ELUCIDE

by

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ABSTRACT

This thesis presents the musical composition *Elucide*, scored for a chamber ensemble of ten players. The work builds upon concepts and compositional methods that are central to the spectral approach to composition, established by such composers as Gérard Grisey, Tristan Murail, and Hugues Dufourt. This musical genre is characterized by a focus on the acoustic properties of sound, a concern that is typically reflected both in rich and colourful musical textures, as well as in the conceptual foundations of compositional processes. It is often the case that spectral composers will refer to computer analyses of acoustic phenomena during the pre-compositional stages of a work's development, using these data to generate the piece's raw materials and to inform structural decisions. Although the spectral approach is rooted in the perceptual appreciation of sonic phenomena, the manner in which analysis data are obtained and applied can encourage a range of listening postures, potentially leading the listener towards both perceptually- and semantically-oriented hearings. Furthermore, this music displays varying symbolic facets stemming from the poetic idea of a musical composition unfolding from the internal structure of sonic materials. The interplay of these dynamics raises a number of issues that are inherent in the compositional application of spectral information; this thesis first examines the spectral endeavor from a philosophical perspective, and then goes on to demonstrate the ways in which *Elucide* develops from and comments upon these issues.

In order to explicitly engage these dynamics in a musical composition, I developed a set of software tools using the graphical programming environment "OpenMusic". These tools provided raw musical materials that were employed at various levels during the compositional process. While the early stages of the work aim to draw aural connections between the overtone structures of source sounds and musical structures, individual spectral elements are progressively divorced from their acoustic origins and woven into musical semantic patterns over the course of the piece. In its elucidation of the relationships between perceptual phenomena and musical semantics, therefore, *Elucide* represents a broader exploration of the mechanisms by which the human mind finds meaning in sensory information.

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CHAPTER 1: Introduction and Background

1.1 Introduction

The dissertation contained herein presents a musical composition, entitled *Elucide*, as well as a prose document, the latter submitting an explication of the motivations, structures, and intentions of the former. The composition is scored for a chamber ensemble of ten players, and lasts approximately seventeen and a half minutes in performance. In a poetic sense, the piece can be heard as an investigation of the act of perception and the mechanisms through which we come to find meaning in aural experience; the guiding metaphors for the work thus center around the examination and unraveling of sonic objects, and the progressive weaving of these elements into musically semantic structures. The music aims to guide the listener between perceptually- and semantically-oriented listening postures, ultimately finding significance in the interplay between various modes of reception.

In order to engage these concepts in a musical composition, I have drawn upon the tenets of the spectral approach to composition, as established by such composers as Gérard Grisey, Tristan Murail, and Hugues Dufourt. The conceptual foundations of spectralism rest on a belief in the primacy of the sonic materials of music, expressed through the use of colourful and aurally engaging timbres and textures, as well as through the application of relationships found within acoustic structures to musical ones. In correlating the materials of composition with natural sonic phenomena, spectralism provides a bridge between a compositional approach that aims to heighten a listener's appreciation of sensory experience, and one whose focus is on the structural relationships between compositional elements; the spectral approach therefore offers an apt philosophical and technical framework for *Elucide's* metaphoric discourse.

The first chapter of this document traces the musical and philosophical antecedents that *Elucide* adopts as a point of departure, addressing the nature of perception itself as well as the characteristics and techniques of the spectralism. Chapter 2 progresses to examine dynamics of the spectral endeavor that appear to be inherent in compositional applications of spectral analysis information, and describes the methods by which I engaged these dynamics during the pre-compositional stages of the piece's development. A description of the ways in which *Elucide* expresses its philosophical and metaphoric underpinnings is found in chapter three; this analysis addresses the work's processes, structures, and symbolic significance on both large and small scales. The fourth chapter summarizes the preceding discussion, and is followed by the score of *Elucide* in chapter five. The remainder of the document includes two appendices that detail the spectral sources referenced during composition and the software tools (developed by the author) that were employed in manipulating spectral information.

1.2 Perceptually-Oriented Music

One of the dominant currents in twentieth-century composition centres on an awakening of the faculties of perception, finding artistic meaning through heightening the listener's appreciation for the rich variety of auditory stimuli available to the human ear. The writings and music of John Cage most famously express this attitude towards composition, and its underlying philosophies find resonances in music from the beginning of the twentieth century to the present. Certain works by composers such as Edgard Varèse, Conlan Nancarrow, Karlheinz Stockhausen, Giacinto Scelsi, James Tenney, and Salvatore Sciarrino (to name only a few) share a common underlying impulse to stimulate the listener's auditory faculties beyond their usual compass, though they may differ widely in many other ways. Many compositions written in the past century invite the listener to adopt such a phenomenological listening posture, emphasizing sensory experience and exploring the intrinsic interest in acoustic phenomena; since these approaches have proven to be pervasive and continue to exert a powerful force on contemporary musical culture, they will provide an apposite point of departure for this dissertation.

1.3 An Examination of Perception

An appreciation of the value of sonic perception is expressed in R. Murray Schafer's book entitled *Ear Cleaning*[1], which describes a pedagogical method aimed at exercising students' perceptual abilities. Although the world of sound is rich and transparent to young listeners, Schafer finds that the ability to perceive the fine details of the auditory landscape tends to dull with time, as the brain adapts to remove unwanted sounds from a cluttered and often obtrusive auditory environment. He notes how we parse the continuous stream of sound presented to our ears in order to protect our conscious minds from unwanted sounds, suggesting that our sensory mechanisms are not simply passive; the act of perception involves complex processes through which signals sent by our sensory organs undergo a significant amount of sub-conscious processing before registering as sense data in the listener's consciousness. Beyond filtering desirable or useful sounds from noise, the subconscious mind participates in a myriad of processes that mediate, parse and structure a continuous sound stream so that our minds may understand them: complex sounds may be reduced to simple mental signifiers, harmonically related frequencies are synthesized into a single tone endowed with a qualitative timbre, phase differences between the ears' respective signals are measured to determine location, and so forth. Although many of these mental activities will likely remain inaccessible to conscious perception, Schafer's book illustrates how, through careful attention and study, a listener can gain access to perceptual information that was once restricted to the subconscious.

Once sensory stimuli register in the conscious mind, the processes of organization and structuring continue as we seek to understand our perceptions and find meaning in the world around us. We learn to attach symbolic significance to sounds and their patterns, from the sounds of everyday events to the complex structures of speech or music. The complex relationships between objective stimuli and their organization into sense data and ultimately into symbolic communication recalls an image depicted by the

[1] R. Murray Schafer, *Ear Cleaning – Notes for an Experimental Music Course*, Berandol Music Limited, Toronto (1967).

philosopher W. V. Quine in his essay entitled *Two Dogmas of Empiricism*[2]. In this essay, Quine states that "The totality of our so-called knowledge or beliefs, from the most casual matters of geography and history to the profoundest laws of atomic physics or even pure mathematics and logic, is a man-made fabric which impinges on experience only along the edges."[3] In Quine's metaphor, objective sense data is understood through a complex web of connections constructed by the human mind; when presented with unfamiliar sensory information, new connections are drawn and adjustments are made to other structures in the fabric in order to support and understand the experience. As one traces a path from the outer periphery towards the centre of Quine's fabric, the structures form connections that become increasingly abstract and inclusive, moving into areas that deal with progressively deeper significance. In applying this metaphor to a perception such as hearing speech, we find a progression that begins with a continuous sound stream, is parsed to identify the speaker and their location, and divided into phonemes. These elements are then searched for patterns and compared against archetypes generated through previous experiences in order to identify words, sentences, semantic significance, and so forth, potentially progressing to very sophisticated and profound ideas. This image of the process of cognizing sense data will serve as a one of the guiding metaphors for the composition presented here, and will be discussed in more detail later. For the moment, let us turn our attention back to the domain of musical culture.

1.4 Spectralism

The attitudes conveyed in the music of perceptually-oriented composers such as those mentioned above, in particular a belief in the primacy of sonic materials and the value of heightened perception, provided a foundation for the technical and structural principles of the loosely-defined "spectral" school of composition that emerged in the late 1970s. The spectral approach, represented in such works as Karlheinz Stockhausen's *Stimmung* and Gérard Grisey's *Partiels,* emerged alongside technological developments

[2] W. V. Quine, "Two Dogmas of Empiricism," in *From a Logical Point of View* by W.V. Quine, Harvard University Press, Cambridge (1953).

[3] ibid. pg. 42.

that offered musicians a more comprehensive understanding of the physical nature of sound and of auditory perception, enabling composers to support their desire to root musical composition in the domain of acoustic phenomena with detailed analytical methods for understanding and organizing their materials.

Although the aims and processes of composers whose works have been labeled "spectral" vary, the works reflect an acoustically-informed conception of musical sound, in terms of their pre-compositional methods, their application of instrumental and/or electronic sounds, or both. The composers of the genre demonstrate an awareness of the acoustic properties of the sounds they use, typically reflecting a conception of timbre as being intimately related to pitch. Loosely applied, the term can refer to music that is highly colouristic or textural, where a primary source of interest is found in the interplay of timbres. Compositional techniques that could be more specifically termed spectral, however, are found in works in which analyses of sounds or knowledge of acoustic principles are used to generate or inform the materials and structures of a composition; it is this sense of the term that is of particular interest to this dissertation.

1.5 Spectral Analysis Tools

Since composers first gained access to computer analyses of sound such as FFT (Fast Fourier Transform[4]) and waveform analyses, it has become common for analyses of sounds to be used to inform the compositional structures of a work. FFT analyses have proven particularly interesting, since the manner in which they represent complex sounds is analogous to the physiological structures of the human ear; just as an FFT divides a signal into narrow frequency bands, representing a complex sound as varying energy levels within these bands, the ear senses sound using an array of hair cells, each of which vibrates in response to a narrow range of frequencies. Owing to this physiological mechanism, our perceptual images of sounds tend to align intuitively with the graphic

[4] Fourier's theorem states that a complex waveform can be expressed as the sum of a series of sinusoids of varying amplitudes and phases. A Fourier analysis thus decomposes complex waveforms, such as those created by instrumental sounds, into constituent frequency components, providing frequency, amplitude, and phase data for the sound's individual partials.

representations of FFT data; with careful attention and practice, the ear can differentiate individual partials of many stable timbres in much the same way that the FFT divides a signal into component sine waves.

That a complex timbre can be interpreted and perceived as a union of simpler partials had been demonstrated well before the advent of computer analyses, in the work of Mersenne and Helmholtz. However, the Fourier transform provides a much more sophisticated and complete analysis of even very complex signals than was previously possible, yielding information about components that are too subtle for the human ear to resolve without some kind of technological assistance. This fecundity has proven appealing to composers searching for sources of compositional materials; a short sound sample of a relatively complex timbre can generate a very large amount of frequency and amplitude data, from which can be derived harmonic materials as well as various curves, ratios, and other information that may be of interest. (See Appendix I for examples of FFT data and their graphic representation.)

Although a variety software tools are capable of producing FFT analyses and manipulating the results, two products from the Institut de Recherche et Coordination Acoustique/Musique (IRCAM) were used in this thesis: “AudioSculpt” and “OpenMusic”. AudioSculpt is an application for sound analysis and processing, and is used in this thesis to perform FFT and partial-tracking analyses, and subsequently to export this data for manipulation in OpenMusic. OpenMusic (OM) is a graphic user interface for the LISP programming language, developed by Carlos Agon and Gérard Assayag. The environment implements a set of music-oriented objects, operators, and editors, facilitating the translation between score-based musical information and the numerical data required of programming. In order to generate and manipulate pre-compositional materials for this thesis, I developed a modular collection of OM programs (or patches), described in detail in Appendix II. These patches facilitate the parsing of spectral analysis data during the process of selecting source spectra, and provide the composer with methods of expanding and projecting them into score-based representations for use as pre-compositional materials. While some of the patches perform functions that are relatively specific to this thesis, most implement general operations and can be combined with one another in a variety of configurations, affording the composer a versatile set of tools for use in a wide range of situations.

CHAPTER 2: Philosophical Foundations and Pre-Composition

2.1 Depth of Analysis

The detailed spectral information provided by FFT analyses affords the composer access to those subtle components of a spectrum that are difficult to isolate aurally, yet nevertheless make important contributions to the sound's overall quality; these components (such as frequency band activity at very low levels, attack transients, and minor fluctuations in partial amplitudes) tend to imbue a sound with its characteristic qualities, and their presence is often necessary for the identification of a sound's source. If one's goal were to electronically re-synthesize a signal so that the result is perceptually identical to the source, a greater amount of accurate analysis data would produce a more accurate re-creation; while such re-creation may not be a composer's goal in applying spectral data in a musical work, a reflection of these elements in musical structures strengthens the symbolic connections between the music and its source sound, given that such spectral data is likely to be unique to a particular sonic event. At the same time, however, the less prominent a component is in the spectrum, the more tenuous is the perceptual connection between that component and the characteristic features of the source sound, since these weak, fleeting and unstable partials are harder for a listener to isolate. A continuum between perceptibility and mimesis thus emerges, dependent on the sensitivity, or depth, of the analysis: at one extreme, an analysis that produces only the most prominent partials describes those components that are relatively easy for the ear to resolve, at the expense of completeness in representing the source sound; at the other extreme, a detailed analysis that identifies the most subtle components more accurately represents the original sound and its identifying characteristics, yet includes components that cannot be perceptually related to the source. This range suggests analogies to optical magnification; a great deal of interest can be found in viewing an object at progressively higher degrees of magnification, yet the further the image is magnified, the less resemblance it bears to the unmagnified view, and therefore the weaker is the viewer's association between the image and the object.

