn in F
   1 trombone

1 double bass

Scordatura:

*NOTE: Lower two strings are to be tuned one-quarter tone sharp, and the top string one-quarter tone flat.

Duration: approx. 15 minutes
Notes

The score is notated in C
The guitar and double-bass sound one octave lower than notated
The piccolo, one octave higher

Guitar Techniques and Notations

percussion-staff for guitar
denotes golpe (striking the body), with thumb above strings (top staff), or with ring finger below strings (bottom staff)

T indicates tambora
(sounding the indicated strings by striking with the palm)

R indicates rasgueado (finger strumming)

Slashed, double-stemmed chords indicate repeated articulations at the approximate value of the upper stem, lasting for the value of the lower stem

repeat pattern for indicated length

Ensemble

choose multiphone to sound in given range

choose alternate fingerings for given pitch to emphasise timbre difference
sans fin sans
(Endlessness)
sans fin sans
Fl.
Ob.
Bsn.
Gtr.
Cb.
sans fin sans

Cl.

Bsn.

Tbn.

Gtr.

Cb.

(p) gradually increase bow pressure

expressivo

f

on the bridge

scratch tone
graciously increase bow pressure