2.2 Degree of Abstraction

Another dialectic emerges in considering composers' applications of spectral data. One approach that has become relatively common involves the use of a spectral analysis in generating harmonic collections, whereby structures such as pitch sets (often rounded to half-tone, quarter-tone, or eighth-tone intervals), pitch class sets and set classes are abstracted from the frequency information provided by FFT data. Once these materials have been obtained, they are often manipulated with standard procedures such as transposition, inversion, Boulezian multiplication, and so forth, generating the basic materials for use in a composition. Other methods of expanding spectral data involve simulating FM synthesis, or performing frequency-domain interpolations between two spectra. These methods stem from a desire to generate interesting and varied pitch materials from the source analysis, maintaining a connection with the original spectrum while producing a sufficiently rich harmonic palate for intuitive and unrestricted composition. It is perhaps obvious that as the degree of abstraction increases during compositional manipulations, the aural connection between the harmonic materials and the source spectrum becomes progressively more strained. If the frequencies of a spectrum's prominent partials are converted to (registrally fixed) pitches, a chord made up of these notes will tend to bear a strong resemblance to the original timbre, tolerating even a fair degree of rounding. If those pitches are subsequently treated as (octave equivalent) pitch classes, the connection between the more abstract harmony and the original spectrum becomes more tenuous; further disassociation occurs if the interval class relationships between the pitches are abstracted into a set class and manifested in a new set of pitches.

Similarly, frequency domain interpolations between two spectra, as described by Joshua Fineberg[5], employ an abstract conception of spectral data to create harmonic interest. In generating intermediary harmonies, each partial is treated as an independent entity, divorced from the frequency ratios that the partials manifest in the original spectra.

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[5] Joshua Fineberg, "Guide to the Basic Concepts and Techniques of Spectral Music," *Contemporary Music Review 19-2*, 2000: 81-114.

Since these proportions help to define a spectrum's timbral identity, treating the partials as discrete pitches capable of independent variation engenders both a conceptual and a perceptual shift away from the understanding of the spectrum as a discrete and locatable sonic object. As the partials drift independently of one another, the timbral identity, and therefore the connection to the original sound, grows increasingly tenuous. In procedures mimicking FM synthesis, a similar abstraction takes place; these techniques apply an artificial process to spectral materials, generating rich harmonies that may not bear resemblance to naturally occurring phenomena.

At a certain level of abstraction or at a certain depth of analysis, the connecting thread between a sound source and the material derived from it breaks, and the resultant musical materials no longer bear any resemblance to the original sound. Such obfuscation of the music's physical origins is often specifically desired by the composer, since an awareness of a sound's representational significance may inhibit the listener's perception of the intrinsic characteristics of the sound. By subjecting physically-derived spectra to degrees of abstraction or magnification, or by generating synthetic harmonies, the composer does not negate the perceptual orientation of the music, nor are the piece's conceptual premises necessarily weakened. Although there may be little or no perceptual link between a piece's materials and the sound source(s) from which they originate, a symbolic connection may still remain in the continuity of processes that is relevant to the symbolic discourse of the work, both for the composer during the developmental process and for the listener in a holistic appreciation of the work. A semiotic chain is engendered through the selection of an object to record, the selection of a section of that recording to analyze, the subsequent extraction and manipulation of data, and the use of that data during composition. There is an attractiveness in the logic of this process, a poetry to the idea that an ephemeral sonic phenomenon can be seized, unraveled, and woven into a piece of music. The transparency of this process is at the artistic discretion of the composer, as is the rigidity with which the spectral processes are applied, but even a metaphoric connection to the idea of spectral derivation can provide an added dimension of significance to a piece.

In constructing such a semiotic chain, the spectral composer invokes an ideal that has been expressed in many treatises on music, from early works by Lippius and Zarlino to nineteenth-century texts by Riemann and Oettingen, in which compositional practice is presented as being rooted in natural harmonic phenomena. While the numerological motivation of many early writers contrasts with our modern empirical approach in the field of psychoacoustics, the shared impulse towards naturalistic justification is striking. Whether such an appeal to scientific objectivity offers any advantages over the opacity of intuitive creativity is a matter for debate, but it is worth noting how this attitude has the potential to be a motivating force for endeavors in spectral composition.

2.3 Semantic Organization of Perceptual Data

Related to the two dialectics described above is a third dynamic that surfaces in spectral music, and is of particular interest in this dissertation: the relationship between the perception of sense data and the organization of that information into musical semantic structures. Although this dynamic is difficult to define due to its subjectivity, variations in cultural conceptions of music, and challenges in understanding our psychological reactions to music, the concepts are sufficiently precise to define a metaphor for artistic representation and intuitive exploration. Applying the act of musical listening to the above description of Quine's image will serve to illustrate the sense in which I aim to engage these concepts.

When listening to a piece of music, especially for the first time, the mind constructs a web of connections to support the acoustic phenomena in some way. As described above, when confronted with new sense data, the human mind searches for ways in which that data can be understood, finding patterns into which the new stimuli might fit, grouping them with like phenomena, and creating abstract categories and generalized symbols so that the perception can be understood within the context of the existing web of connections. After the initial stage during which basic events are identified, the mind begins a process whereby these events are progressively grouped into larger and more complicated units, possibly including such semantic units as motives, themes, large-scale sections, layers of activity, transformations between states, textures of varying cohesiveness, and so forth. Furthermore, the web of connections drawn by a particular piece are judged against pre-existing structures that have been established through long-term exposure to music from one culture or from many traditions, invoking such concepts as normative harmonic languages, modal frameworks, stylistic associations, and so forth. These abstractions may be consciously or sub-consciously created as we listen to a piece, and are further developed and reinforced with repeated listening and study. Although I am reluctant to make claims that encompass all musical activities, I contend that even in the most freely defined musical endeavors, the listener comes to find meaning by constructing patterns and finding relationships among sound events (recently heard, remembered, or projected) within a context of culturally acquired concepts.

As the systems of patterns grow increasingly complex, moving from the edge towards the centre of Quine's fabric, it can be said that the concepts engaged move progressively towards the domain of musical semantic discourse, while becoming further removed from the perceptual periphery. It is therefore this motion that defines the third and final continuum that this dissertation will address. In one sense, this dialectic is explored only by the listener, whose mental activity could potentially lie anywhere in the continuum at a given point in almost any piece of music. For instance, while listening to a Baroque fugue, the listener could be tracing the development of a particular motive, or focusing on the subtle timbral variations between pitches of the harpsichord, or thinking about the work's Italian influences, and all of these in rapid succession; this is to say that music can be rich in semantic interest and simultaneously present a fascinating aural image, and it is up to the listener to decide how to respond to the work. For the purposes of the present compositional endeavor, however, these concepts shall be applied to issues of compositional intent; the manner of composition can be more or less inviting to particular modes of reception, and it is with this in mind that I am delineating this dynamic.

It should be noted that these processes are not unique to listeners with musical training. Although it is the aim of musical education to hone perceptual faculties and further develop the ability to cognize musical materials, many of these abilities are acquired subconsciously through exposure to a musical culture.

Since its nascent stages, spectral composition has engaged the dialectic between acoustic phenomena and semantic structures to a certain degree. In his article "Structuration des timbres dans la musique instrumentale"[6], Gérard Grisey describes his exploration of the liminal regions of perception, areas of ambiguity between the perception of a unified timbre and that of a collection of individual pitches in a chord. He characterizes this approach as a negation of the exclusive categories of timbre and polyphony, as well as those of melody and rhythm, in favour of a more ambiguous combination of states. In Grisey's *Partiels* (1976), one of the seminal works of the genre, the timbre of a trombone's low E is synthesized by the orchestra, each instrument playing a different partial of the spectrum. Due to unavoidable variations in the instruments' sound production, the addition of new overtones in each of the instrumental timbres, and spatial variations, the listener does not perceive the orchestral synthesis as a unified timbre, as he or she does when hearing an actual trombone. However, the pitches' harmonic proportions and the performers' manner of playing lends the sound a cohesive quality, and the ensemble tends towards fusion. The resultant sound is thus too disjointed to be a single timbre, yet fuses into a single entity more than would a typical chord, confronting the listener with a sound that is somewhere between a sonic object possessing a qualitative timbre and an amalgam of discrete elements expressing intervallic relationships. As the piece unfolds, either side of this ambiguous region is explored; the texture periodically fluctuates between states of cohesion and disjunction, as individual notes gradually emerge from the cohesive textures and are later subsumed within other instrumentally synthesized timbres. The music thus vacillates within Grisey's liminal region, in turn emphasizing one side or the other; at times, extended and

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[6] Gérard Grisey, "Structuration des timbres dans la musique instrumentale," in *Le timbre, metaphore pour la composition*, Bourgois (1991).

slowly changing sonorities and the absence of other complex events encourage the listener to focus on the perception of the acoustic phenomena, yet when individual pitches and articulations emerge from the texture, the listener's attention shifts to the relationships between those events. At certain points in the work, rhythmic and harmonic regularities emerge, creating the highest degree of semantic patterning in the work by leading the listener to focus on variations within clearly defined structures.

A similar trajectory is traced in the opening sections of a more recent work, Kaija Saariaho's *Cendres* (1998). The piece begins with a plucked Eb2[7] piano string, a technique that emphasizes the upper partials of the piano's timbre. In this spectrum, the fourth partial is particularly strong; a perceptive listener thus hears the pitch G4 in addition to the fundamental Eb2. To make it clear that these are the pitches the composer wants the listener to hear, the cello enters with a tremolo between Eb2 and a fingered harmonic producing G4. In the subsequent measures, other pitches of the harmonic series built on Eb2, as well as a harmonic series built on Gb3 are gradually introduced. By shifting its focus from the perception of an acoustic spectrum to the intervallic relationships between pitches derived from this spectrum, this opening passage suggests that the harmonic materials of the rest of the work grow out of these simple spectral sources in some way, if only in a poetic sense. Although such a clearly audible connection is never again made between a natural spectrum and harmonic materials, the composer effectively sensitizes the listener to connections between these modes of reception and orients him or her towards an acoustically-based interpretation of the rest of the work.

By illustrating the ways in which the continuum between acoustic perception and musical semantics can be delineated, these examples highlight a potential for expression that is unique to the spectral approach to composition. In developing my thesis composition, one of my primary aims was to explicitly and effectively engage the theoretical dynamics described above, rendering these concepts perceptible and

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[7] The register numbering system used in this thesis refers to middle C as C4; the range between this C and the B above it thus comprises octave 4, and the C above that begins the fifth octave.

meaningful in both musical and philosophical ways. The following discussion will outline my approach to this endeavor and describe the technical means that I intend to employ.

2.4 Navigating the Dynamics of Spectralism

As mentioned above, the continuum between perceptibility and mimesis can be navigated by controlling the depth at which materials are extracted from an FFT analysis. The techniques required to control the depth of an FFT analysis are relatively straightforward, however before providing an explanation of these techniques it will be necessary to outline my methods of obtaining this data. The process I used for extracting spectral information begins with FFT and partial-tracking analyses performed using AudioSculpt. The results of these analyses can be evaluated visually, facilitating the adjustment of analysis parameters so that the partials identified are of a desirable number and fall within acceptable temporal and amplitude ranges. Once an interesting partial tracking analysis has been produced in AudioSculpt, this data may be transferred to patches in OpenMusic using the Sound Description Interchange Format (SDIF) file format. These files contain frequency and amplitude information for each identified partial, organized in a succession of frames; each frame represents a particular temporal position in the analysis, containing a 4 by n matrix where the columns hold the partial number, frequency, amplitude, and phase data, and where n equals the number of partials.

Once this data has been imported into OpenMusic, it can be viewed and manipulated using a modular set of patches that I have developed. In order to navigate within the SDIF data according to the depth of analysis, I employed a concept that I have termed a “hierarchy vector”, or “HV”. In an HV, a weighting value is attached to each pitch in a set, denoting that pitch’s relative importance within the set. Since the prominence of a given partial within a spectrum is related to its amplitude, HVs derived from spectra map amplitude data onto weighting values (which range from 0-127). HV data is represented in a Lisp tree, as shown in the example below:

((7300 103) (7400 64) (7600 28) (7700 52) (7800 14) (7900 46) (8000 37) (8100 25) (8200 19) (8600 18) (8700 16) (8900 77))

Figure 1. A numerical representation of an HV.

In an HV, each of the nested two-element lists (the "branches" of the "tree") contains a pitch value (expressed in midicents, or midics, where 6000 = C4, 6100 = C#4, 6137 = 37 cents above C#4, etc.) and a weighting value. The first pitch of the HV shown in Figure 1, therefore, is 7300 = C#5, and has a weighting of 103, meaning that it has approximately twice the degree of importance as the fourth element, the pitch 7700 = F5. The pitch values in this example have been rounded to conform to equal-temperament; although this approach is preferred for particular applications, such rounding is not required in most of my patches.

By filtering a set of spectrally-derived pitches according to their HV values, the depth of analysis can be dynamically controlled during pre-composition. A set of OM patches allows the composer to parse HV data, removing those pitches whose weighting values are above or below the specified limits; this filtering can be performed over a sequence of pitch sets, whereby the composer can denote the limits with a dynamic curve. In generating the passage found in Figure 2, the HV shown in Figure 1 was repeated eight times, and this sequence was filtered according to a dynamic curve set by the composer[8]. A more thorough discussion of this process can be found in Appendix II.

[8] The upper staff in Figure 2 sounds two octaves higher than the standard treble clef staff found on the second staff. This convention is followed in all subsequent representations of OM score editors. Where a lower bass clef staff appears, its pitches sound two octaves lower.

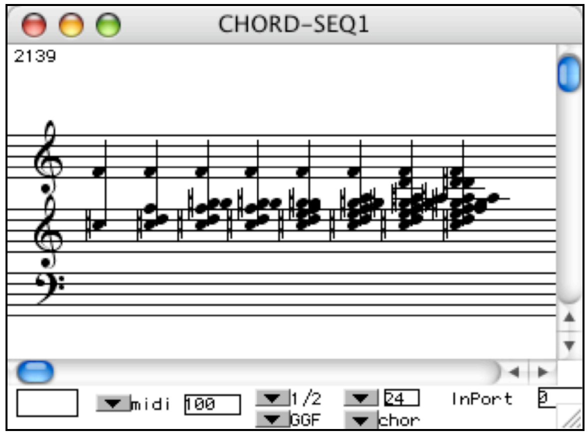


Figure 2. A repeated and filtered HV.

In the first few chords, only the most prominent pitches of the HV (corresponding to the strongest partials of the spectrum from which it was derived) are present. As the passage progresses, the weaker elements are gradually added, until all of the partials found in the SDIF file are represented. This chord sequence thus traverses the first continuum, highlighting the elements that are the most readily perceivable at the beginning and expanding towards a more mimetic representation of the original timbre at the end. By adjusting parameters and dynamic curves in the OM patches, the composer is able to expand HVs to generate a wide variety of pre-compositional materials in a flexible and intuitive manner.

In composing with HV materials, the concept of relative importance may be applied in a variety of ways, ranging from an imitative approach, whereby these values are mapped onto musical dynamics, to more abstract representations in which HV values are applied in stochastic processes or used to guide intuitive composition. In the chord sequence in Figure 2, for example, the HV is expressed by the prominence of a particular pitch within the passage: the pitch F6 is present in every chord, and therefore has a more significant presence in the sequence than the D#6, which only appears in the final chord. I have designed a set of patches that project chord sequences such as the one in Figure 2 in time, creating raw materials for use in melodic lines or in polyphonic textures; in both cases, the probability of a pitch appearing at a particular temporal position is relative to its HV value. Figure 3 gives an example of a monophonic projection of the chord sequence in Figure 2, generated by an OM patch:

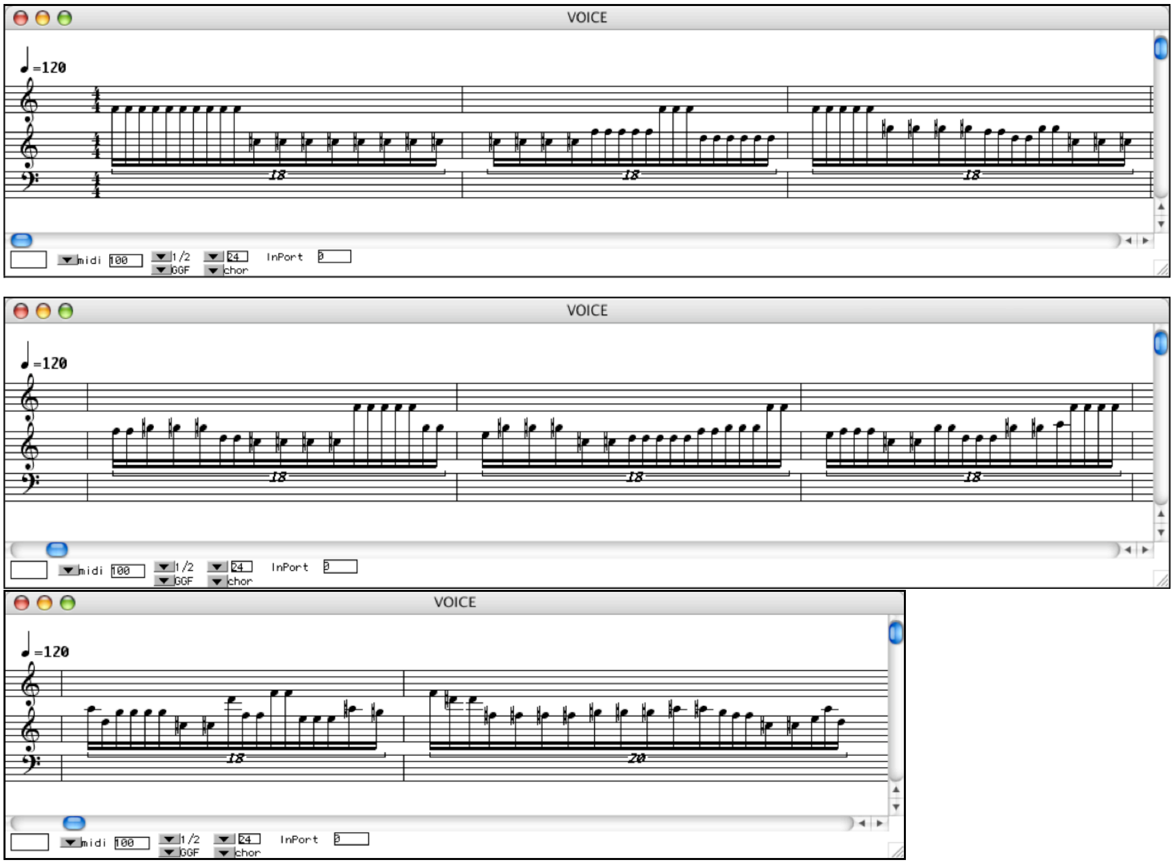


Figure 3. A monophonic projection of the HV in Figure 2.

Certain situations warrant the transference of materials produced by such automatic processes into the final musical score with minimal adjustment by the composer; at other times, however, passages such as that shown in Figure 3 may also function as a pre-compositional guide to more intuitive compositional activity. The melodic line shown in Figure 4 demonstrates an intuitive realization of the passage in Figure 3, which appears distributed between the piano and flute parts in mm. 45-50.

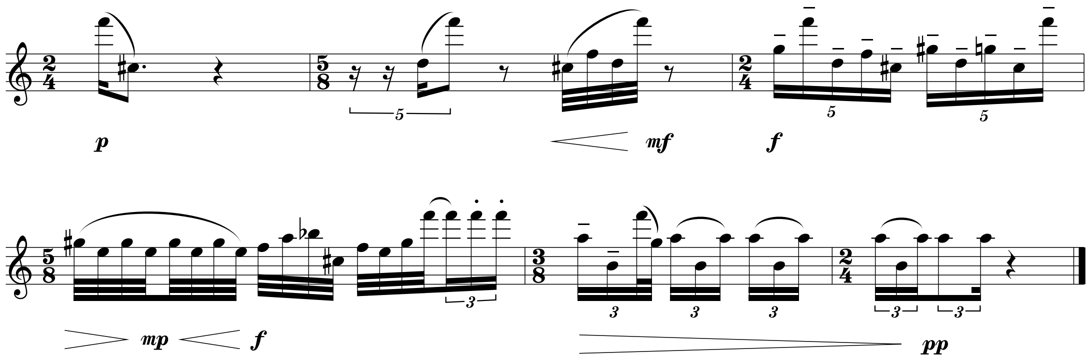


Figure 4. A melodic line composed from the passage in Figure 3.

The progression from HV to finished musical passage need not follow such a strict process, since the relative importance of the elements of a pitch set can be expressed in a variety of different ways, and exercised at the composer's discretion. However, certain points in the piece will demand relatively strict adherence to processes such as that delineated above in order to retain a strong theoretical connection to the work's fundamental concepts.

In tracing the continuum between the faithful reflection of a spectral analysis and a high degree of abstraction of that data, I have referred to more or less well-defined stages along the continuum. At the least abstract stage, octave equivalence is not assumed, pitch rounding is minimized, and amplitude values are mapped to dynamic indications. The next stages of abstraction round pitches to equal temperament, introduce octave transpositions, and allow for the selective omission or emphasis of pitches. Pitch sets then become movable while still retaining interval relationships. In the final stages, pitch sets are abstracted into pitch class sets and set classes, which are then freely combined, truncated, transposed, inverted, and so forth. Although this progression is somewhat imprecise – it is debatable whether the rounding of pitches is more or less abstract than the octave equivalence, for example – its outline is sufficiently clear to inform compositional decisions, given that the music traces this continuum in a fairly free and intuitive manner. A tracing of the early stages of abstraction can be found near the beginning of the piece: in the re-synthesis textures in mm. 3-10 and 12-25, FFT-derived pitches are rounded to quarter-tone intervals (finer pitch resolutions such as sixth-tone or eighth-tone intervals were avoided for practical reasons), representing mimetic re-creation; this resolution is subsequently coarsened in the stochastic texture in mm. 38-44, as pitches are rounded to half-tone intervals. Section 3.8 below provides further discussion of the later stages of abstraction, represented by the assumption of octave equivalence and the abstraction of set classes.

Over the course of the work, the navigation of the two continua discussed above (the first concerning the depth of analysis and the second concerning the degree of abstraction) contributes to the overarching progression along the third, dealing with musical semantics. The early stages of the piece focus on the exploration of acoustic phenomena created by the instruments of the ensemble, using instrumental re-synthesis to highlight the components of a source sound as well as extended techniques which produce complex and interesting timbres and textures. In instrumental re-synthesis, the re-creation of a spectrum on an augmented time scale affords the listener the opportunity to perceive the spectrum's transitory elements, and the use of different timbres for each partial allows the individual components to be distinguished, even though the instruments' identities will be masked with *al niente* attacks. Between such re-syntheses are interjected passages of inharmonic and unstable sounds which resist straightforward parsing into categories of pitch and instrumental identity; the complexity of these sounds aims to draw the listener's attention to their aural sensations in a way that complements the clarity afforded by instrumental re-synthesis.

While these passages engage the listener's perceptual faculties, they also serve as a point of origin from which semantic structures may be progressively developed. From a relatively cohesive timbral re-synthesis, individual pitches begin to emerge, participating in individual motions that distinguish them from the rest of the texture. As discrete elements gradually break free of the sonority, they are progressively manipulated, organized, and re-interpreted in a variety of contexts. The materials that began as components in a unified timbre are thus progressively transformed into gestures, motives, and eventually musical phrases.

Although the degree of semantic structuring is primarily explored in the pitch structures of the work, this dynamic is also engaged through manipulation of the listener's impressions of pulse and meter. The rhythmic aspects of the work thus range from completely ametric textures (as in mm.3-10), through suggestions of pulse (mm. 31-33) and pulsed textures that do not suggest meter (mm. 207-209), to well-defined meters. Just as the use of highly developed semantic pitch organization is reserved for the conclusion of the work, rhythms that clearly define a particular meter are found only in the final section, as in the articulation of a 2/4 meter in m. 275.

Although the broad trajectory of the entire work progresses from the domain of perception to that of musical semantics, features representing both ends of the continuum appear throughout, as motion within the continuum is traced on both small and large scales. In addition, the materials found within a particular spectrum often find reflection in a number of different ways, thereby expressing the central thesis of Quine's essay. Quine uses his analogy of a conceptual fabric to argue that no single configuration of this web is the sole candidate for supporting the perceptual periphery. This relativistic idea is reflected in the construction of *Elucide's* semantic materials, addressing issues surrounding the subjectivity of musical reception and the cultural relativity in musical expression and reception.

2.5 Spectral Sources

The source sounds whose spectral analyses form the basis for *Elucide* are listed in Table 1 below. The labels given to each of the source sounds will be used for reference throughout this document. A detailed account of the data derived from these sounds is found in Appendix I.

Source Sound		Label
Piano Harmonics	B1/C#5	PnoHrmBC#
	B1/D#5	PnoHrmBD#
	A1/D#5	PnoHrmAD#
	A1/B4	PnoHrmAB
Struck crotale on the pitch G7		Crt
Bass playing E1 *forte*		BassE1
Singing bowl, struck with a wooden beater		SngBwl

Table 1. Sound sources.

The piano harmonics are performed by lightly touching a node on the piano string when striking a note, in the combinations of struck string and harmonic pitch denoted in the second column of Table 1. The pianist is asked to strike the key forcefully so that the resultant spectrum is quite rich, as well as to hold the sustaining pedal to create sympathetic vibrations in the instrument's other strings. Piano harmonics were selected to provide spectral material for both perceptual and structural reasons. The richness of the piano harmonics will focus the listener's attention on the timbral characteristics of the sounds, particularly since these timbres are generally not expected to emerge from the piano. Since so many of the higher partials of these spectra are emphasized by this technique, the sound bears a resemblance to the bell-like timbres of the crotale and singing bowl spectra used later in the piece. However, since the partials originate from the vibrations of a piano string, they remain harmonically related to the string's fundamental frequency (that is, the frequencies of the high partials are integer multiples of the string's normal oscillation frequency); in this regard, the piano harmonics are related to the harmonic spectrum created by the bass. Thus, by being perceptually related to the crotale and singing bowl spectra and theoretically related to the bass spectrum, the piano harmonics form a conceptual link between all of the source spectra.

The particular pitch combinations of the four selected piano harmonics were chosen so that adjacent pairs of spectra would share one of their most prominent partials;

the first pair share the pitch B1, the middle pair share the pitch D#4, and the last pair share the pitch A1. Such chains of spectra are used throughout the piece, in order to create smooth transitions between harmonies. The B4 component of the final piano harmonic aligns with a prominent partial from the bass spectrum, and also creates a pitch class connection to the first piano harmonic of the series.

The bass E1 spectrum was chosen both because it is the lowest note playable on any of the ensemble's instruments apart from the piano, and because of the bass's ability to dynamically alter the amplitudes of the upper partials though alterations of bow placement and bow pressure, as well as by touching the string with the fingers of the left hand. As the lowest note in the work, the arrival of this pitch at the mid-point of the piece provides a formal marker, identifying a point of farthest remove within the work's temporal and registral spans. The bass's ability to elucidate the components of its spectrum facilitates an aural connection between the bass's sound and the application of this spectrum in the background structure of the second section, whereby each of the prominent partials of this spectrum in turn become focal pitch areas for extended passages.

The inharmonic timbres produced by a struck crotale and a struck singing bowl were chosen as source sounds to introduce a physically-based complexity to the harmonic language of the work. While the crotale sound is found in the piece, the singing bowl is not present in the ensemble; the latter source sound was incorporated both because of its rich inharmonic spectrum and for the symbolic significance of the singing bowl as a potential tool for meditation, which may be performed by focusing one's perception on the bowl's rich timbre.

The first four of the sounds in Table 1 are clearly presented during the piece so that the audience may perceive the relationships between these sounds and subsequent harmonic structures. The connections between the first piano harmonics and their re-creations are the most straightforward, tending as much as possible towards mimesis. Once these basic ideas have been established, however, the ensemble's reflections of the source sounds become more abstract, though still audibly connected with a clear presentation of the spectral source. Further distance is added between the crotale spectrum and its representation, since this spectrum is transposed and the spectral source is not isolated. The point of farthest remove in this progression is reached in the presentation of a spectrum produced by a singing bowl; since this instrument is not present in the ensemble, its spectral materials are fully detached from their source, carrying symbolic rather than perceptual significance.

CHAPTER 3: *Elucide* for Chamber Orchestra

3.1 Form, Background Structures and Large-Scale Trajectories

As mentioned above, the composition that comprises the musical portion of this thesis is entitled *Elucide*, and is scored for an ensemble of ten players: flute, clarinet, horn, trombone, percussion, piano, violin, viola, cello, and bass. The piece divides into three main sections that are to be played continuously. The title of the work relates both to its spectral foundations and to its progression towards semantic construction; by drawing aural connections between sonic events and spectrally-derived structures, the music represents an elucidation of the source sounds. At the same time, the piece aims to engender a certain kind of lucidity, in the sense of intelligibility, whereby spectrally-based materials are organized into semantic structures.

The majority of this chapter is devoted to a description of the structural foundations that support the piece's surface features, and that provided an organizational guide during the compositional process. However, before examining these aspects in detail, a discussion of the role that structural and theoretical considerations occupy within the work will provide a context for the following discussion, first by outlining the overall dramatic contour in which structural materials are arranged, and then by describing the manner in which these are realized and elaborated in the music.

The early stages of the piece establish a generally placid point of departure, using extended passages of gradually shifting washes of colour to encourage the listener to be receptive to the sonic experience and to appreciate the subtle timbral interplays for their intrinsic perceptual qualities. This restful, contemplative aural fabric does not remain unperturbed, however, as progressively greater disturbances are periodically injected, creating ripples of energy that begin to agitate the calm surface. These disturbances provide the impetus for the forward motion of the piece, tending to emerge in a series of increasingly expansive waves, each surge momentarily pushing the music into new territory before returning to a more familiar, stable state. As the swells in activity increase, they engender an accumulation of tension and energy that peaks at the end of the second main section.

In the first stage of the piece's evolution, the cohesive opening texture begins to fragment, as though the waves of energy were causing pieces of the sonic fabric to break off from the whole. This process gradually begins unsettle the general character of the music, which transforms into a kind of nervous energy by the end of the first section. In terms of the piece's symbolic drama, the impulse that disturbs the initial peaceful act of contemplation represents humanity's natural curiosity, the innate urge to investigate and wrestle with the complexities of the world as presented to our senses. The division of the unified sonic fabric into fragmentary elements, therefore, represents the first stages of exploration; at the end of the first section, the music remains unsettled since more questions are raised than answered.

After the overall texture has been fragmented, the piece's momentum continues to grow, as the search for patterns among the components begins. The dramatic arc of the second section is preoccupied with this endeavor, developing a visceral and, at times, primitive texture from an interplay of brief, fragmentary gestures. As the piece builds towards its climax, the music's fragile, tentative character eventually grows robust and forceful, creating incisive textural juxtapositions at the end of the second section. Once the excitement of the climax has subsided, dissolving into an ambiguous texture of noise, the music's character gradually turns towards lyricism, eventually finding resolution in long, expressive melodic lines and gently vibrating textures. By weaving the material exposed during the preceding exploration into cohesive, developed musical utterances, the final section of the work aims to provide a sense of conclusion to the work.

The structural materials that constitute the piece's underlying architecture were selected to support this large-scale dramatic contour according to considerations of harmonic character and potential for elaboration. Since the OM environment allowed the background spectral constructions to be heard on a diminished yet proportional time scale, the harmonic evolutions of many passages in the piece could be evaluated and adjusted prior to being expanded to fit the work's final dimensions. On all levels of the compositional process, my goals in working with the OM environment were both to capture a measure of the source sounds' intrinsic beauty in the work's harmonic structures, as well as to reveal from within the structure of these sounds engaging and attractive features that were previously unheard.

In composing the musical surface upon these structural foundations, I aimed to create a colourful and perceptually interesting aural appearance, expressing the fundamental concepts of the work through transformations of textural characteristics, interjections of contrasting materials, and symbolically significant musical figures. By reflecting an awareness of the interplay between perceptually- and semantically-oriented techniques and textures, the music explores the ways in which these aspects complement one another, finding significance in the dynamic between the two. Techniques that produce unusual timbres are therefore used throughout the work in order to stimulate perceptual interest, and are are frequently accompanied by or contrasted with motivic, gestural, or melodic statements to encourage an examination of the relationships between these modes of reception.

As OM-generated materials were transformed into the gestures and textures that pervade the piece, I generally employed a fairly flexible and intuitive working process, interpreting, re-arranging, and exploring the raw materials in a search for compelling gestures and textures. While the philosophical underpinnings of the work occasionally demanded a higher degree of objectivity in realizing these materials (as in the piece's stochastic textures, discussed in section 3.4), even these passages bear the mark of the composer's hand, as I sought to ensure that the results would be congruous with the aesthetic and dramatic contours of the piece. In addition to providing concrete materials for composition, the OM projections of spectral data supplied metaphoric and poetic inspiration for surface features, as certain intuitively composed passages were designed to imitate particular sonic characteristics that were revealed during the analysis process.

The gestural materials that appear throughout the work in a variety of contexts tend to exhibit certain idiosyncratic qualities; these were composed according to a number of general principles that contribute to the work's aesthetic and conceptual import. Since one of the piece's metaphors concerns the fragmentation of an initially stable texture, gestural lines frequently follow a progression that begins with sustained pitches, initiates motion within a narrow range, then develops into flowing gestures and eventually disjunct leaps. This evolution typically follows a wave-like contour, accumulating tension through fragmentation and then receding to a more stable state, the latter often involving a degree of rhythmic regularity (see the passage in mm.45-50 for an example of this contour). Surface level representations of the idea of fragmentation are found throughout the work, manifested in disjunct motion, fast rhythms, short articulations, and unstable timbres. In moving back and forth between these states of stability and fragmentation, the gestural motion possesses a fluid quality, achieved through rapidly changing rhythmic subdivisions and temporal placements that often obscure the notated pulse; this fluidity was a goal not only in the composition of individual lines, but also in the motion of the piece's broader textural transformations.

Throughout the composition of the piece's surface, I drew upon one of the most compelling facets of the spectral approach to orchestration, whereby the acoustic attributes of each instrument's sound all participate in the creation of an overall sonic fabric. Rather than conceiving of a given note as an amalgam of pitch, timbre, dynamic and articulation attributes, the sound is assessed according to its spectral characteristics. Playing a note *sul ponticello* on a string instrument, for example, would emphasize the spectrum's higher partials and generate more noise components relative to ordinary bow technique; taking these features into consideration, this timbre might be paired with brass instrument breath sounds to reinforce the noise elements (as in m.1), or used to subtly introduce a higher register for another instrument's melodic excursion (as in m.173). Such considerations were fundamental to the development of the textures of the work; throughout the piece, these concepts are engaged by reinforcing particular partials, unifying multiple pure sounds into complex timbres, and creating timbral transformations and hybrids. By considering the instrumental sounds in this way, I aimed to create interesting and stimulating aural textures, encouraging a perceptually-oriented listening stance.

While the spectral approach encourages an orchestrational conception in which the instruments of the ensemble each contribute to a unified, composite sonic fabric, this very tendency is suggestive of ways in which various degrees of stratification can be achieved for the purposes of contrast. In orchestrating the work, therefore, I maintained an awareness of the degree to which the musical surface is unified, at times aiming to weave the instruments into a single timbre, and at times drawing particular instruments into relief.

The overall form of the piece is detailed in Figure 5, which delineates the work's principal sections with vertical dotted lines. The four sub-sections within Section I are indicated by lower-case roman numerals above the first system. The graph contains information concerning the background spectra, structural markers, textural groupings, and pitch centres that are most significant to the piece's construction (indications concerning the background spectra and structural markers refer to the labels found in Table 1, however for the sake of clarity the "PnoHrm" prefix was omitted from the labels of the background spectra; the marking "AB" thus refers to material derived from the PnoHrmAB spectrum.)

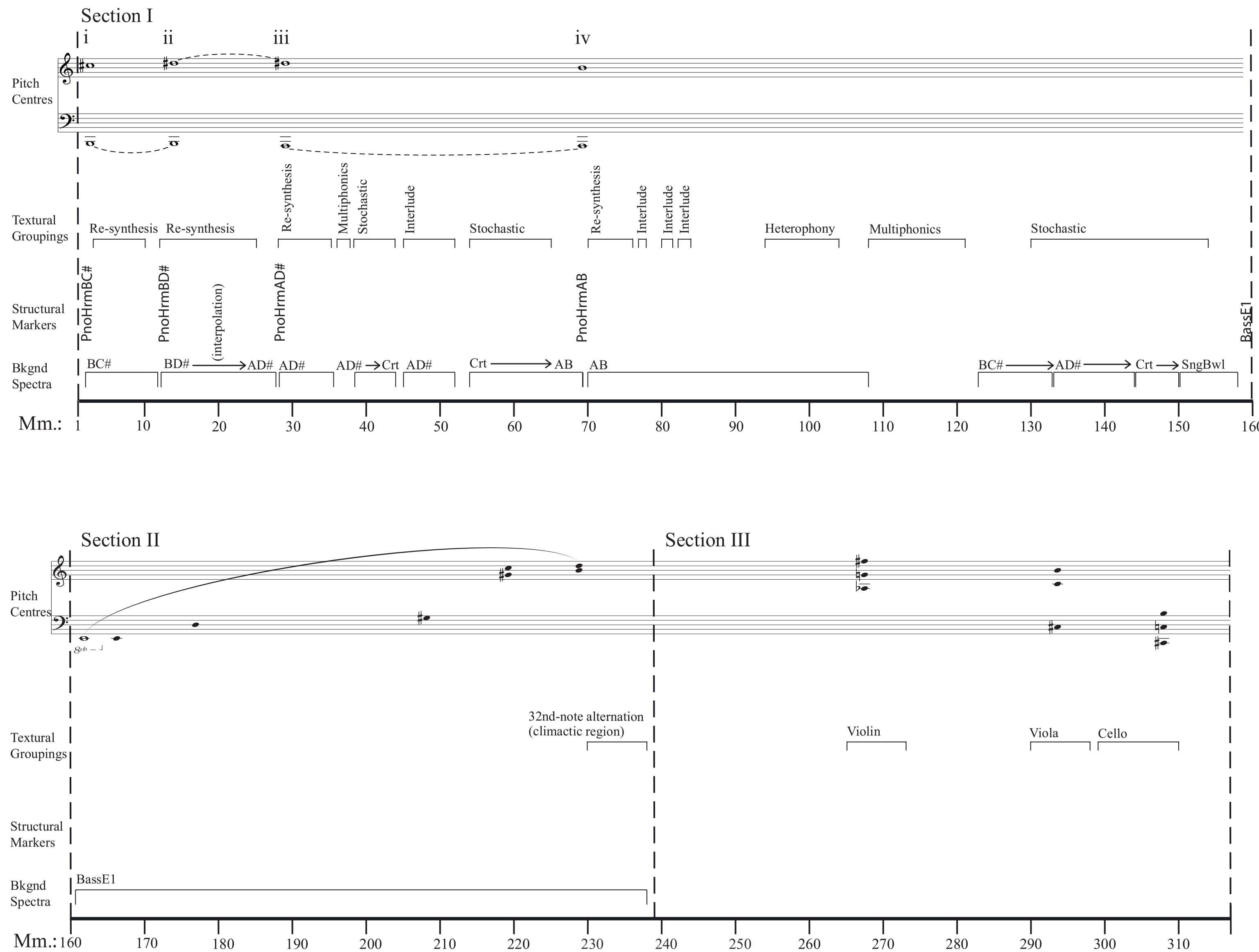


Figure 5. Formal Structure

Although the piece is conceived as a single, unified expression, each of its three sections is characterized by particular compositional goals and idiosyncratic behaviours, reflected in both large- and small-scale constructions. The following discussion outlines the background structure and general trajectory of each section.

3.1.1 Section I

The first section comprises approximately half of the duration of the piece, and is further subdivided into four sub-sections. The boundaries between these sub-sections are marked by articulations of the four piano harmonics listed in Table 1 above, and the intervening passages arise from the spectra of these sonorities, reflecting their spectral structures in ways that trace a general trajectory from mimetic re-creation to more abstract modes of interpretation.

To guide the progress of these four sub-sections, I have drawn upon a metaphoric image that consists of a series of mirrors, each of which is oriented to reflect light from the previous mirror to the next. In this metaphor, the mirrors are imperfect, as is the medium between them; when an image is projected towards the first mirror, it is reflected through the chain of mirrors, flipping backwards and forwards as it progresses, and gradually becoming more and more distorted. In applying this idea to the music, the flipping operations are represented by retrograde transformations, and the amount of distortion is expressed as the degree of abstraction to which the materials are subjected.

Following the first piano harmonic (PnoHrmBC#), the ensemble re-creates (as faithfully as is possible and practical, using an augmented time scale) a retrograde version of that sound's spectral data, using the technique of instrumental synthesis. Once this passage reaches the original sound's attack point, the piano plays the next harmonic (PnoHrmBD#), which shares some of its components with the first, but also has some differences. The passage between the second and the third harmonic begins in a similar fashion to that which precedes it, but contains two additional "mirrors" within the passage; positions within the two surrounding spectra were selected as axes of retrograde transformations and connected using HV interpolations, producing an added degree of variation and abstraction beyond straightforward spectral re-creation.

As in the first two sub-sections, chained temporal reflections of spectral materials form the basis for both the third and fourth sub-sections. However, this harmonic background progressively deviates from the piano harmonic spectra with which the sub-sections begin; an un-transposed crotale spectrum is incorporated into the background of the third sub-section, and the fourth sub-section incorporates transposed versions of the piano harmonic and crotale spectra, as well as the un-transposed singing bowl spectrum. Just as adjacent piano harmonic spectra in the series form chains by sharing one or more pitch, the series of spectral harmonies in these passages are similarly connected. The background harmonic structure thus represents a progression that begins with the spectral re-creation of heard acoustic phenomena, moves through increasingly modified versions of those phenomena, and culminates in the overtone structure of an unheard source. Since this progression gradually disassociates the harmonies from heard source sounds, introduces harmonies of greater dissonance, and moves upwards in register, a sense of harmonic motion and accumulated tension is effected, culminating at the end of the first section.

Whereas the focus of the first two sub-sections is on mimetic re-synthesis and acoustic phenomena, the third sub-section begins a motion towards a greater degree of abstraction. The unified texture of instrumental re-synthesis is gradually dissolved first by faltering re-articulations that suggest elemental ideas of rhythmic regularity (as in mm. 31-33), then by stochastic textures that present probabilistic expressions of spectral pitch hierarchies (as in mm.38-44). These techniques express one of the fundamental concepts of the work, that of gradually breaking a unified texture into discrete elements. Furthermore, the continuous texture that dominates the piece from the beginning is disrupted in this passage by two brief interpolations of contrasting textures: a flute multiphonic (m.37) and a passage of fragmentary melodic gestures (mm. 45-50).

The fourth sub-section continues to develop the transformations begun in the third sub-section. As in the previous sections, a retrograde of PnoHrmAB forms the basis for the passage following that piano harmonic. However, here the materials are worked into textures comprised of fragmentary melodic gestures, and divided into three iterations representing late, middle, and early points in the spectrum; these passages therefore represent a fairly high degree of abstraction of the piano harmonic spectral data. The other features of the third sub-section are again represented in this passage, yet in more expanded and developed forms: textures constructed from melodic fragments are interpolated, as is an extended passage built upon flute and clarinet multiphonics. As well, an extended stochastic texture manifests chains of spectra at the end of the passage, culminating in a re-creation of SngBwl that marks the highest registral point in the piece and the end of the first half; details of these passages are given below.

Overall, Section I leads the listener through a process whereby source timbres are gradually disintegrated, eventually yielding collections of individual spectral components that are isolated as discrete elements. From these materials, the beginning of a progression towards the construction of semantic structures emerges, as they start to crystallize into inchoate rhythmic, motivic, and gestural concepts.

3.1.2 Section II

The arrival of the bass's low E in m.159 marks the halfway point of the piece, and the beginning of the second main section. As mentioned above, the sound of a bass playing this pitch served as one of the sources of spectral materials for the piece, and it is primarily in the second section that this spectrum is explored; in a poetic sense, the entire second section may be considered as an outgrowth from the bass's articulations of this note. While the compositional approaches used in the first section typically retain the relative temporal alignments of spectral components, in the second section each of the bass's prominent partials are considered in turn, displacing the elements so that each may be considered separately. As each of these partials emerges, its pitch is adopted as a focal point for an extended passage. The approach taken in this section thus completes the progression begun in the first section whereby the components of spectra progressively emerge from their origins within unified timbres as discrete elements. Over the course of the section, the aural connections between the individual partials of the bass sound and their corresponding sustained pitch centres grow more tenuous until, at the climax of the section, the pitch centres have become aurally divorced from their origins in the bass timbre, retaining only theoretical or symbolic ties to the bass spectrum.

By presenting a background structure based on a harmonic spectrum, the second section can be heard to resolve the tension accumulated by the use of the inharmonic crotale and singing bowl spectra in the first section. In addition, the clarity of the harmonic spectrum provides a robust framework that is capable of supporting a variety of complex elaborating materials that develop from other methods. The pitch centres themselves are progressively thickened by heterophonic textures, played mostly by the cello and bass and utilizing pitches within a narrow range above and below each pitch centre. This core activity is further elaborated by gestures that increasingly branch off and break away from the pitch centres, thus expanding upon the images of fragmentation that guided processes in the first section.

While the background structure of the second section can be aurally connected to the phenomena of the bass's spectrum, the pitch materials used by this section's elaborating gestures rely more and more heavily on octave equivalence, progressively altering the spectrum's intervallic structure by transposing pitches into other octaves. As the section progresses, this elaboration and thickening grows more extensive, so that at times multiple adjacent pitches from the BassE spectrum are presented as a harmonic centre (as in the G#4/C5 dual centre articulated in mm. 218-221), and at times the pitch centre is completely enveloped with figuration.

Section II relies more heavily on pitch class abstractions of spectra than does Section I, and represents a mid-point along the piece's broad progression towards abstraction. Furthermore, this section engages a higher degree of semantic patterning than occurs previously, as motivic structures appear more frequently (this will be explored in greater detail in section 3.9.1 below). The trend towards semantic organization reaches a significant point at the arrival of the piece's climactic region (mm. 230-238), symbolized by an elemental semantic unit, represented by 32^{nd}-note alternation between pitch classes D and B. Although these pitches are prominent in the bass's spectrum, their presentation is more likely to be heard as an elementary motive, a basic building block of semantic structuring. This point thus represents a crucial moment in the large-scale evolution of the piece, whereby the background manifestations of spectral components are fully divorced from their acoustic origins and register as semantic materials; this focus on motivically-oriented material sets the stage for the final section, which is primarily oriented towards semantic constructions.

3.1.3 Section III

After the energy of the climax has dissipated, the piece moves into the third and final section, which offers a dramatic resolution to the preceding sections' explorations by developing their materials and abstractions thereof into more extended and semantically organized musical structures than occur previously. Although the forms of semantic organization found in the third section do not parallel those found in the complex grammars of much other music, the thematic and developmental structuring of its melodic lines will represent the farthest point along the continuum of musical semantic content that this piece will reach. The decision to limit the extent to which the piece progresses along this continuum was made for aesthetic reasons; were the piece to construct such semantic patterns as a well-defined meter or an extant musical grammar, the result would be too stylistically distant from that of the earlier parts of the work, and would inevitably introduce cultural associations that would be foreign to the intentions of this thesis.

In Section III, the violin, viola, and cello successively present melodic lines that are based upon set class structures found earlier in the work, both in their background and surface structures. (The background structures are detailed in Figure 5, the derivation of which is discussed in detail in section 3.9.2 below, along with their relation to the concepts of the piece.) As the three solo string lines are presented, other instruments of the ensemble reinforce particular aspects of those lines; these melodies are thus supported by an orchestrational texture that expresses a hierarchical relationship between the respective solo instruments and the rest of the ensemble. This approach stands in contrast to the textures of the first and second sections: the first tends towards homogeneity, while individual instruments tend to emerge from the texture of second section only for brief gestural outbursts. This textural shift highlights the melodic lines and orients the listener towards a semantic hearing of the musical phrases; section 3.9.2 below describes the ways in which musical semantics are expressed in these passages.

3.2 Instrumental Re-Synthesis

As described above, the evolution of the first section follows a trajectory that originates in the mimetic re-creation of a perceptual event using the technique of instrumental re-synthesis. In the first sub-section, spectral analysis data from PnoHarmBC# was applied to the instruments of the ensemble in an effort to reproduce the source timbre as faithfully as possible: frequency and amplitude data were mapped to pitches (with quarter-tone rounding) and relative dynamic levels, respectively, and the passage arises from only a single analysis. Although the re-synthesis in the second sub-section begins in a similarly imitative fashion, certain pitches grow unstable at the end of the passage (mm. 24-25), as first *glissandi* and then stepwise motions are introduced. The independent pitch variation of these voices differentiates them slightly from the unified sound of the ensemble, allowing these individual elements to emerge from the texture. The instrumental re-synthesis in the third sub-section (mm.28-33) also begins to fracture near the end of this passage, however in addition to pitch alterations similar to those found earlier, the texture is disrupted by re-articulations of all of the pitches. While some of the articulations are aligned with one another, many occur independently; since a listener's ability to identify an instrumental timbre relies heavily on the attack transients of that sound, these re-articulations reveal the identities of individual instruments, subtly dissolving the unity of the texture.

At the beginning of Section II, the technique of instrumental re-synthesis is used again, here reproducing the BassE1 spectrum (mm. 155-158). As in the passages leading to the third and fourth piano harmonics in mm. 28 and 69, respectively, the re-construction of the BassE1 spectrum occurs before the source sound is heard in m.159. However, while the re-syntheses of PnoHrmAD# and PnoHrmAB reproduce timbres that are very similar to the piano harmonics heard earlier, the bass does not play the pitch E1 (nor does it present any other pitch prominently) prior to m. 159. By preceding a source sound with its spectral re-synthesis, the music expresses one of the work's philosophical metaphors, connected to the ideas of relativism discussed in 2.4 above: although the cognitive processes activated during perception are often simply considered to respond to external stimulus, it is also the case that existing mental constructs influence the subconscious processes by which stimuli become percepts. In Section I, therefore, the appearances of the PnoHrm spectra before the piano harmonics represent a subtle awakening of perceptual cognitive abilities, whereby the brain gains access to the piano harmonic percepts through its previous exposure to and contemplation of similar sensations. The reconstruction of the BassE spectrum represents a more dramatic conceptual shift, the revelation of a perceptual domain that was previously excluded from awareness.

3.3 Perceptually-Oriented Interjections

Each of the first three piano harmonics is preceded by a short interjection in which noise elements and other unstable frequency components create acoustically complex textures. The techniques used in these passages obscure the identities of the instruments and overlap in their aural profiles, producing complicated and rich sonic fabrics that nevertheless appear unified. Because these sounds are noisy and unstable, the texture resists straightforward parsing, thereby separating the sound from its source and drawing attention to the aural phenomena. These passages achieve similar aims as the passages of instrumental re-synthesis into which they are interposed, albeit through contrasting means.

Three perceptually-oriented interjections appear in m. 1, mm. 10-12, and mm.25-27, each preceding a piano harmonic. In the first passage, breathy tones, flutter tongue and a trill in the woodwinds, breath noises in the brass, and *sul ponticello* trills, tremolo and *glissandi* in the strings combine to form an acoustically rich texture. These and other similar techniques are applied in the other two passages, such that each interjection develops beyond the scope of the last. In the third passage, gestural materials begin to emerge from the noise-based texture, signaling the start of an evolution towards semantically-oriented construction.

In the passage preceding the fourth piano harmonic, the pattern established by the preceding interjections is broken in order to indicate the start of a motion into newer territory. However, elements derived from these interjections do appear in the measures leading up to the fourth piano harmonic: noise elements are produced by the bass drum, snare drum and cymbal rolls in mm. 67, 68 and 69-70; breath noises appear in mm.60-63, and *glissandi* and bow noises appear in mm. 59-60. Since these components are removed from their original presentations within a unified texture, the progression of interjections expresses the metaphor of fragmentation that runs throughout the piece.

As well as adding interest and variety to a texture which otherwise could become monotonous, these interjections contribute (though more poetically than objectively) to the re-creations of the PnoHrm spectra by representing the noise elements that are found at these source sounds' attack points. Throughout the piece, noise-based techniques are used in an effort to represent the unstable aspects of the source spectra, recognizing that the strongest stable partials constitute only part of a complete spectral image.

A variety of other techniques are employed in the work to similarly stimulate listeners' perceptual faculties. For example, the technique of timbral transformation, whereby a note articulated by one instrument is taken up and sustained by another, is found frequently throughout the piece, and is a particular focus of Section III. This technique allows the attack characteristics of one instrument to be combined with the sustain of another, places emphasis on selected pitches, and can be used to create a kind of selective resonance. By masking the attack of the sustaining instrument's sound envelope, that instrument's identity can be partially obscured, so that its sustained pitch can appear to seamlessly emerge during the decay of the other. Such transformations can instill a momentary sense of uncertainty in the listener, as the physical source of the sound is obscured. By temporarily disassociating the sound from its origins, this technique engenders a fissure between the percept and that which it signifies; this transitory separation heightens the listener's attention to the sonic phenomena, encouraging a perceptually-oriented reception of the overall sonic fabric.

3.4 Stochastic Textures

The preceding discussion of the passages instrumental re-synthesis describes the start of a process of disintegration, heard in the emergence of individual pitches from a unified spectrum. Developing this process further, certain passages in the third and fourth sub-sections present stochastic textures that further differentiate the individual pitches of a spectrum, while still representing the spectral analyses of the source sounds. The passages that use this technique are found in mm. 38-44 and mm. 53-65 in the third sub-section, and mm.129-154 in the fourth sub-section.

In generating each of these stochastic passages, individual frames from particular spectral sources were selected, and HV interpolation was used to produce transitional chords between them in a series of HVs. Using the OM patch "textureproject" (described in detail in Appendix II), these series were divided registrally and projected into measures such that the probability of a particular pitch occurring at a given point in a measure is proportionate to its weighting value, thereby expressing the pitches' hierarchy in the temporal dimension. (HV values are represented both in the durations of pitches as well as in the frequency with which a pitch is attacked, depending on the desired textural effect.) Due to the insertion of silence (or noise) between the iterations of pitches, the individual notes can be heard as discrete elements. However, since all of the instruments participate in essentially the same kind of activity, the overall texture presents a certain kind of homogeneity, and can therefore be heard to occupy a region between a differentiated collection of disparate elements and a unified texture.

The stochastic passages in Section I demonstrate a variety of methods by which the raw materials generated by the "textureproject" patch were composed into the final score. In mm. 38-44, the compositional approach aims to reflect the OM data objectively, as the passage is allowed to unfold from the acoustically-based pitch hierarchies with minimal subjective interference. In the subsequent stochastic passages (mm. 53-65 and mm. 129-154), the OM-generated materials are realized with musical surfaces that, while remaining faithful to their pre-compositional materials, evince a somewhat greater degree of organization; whereas the first stochastic passage tends towards a pointalistic texture, the elements in the other two passages are grouped and arranged into short gestures. These passages' progression between and integration of objective and semantically-suggestive compositional approaches, in conjunction with their differentiated texture, makes them an intermediary link between the instrumental re-syntheses of the opening and the passages of individuated melodic lines that are found in the second half of the piece.

3.5 Inchoate Semantic Interludes

Although the extended textures and processes described above dominate the early stages of the work, these are progressively fractured by increasingly frequent interruptions. One such interlude appears in mm. 45-50 in the third sub-section, and is characterized by the emergence of gestural materials and a degree of rhythmic regularity, especially at its climax (m. 47) and its conclusion (mm. 49-50). The pitch materials used in this passage originate from a melodic projection of a sequence of HVs generated by repeating a frame from PnoHrmAD# and passing those chords through a dynamically changing HV filter, in a manner analogous to that described in section 2.4 above; this process creates a harmonic progression in which pitches accumulate from the strongest to the weakest, so that a given pitch persists for a duration that is proportional to its weighting value. The arrangement of these chords into cohesive, regular gestures momentarily suggests the development of semantic organization, foreshadowing later stages in the piece's large-scale evolution. Since the HV materials upon which this interlude is based are the same as those expressed in the preceding instrumental re-synthesis and stochastic textures, the passage can be heard as an outgrowth of this spectral material, whereby the elements are progressively structured, albeit in an elementary fashion.

At the end of this interlude, the regular structures that surfaced briefly dissolve into a texture of *spiccato* and *ricochet* bowings, trill and tremolos, and timbral alterations such as breathy tones and *sul ponticello* playing (mm. 50-52). These techniques fracture both the musical and the acoustic regularities of the interlude, returning a degree of disorganization to both domains. These and similar techniques appear throughout the work, generally following apogees of semantic patterning, presenting further manifestations of the fragmentation ideas that permeate the piece.

In the fourth sub-section, the impulse behind the interlude in the third sub-section is developed, as similarly constructed passages appear with greater frequency and grow more extensive. Three such passages emerge from the instrumental re-synthesis at the beginning of this sub-section (mm. 69-76), each manifesting a different frame from the PnoHrmAB spectrum. These passages, found in mm.77, 79-81, and 82-84, develop out of a sequence of frames that begins near the end of the PnoHrmAB analysis and moves towards the sound's attack point; these three passages thus represent a retrograde of the source sound analogous to the temporal mirrors found earlier, but are presented in a more abstract and fragmented manner than occurs previously.

Although the semantic interludes in the third and fourth sub-sections exhibit a higher degree of abstraction and semantic organization than the textures that surround them, they retain a certain amount of objectivity in their realization of OM generated materials; while these passages are more highly structured than the stochastic textures discussed above, their lack of repetition, signification of motives, and hierarchical texture marks them as inchoate semantic expressions.

3.6 Multiphonics

In order to express the concept of examining the audible structures of sounds, all of the players in the ensemble are required to perform techniques which reveal spectral components that would normally be either imperceptible or absent in ordinary instrumental playing. Of course, the rich spectra of the piano harmonics used to provide spectral source material exemplify this idea. In addition, each of the string instruments utilize a variety of harmonics, including ordinary open string and fingered harmonics, trills between fingered harmonics and regularly stopped notes (which produce a variety of unstable components in addition to the two expected pitches), and harmonic glissandi. As well, the use of *sul ponticello* bowing emphasizes higher spectral regions. In order to explore the spectra of the brass instruments, various muting techniques are employed by these players in order to create shifting emphases within the instruments' spectra. Finally, the use of a bow on the percussionist's cymbals create alterations of this instrument's spectrum.

While most of these techniques are encountered throughout the work, the expansion of the woodwind instruments' spectral characteristics with multiphonics occurs in two specific passages; the first occurs in the third sub-section of Section I (in m. 37), and serves to foreshadow the extended passage in the fourth sub-section (in mm. 108-121). In creating the multiphonics in these passages, the players begin by playing a single pitch in an ordinary fashion, then gradually bring out the other components to form the complete multiphonic spectrum. Since this playing technique is strongly representative of the fundamental concepts of the work, and is audibly analogous to harmonic processes such as the HV filtering described in sections 2.4 and 3.4 above, its application has been isolated and highlighted in these two passages. In the second passage, the flute and clarinet multiphonics are augmented by the use of string harmonic trills, all of which are arranged in the chained fashion similar to that which supports the large-scale harmonic structure of the piece. In the passage's unfolding, the spectrum of a single pitch can be heard to expand into a more complex harmonic structure, individual elements of which are taken up as new pitch centres whose spectra in turn give rise to or connect with new harmonies, and so forth.

3.7 Heterophony

Section 3.2 above discusses ways in which divisions between timbre and harmony are blurred by using the technique of instrumental re-synthesis. Just as the transference of an overtone structure to a harmonic collection integrates the concepts of timbre and harmony, the categories of harmony and melody are similarly combined in the piece's heterophonic textures. By using multiple instruments of the ensemble to trace essentially the same melodic contours at slightly displaced temporal positions, these passages represent an intermediary stage between stochastic textures and fully differentiated melodies in the work's broad progression towards semantically-oriented constructions.

The first heterophonic passage in the piece occurs in mm. 95-107, and can be heard as a development of the fragmentary texture based upon PnoHrmAB that precedes it in mm. 82-84, since it presents an elaboration of a frame from this spectrum. While this is the only such texture in the first section, it serves to prepare the listener for further development of this technique in Section II.

As mentioned in section 3.1.2 above, Section II is built upon a framework consisting of pitch centres that successively move through partials of the BassE1 spectrum. At the beginning of the section, the pitch centre E2 is presented clearly by the bass and cello (reinforced briefly the by the trombone), using asynchronous attacks that suggest a heterophonic texture (mm. 164-168). The bass and cello proceed to thicken this centre in mm. 169-173 with pitches above and below E2, gradually expanding in compass. This process of expansion, analogous to numerous other processes used throughout the piece, is developed throughout the section, leading to streams of activity that branch off from the pitch centre in heterophonic textures. One such passage appears in mm. 186-189, in which the pitch centre B2 is expanded into a rising line, variations of which are superposed by the brass and string instruments. Numerous other passages in Section II exhibit this approach in varying capacities, the most significant of which appears in mm. 226-229 and effects the final approach to the section's climax. In the course of this passage, all of the string and woodwind instruments are eventually added to the texture, creating a very dense layering of melodic lines in which the perception of individual lines is obscured by the general harmonic content of the passage as a whole.

3.8 Pitch Abstractions

3.8.1 Octave Equivalence

One of the prominent features of Section II is its more frequent use of pitch class abstractions of spectral data than occurs previously. Although the primary structures of the section maintain the registral placements of spectral components, the elaborations built upon this framework assume progressively greater freedom in transposing spectral components into other octaves. Transpositions of spectra appear in some background structures in Section I, however in these instances all elements of a spectrum are transposed equally in order to preserve the spectrum's intervalic structure. In Section II, only selected elements are transposed to other octaves, creating the possibility for much greater variety in harmonic quality, and therefore representing a further degree of abstraction than the transpositions that occur in Section I. Examples of such harmonies appear in m. 179 and m. 191; as shown in Figure 6, some of the notes of these chords are registrally fixed pitches from the BassE1 spectrum, however others are pitch classes abstracted from other regions of the spectrum.

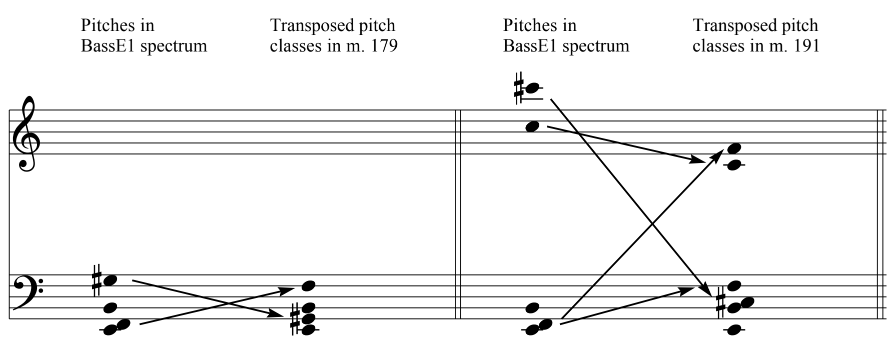


Figure 6. Octave transpositions of spectral pitches in m. 179 and m. 191.

The passage found in mm. 205-206 clearly symbolizes this assumption of octave equivalence, as the pitch class G# appears in octaves 1 and 2 within the same piano harmony, and is subsequently adopted as a pitch centre in octave 3 by the viola in m.206. As Section II progresses, octave equivalence becomes progressively more prominent, and is manifested fully at the beginning of the piece's climactic region in the simultaneous articulation of a motivic fragment in three octaves (mm.230 and 232-233).

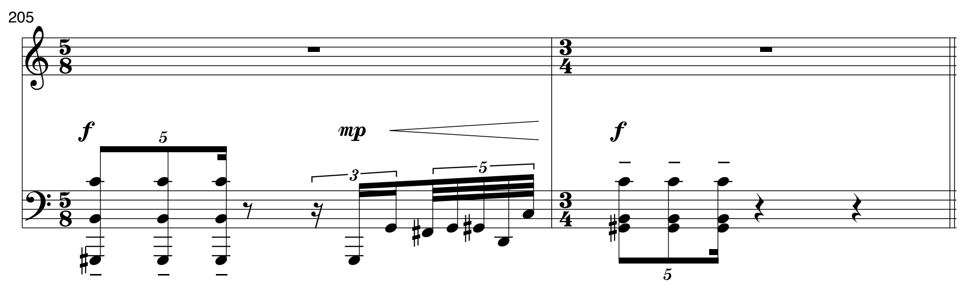


Figure 7. Octave equivalence symbolized in mm. 205-206.

Evidence of the harmonic variety produced through the use of octave equivalence can be found in the materials with which pitch centres are expanded in Section II; for example, the thickening of the B2 pitch centre in mm. 184-189 culminates in a texture comprised both of spectral components adjacent to B2, as well as pitch classes taken from elsewhere in the spectrum.

3.8.2 Set Class Abstractions

The final stage in the process of abstraction of spectral materials is represented by the derivation of set classes from some of the prominent projections of source spectra. Since one of the piece's guiding metaphors is the progressive parsing and abstraction of spectral structures, a repertoire of set class abstractions was drawn from the HV projections that appear in the piece rather than directly from the spectral sources; this process best represents the motion towards the centre of Quine's fabric, since higher level abstractions do not have access to the perceptual periphery in this model. Even though the musical projections in the piece represent only a limited amount of the original spectral data, further parsing and limiting of this material was necessary to generate a musically meaningful collection of set classes. In the context of this piece, relevant individual or groups of set classes are those that bear a representative aural signature or a characteristic harmonic colour while aligning aurally with the work's general harmonic language (this excludes set classes with high cardinalities or those that are too unique to be integrated, such as [037] or [048].)

Table 2 lists the primary set classes that were derived from HV projections. The selection process used in isolating these particular set classes was motivated by a desire to discover patterns and consistencies among various HV projections, despite their disparate spectral origins. As regularities emerged during this process, they influenced the manner in which subsequent materials were approached; this process therefore presents another manifestation of the abovementioned ideas of relativity. The set classes that were selected can thus be divided into two groups: three of the set classes are subsets of the octatonic scale, whereas the remaining six consist of a combination of [012] with another non-contiguous dyad or trichord. The latter group of set classes, though loosely defined, exhibits a characteristic quality, and has been labeled "cluster extensions" in Table 2 since their [012] cluster subsets constitute one of their primary defining attributes.

Set Class Type	**Set Class**	**Spectral Source**	**Projection Location**
Octatonic	[023569]	PnoHrmAB	m.81, piano
	[01367t]	PnoHrmBC#	(cut from score)
	[013467]	PnoHrmAD#	m.47, piano
Cluster Extensions	[012456]	PnoHrmAB	m.80.1-.2, piano
	[012467]	PnoHrmBC#	m.317.1, piano
	[01267]	SngBwl	m.150.1, piano
	[012569]	PnoHrmAD#	m.48.3-5., flute
	[01249]	BassE1	m.235.1, piano

Table 2. Set classes abstracted from projections

Although these set class abstractions (and subsets and alterations thereof) were used to generate pitch structures found in all sections of the piece, instances of well-formed articulations of set classes are rare before the final stages of Section II. Examples of such pitch construction bookend the heterophonic texture that builds towards the climax in mm.228-229; the first six notes of the bass's ascent in m.228 articulate F(I)[01367] (a subset of both [01367t] and [013467] from Table 2), and the violin's final staccato gesture in m.229 (including the D5 on the downbeat of m.230) instances D(I)[01367]. While the passage as a whole portrays a complete octatonic collection of which both pitch sets are subsets, the clear delineation of two projections of this set class in such a pivotal location engenders a symbol of the emergence of this method of pitch structuring.

In Section III, manifestations of set class constructions appear frequently, as these structures assume a primary role in the generation of harmonic materials. For example, the cello outlines an instance of [012569] in the second and third beats of m.276, and then proceeds to articulate [012568] in the remainder of its gesture. In the strings' melodic lines, set class projections are employed on both structural and surface levels; by building set class realizations upon other set class structures, these passages represent a degree of abstraction beyond that which occurs previously.

Each of the three string melodies is constructed within a framework comprised of two stacked major 7ths, as shown in Figure 5. These trichords were derived from the stacked minor 9ths (comprised of B3, C5, and C#6) that emerges from the BassE1 spectrum at the climax of Section II in mm. 238-244. These structures provide anchor points to which articulations of other set classes are affixed, surfacing at key points in each of the melodies; the violin and viola present these structures at high points in their dramatic contours, in m. 267 and m. 292, respectively, and the cello begins its cadential passage with the structure in m. 308.

Around these trichords, each instrument weaves its melodic materials, the pitches of which were derived from the set classes shown in Table 2. At the beginning of the violin melody, for example, the set class [012568] is articulated (mm. 265-267), and at the end appears an instance of [01256] (m. 271); the former presents a modification of the

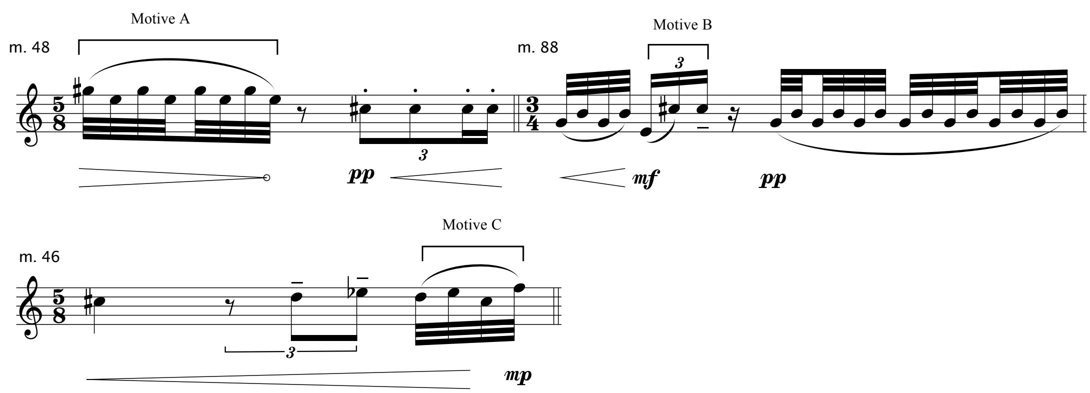
PnoHrmAD# set class [012569], and the latter is a subset of both this set class and the PnoHrmAB set class [012456].

The PnoHrmAD# set class [012569] is outlined in both the viola and cello melodies, in mm. 290-295 and m. 303, respectively. As well, the octatonic-type set class [013467] is reflected in the cello's melody, first slightly altered to form [013478] in mm.299-300, and then as [013467] in mm.305-306. In the latter passage, the cello's melody parses this set class into three ic1 dyads, presented as major 7^{th} intervals; this articulation draws parallels to the "stack of 7ths" background structure, which is presented by the cello in the measure following these sevenths (m. 308). This juxtaposition highlights the division of the set class materials into "octatonic-type" and "cluster-type" categories, symbolizing yet another layer of abstraction applied to the already abstract set classes.

3.9 Semanticism

3.9.1 Motives

A number of motives can be traced throughout the piece, appearing at first sporadically and then gaining prominence as the work moves towards its climax. Collectively, these motives symbolize the early stages of semantic construction, however within this group is displayed a range of sophistication. The most elemental motive, and that which symbolizes inchoate semantic material at the piece's climax, consists only of the alternation of two pitches a minor third apart in a 32^{nd}-note rhythm (as described in section 3.1.2 above), and originates in textural figuration used throughout the piece; this motive first emerges in m.48, as shown in Figure 8. A second motive that presents a slightly more complex profile is first articulated in m.88, outlined by the piano's <E,C#,C#> gesture. Defined by its motion of a leap followed by the repetition of the second note, this figure is more easily identified as a motive than the alternating third motive, owing to its slightly more elaborate structure. One final motive deserves mention, since it presents a highly characteristic melodic contour. The clarinet plays this motive on the final beat of m.46; the idiosyncratic interval pattern (<+1, -2, +4>) makes this melodic fragment particularly distinctive, so that the listener is able to trace its progression as it is presented in a variety of contexts later in the piece. In addition to lending itself to development, this motive forms connections to higher level semantic constructions build upon set class structures (described in 3.8.2 above), as it presents a [0124] subset of three of the set classes in Table 2.



<u>Figure 8. Examples of motives.</u>

As the prominence of these motivic materials increases, their appearance serves to draw the listener's attention progressively towards semantic relationships within the music, eventually leading to the semantically-oriented melodic lines of Section III.

<u>3.9.2 Melodic Lines</u>

The culmination of the piece's progression towards semantically-oriented music is represented in the three melodic phrases presented by the violin, viola, and cello in Section III, in mm. 265-273, mm. 292-298, and mm. 299-310, respectively. Whereas individual voices in the preceding sections are generally restricted to fragmentary gestures, each of the melodic lines in Section III explores a relatively long-range dramatic arc. This feature allows each line to develop its own narrative, involving dynamics of motion and stasis, registral and dynamic contours, and degrees of various kinds of tension. In addition to this self-referential quality, each phrase engages and develops external materials. For example, the alternation between a stopped pitch and a fingered harmonic that is found on the last beat of m. 266 in the violin melody, though originating from similar tremolos that appear throughout the work, is here isolated as a motivic element, forming connections with other leaps found in the melody. This motive is subsequently adopted by the viola and cello lines, each of which presents the idea in a different way.

The connections between the three lines extend beyond their motivic links. The melodies are similar in many ways, but in their variations they form subtle relationships to one another that engenders a larger-scale dramatic contour: the opening of the violin melody initiates the passage's forward motion, however its end drifts upwards inconclusively; the viola's transitional utterance collects the fragments left by the violin and prepares for the cello's entrance; the cello finally crystallizes the materials of the previous melodies, offering resolution and closure to the passage. Although similar dramatic interactions can be found in other parts of the work, these are often roughly outlined in fragmentary textures. By delineating a musical narrative through the use of textural stratification, motivic development, and long-range dramatic contours, the melodies of Section III symbolize a conclusive arrival in the piece's journey towards musical semantic organization.

3.9.3 Speech Fragments

Another symbol of the construction of semantic meaning is expressed by a flute technique in which syllables are the forcefully whispered into the instrument. This technique is first heard in m. 38, appears periodically in Sections I and II, and grows to be a prominent element in Section III. The articulation of syllables such as "te" and "ke" can be heard as natural extensions of both standard double-tonguing technique and playing with a breathy tone or blowing through the flute. The other syllables that are used ("she", "se" and "fe") will grow out of this family of sounds, presenting a region of ambiguity between techniques used to produce flute sounds and spoken syllables. As the flute employs this technique with increasing frequency towards the end of the piece, the syllables used tend more and more to suggest fragments of speech. At the conclusion of the work (mm. 315-317), the other players in the ensemble will join the flutist in whispering these syllables, but whereas the flutist's utterances are mediated by an instrument, the other players will enunciate them directly. In this thread of activity, the non-representational sound of the flute gradually transforms into the components of speech, reflecting the piece's overall tendency towards musical semantics. It is significant that this progression stops short of combining syllables into words, since the introduction of explicitly referential elements would disrupt the aesthetic of the work.

CHAPTER 4: Summary

In developing the conceptual foundations for this thesis, a number of characteristic philosophical issues that appear to be inherent in the spectral compositional approach were identified and examined, as detailed in sections 2.1-2.3 above. By explicitly engaging these concepts in both pre-compositional and compositional procedures, I sought both to provide a new interpretation of the existing works of the genre, and to carry spectral concepts into little-explored territory for future musical endeavors. Furthermore, my aim was to elucidate the dynamics of the spectral approach for the listener, in order to reveal what I find to be compelling ideas, awareness of which provides an added dimension of significance to the appreciation of this music.

Elucide attempts to stimulate the listeners' perceptual faculties, thereby revealing aspects of aural experience of which they may have been unaware. Beyond developing an interesting and attractive aural surface, the piece aims to elucidate aural connections between acoustic phenomena and the musical structures, fostering the listeners' understanding of conceptual underpinnings of spectralism. While a focus on perceptually-oriented facets represents a significant aspect of the work, I felt it was equally important that the work draw connections with deeper philosophical concepts. Since the spectral approach inherently invokes a symbolic dimension, I decided to engage this aspect directly, employing guiding metaphors from the philosophy of science related to perception and the construction of meaning from sensory information. By drawing upon works by philosophers such as Quine, whose ideas permeate an extensive variety of disciplines, this thesis addresses issues that are of broad significance to contemporary culture and that are representative of the current social condition.

More specifically, this thesis aims to reflect trends in contemporary musical culture that are distinct from antecedent practices. Whereas early spectral pieces (and other works of that period) tend to adopt an essentially singular aesthetic position, the current musical climate is conducive to a subtle, fluid integration of a variety of stylistic influences. Although *Elucide's* stylistic profile is relatively unified, the work's principal goal is to guide listeners between perceptually- and semantically-oriented musical situations, so that they might become aware of the variety of listening postures that are available to them. The piece's main concern therefore lies in the tension found between the perceptual and semantic realms; by traversing this dialectic, the work explores the relationships between external phenomena and our perception and understanding, in an investigation of the nature of musical significance.

On a practical level, the OpenMusic patches that I developed in the creation of this thesis offer a set of modular tools to the spectral composition community. My goal in developing these tools was to enrich and support my compositional process, and to facilitate the realization of the colourful and evocative musical textures I sought to create. The patches were designed to be an open system, so that little of the resultant music is determined by mechanical processes; instead, the focus of the patches is on assisting the composer in an exploration of sound, providing a kind of sonic microscope with which to explore the rich inner beauty of sonic materials.

CHAPTER 5: Score of *Elucide* for Chamber Orchestra

Elucide

for chamber orchestra
(2006)

David Litke

Composed for the Ensemble Contemporain de Montréal as part of its Génération 2006 project.

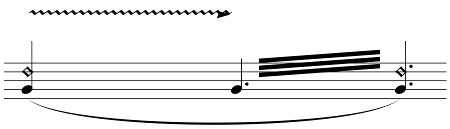
Instrumentation

Flute
B♭ Clarinet
Horn in F
Trombone
Percussion: vibraphone, crotales (upper octave), two suspended cymbals (small and large), bow (for use with vibraphone, crotales, and cymbals,) snare drum, large tom, bass drum, indian ankle bells, egg shaker
Piano (with chalk for marking nodes for harmonics)
Violin
Viola
Cello
Bass

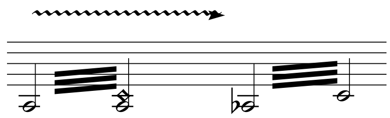
Duration: approx. 17’ 30”

Elucide

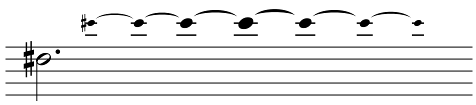
Performance Instructions



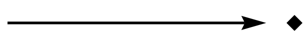
- Gradually introduce an oscillation in the pressure of the fourth finger, until the final tremolo is obtained.



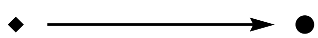
- Gradually increase motion of the oscillating finger until the final tremolo is obtained.



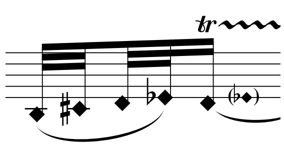
- Gradually bring in and fade out other notes in multiphonic.



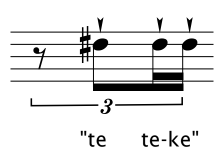
- Make a transition from a pure tone to a breathy tone.



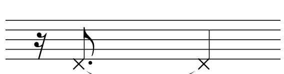
- Make a transition from a breathy tone to a pure tone.



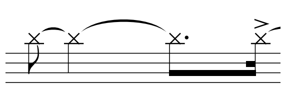
- Play with a very breathy tone, fingering the indicated pitch.



- Articulate each note by forcefully whispering the indicated syllable.

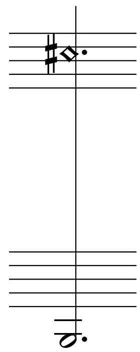


- Brass: blow through instrument, fingering the notated pitch.

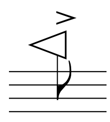


- Strings: mute string at indicated pitch.

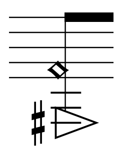
(continued)



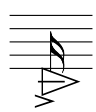
- Piano: fingered harmonic; the upper pitch denotes the predominant sounding pitch, the lower note is the key which is played. Mark the node location on the string with chalk prior to performance. There are four harmonics required for the piece: on the B1 string, C#5 and D#5; on the A1 string, D# 5 and B4.



- Flute: jet whistle.



- Flute: jet whistle followed by tongue ram. Upper pitch denotes fingered note, lower note head is sounding pitch of tongue ram.



- Clarinet: tongue slap.

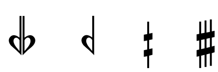
timbral variations

- Flute: alter mouth position and/or fingerings to produce a rapid, random series of timbral fluctuations.

- Gradually increase the width of vibrato.

ext. flaut.

- Extremely flautando; very light bow pressure, far over the fingerboard.



- Microtonal accidentals: ¾ tone flat, ¼ tone flat, ¼ tone sharp, ¾ tone sharp.

Elucide

Score in C ♩= 66

David Litke

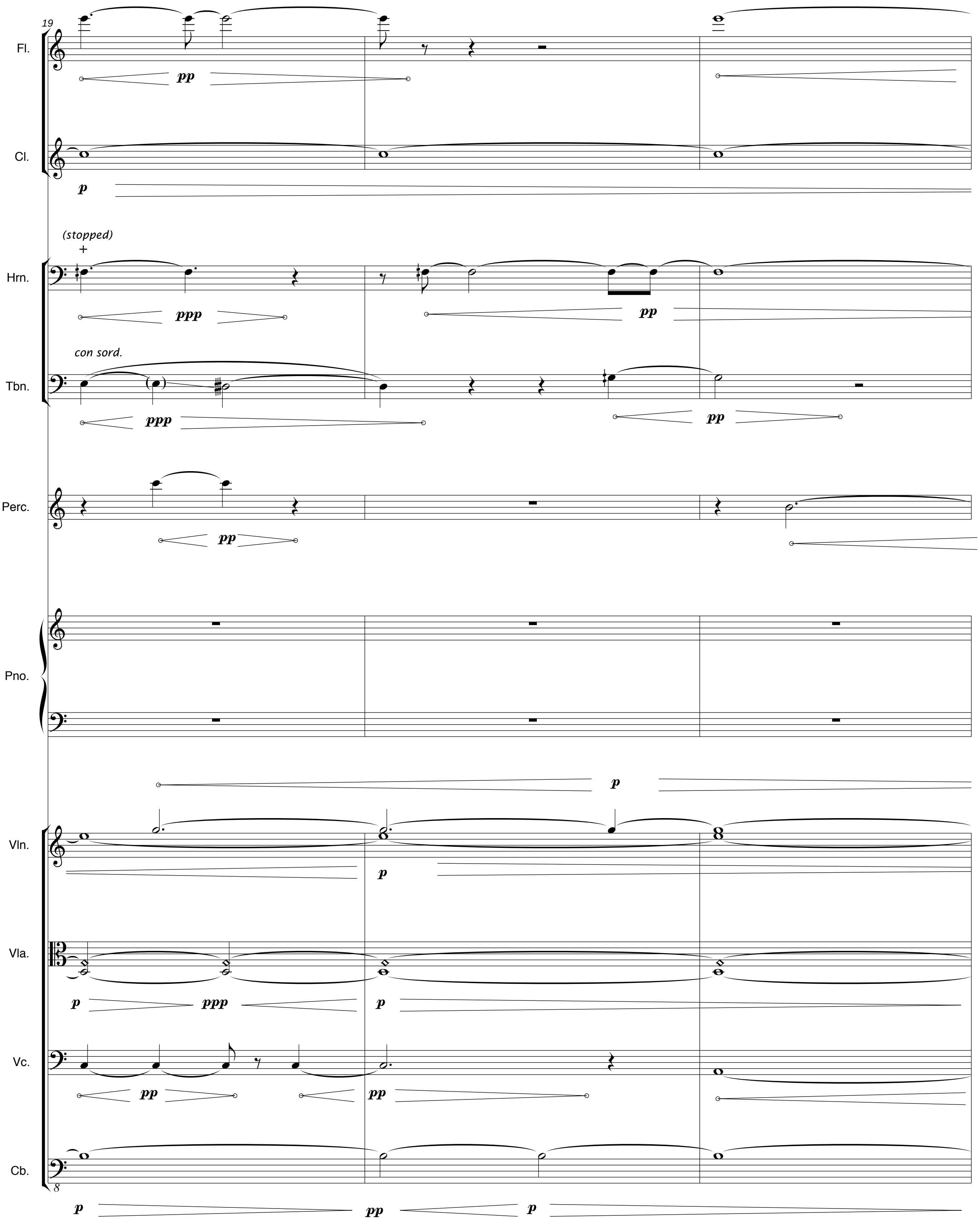

4
Fl.
ppp
Cl.
pp
Hrn.
Tbn.
Perc.
Pno.
Vln.
p
Vla.
p
Vc.
ppp
Cb.
pp
pp

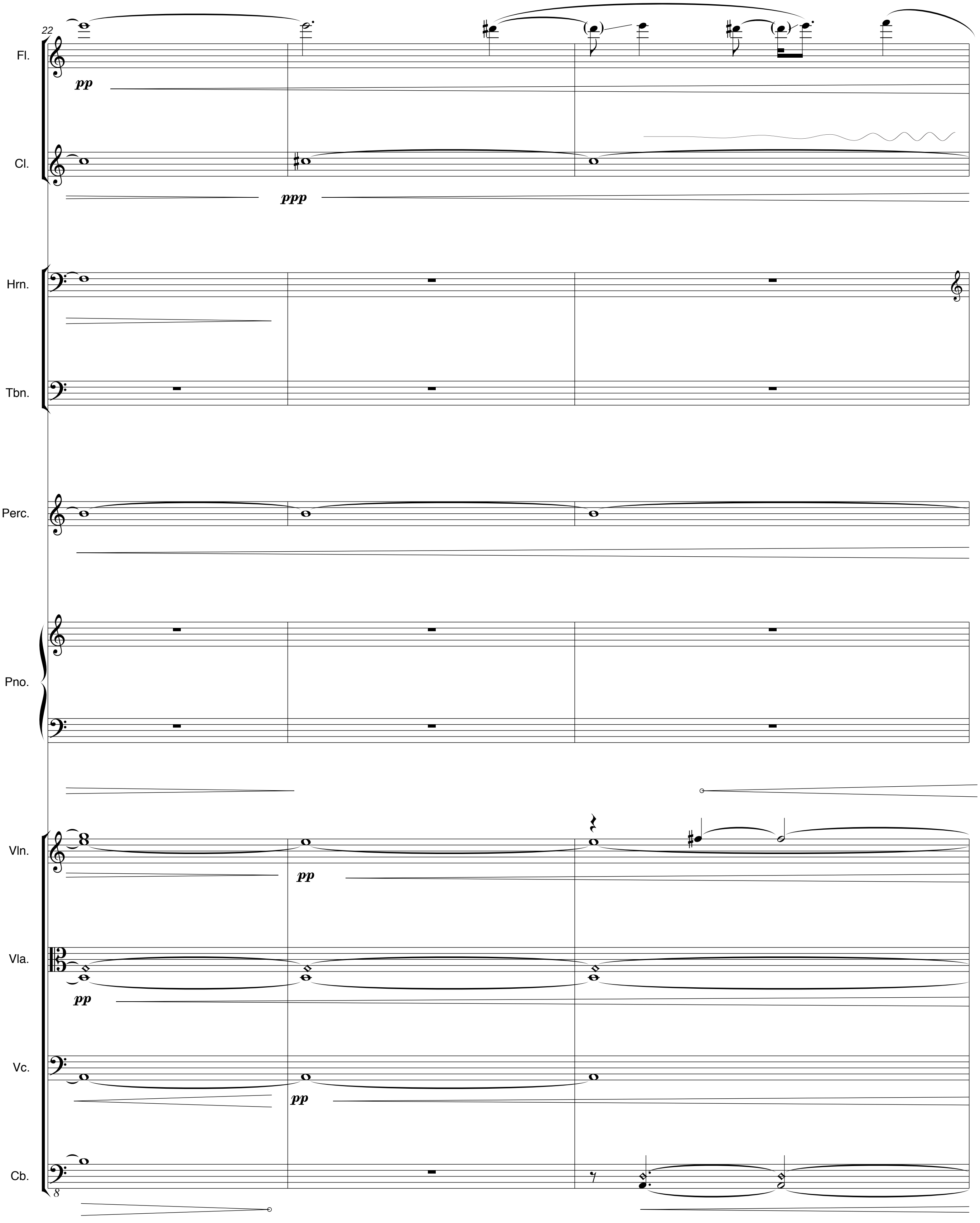

7
Fl.
ppp
pp
Cl.
pp
Hrn.
Tbn.
vibraphone
arco
Perc.
ppp
ppp
Pno.
Vln.
pp
Vla.
mp
p
mp
Vc.
ppp
pp
pp
Cb.
8
pppp
p
ppp


10
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
pp
mf
p
mp
ff
sul pont.
ext. flaut.
sub. p
tr
ppp


13
Fl.
Cl.
pp
Hrn.
Tbn.
Perc.
ppp
Pno.
Vln.
p
Vla.
p
Vc.
pp
Cb.
ppp
pp
p


16
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
pp
p
ppp
pp
p
ppp
pp
ppp
p
ppp
p
pp


19
Fl.
pp
Cl.
p
(stopped)
+
Hrn.
ppp
pp
con sord.
Tbn.
ppp
pp
Perc.
pp
Pno.
p
Vln.
p
Vla.
p
ppp
p
Vc.
pp
pp
Cb.
8
p
pp
p


22
Fl.
pp
Cl.
ppp
Hrn.
Tbn.
Perc.
Pno.
Vln.
pp
Vla.
pp
Vc.
pp
Cb.


Fl.
Cl.
(allow pitch alteration)
Hrn.
con sord.
(harmon mute)
Tbn.
crotales
Perc.
Pno.
sul G
Vln.
sul pont.
Vla.
sul G
sul A
sul pont.
Vc.
flaut.
Cb.


28
Fl.
Cl.
pp
Hrn.
senza sord.
Tbn.
Perc.
ppp
pp
Pno.
f
Vln.
pp
ppp
ord.
Vla.
p
ord.
Vc.
ord.
Cb.
pp


31
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
mf
mp
f
pp
3


35
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
tr
mp
p
pp


38
Fl.
"te te-ke"
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
sul tasto
ord.
Vla.
flaut.
Vc.
flaut.
Cb.
flaut.


41
Fl.
mp
p
mf
3
Cl.
cresc.
mf
Hrn.
mp
mp
Tbn.
3
mp
mp
Perc.
Pno.
Vln.
cresc.
mf
ord.
Vla.
cresc.
mf
Vc.
cresc.
3
6
5
mf
Cb.
cresc.
3
mf


44
Fl.
Cl.
Hrn.
Tbn.
crotales
snare drum (covered)
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.


47
Fl.
Cl.
Hrn.
Tbn.
vibraphone ord.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.


50
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
snare drum (covered)
ankle bells
8va
sul pont.
ord.
ricc.
tr
mf
mp
p
pp
f


53
Fl.
Cl.
Hrn.
Tbn.
Perc.
crotales arco
with stick
Pno.
Vln.
Vla.
Vc.
Cb.

57
Fl.
Cl.
Hrn.
Tbn.
vibraphone
arco
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
sul A
sul D
sul G
flaut.
p
mp
pp

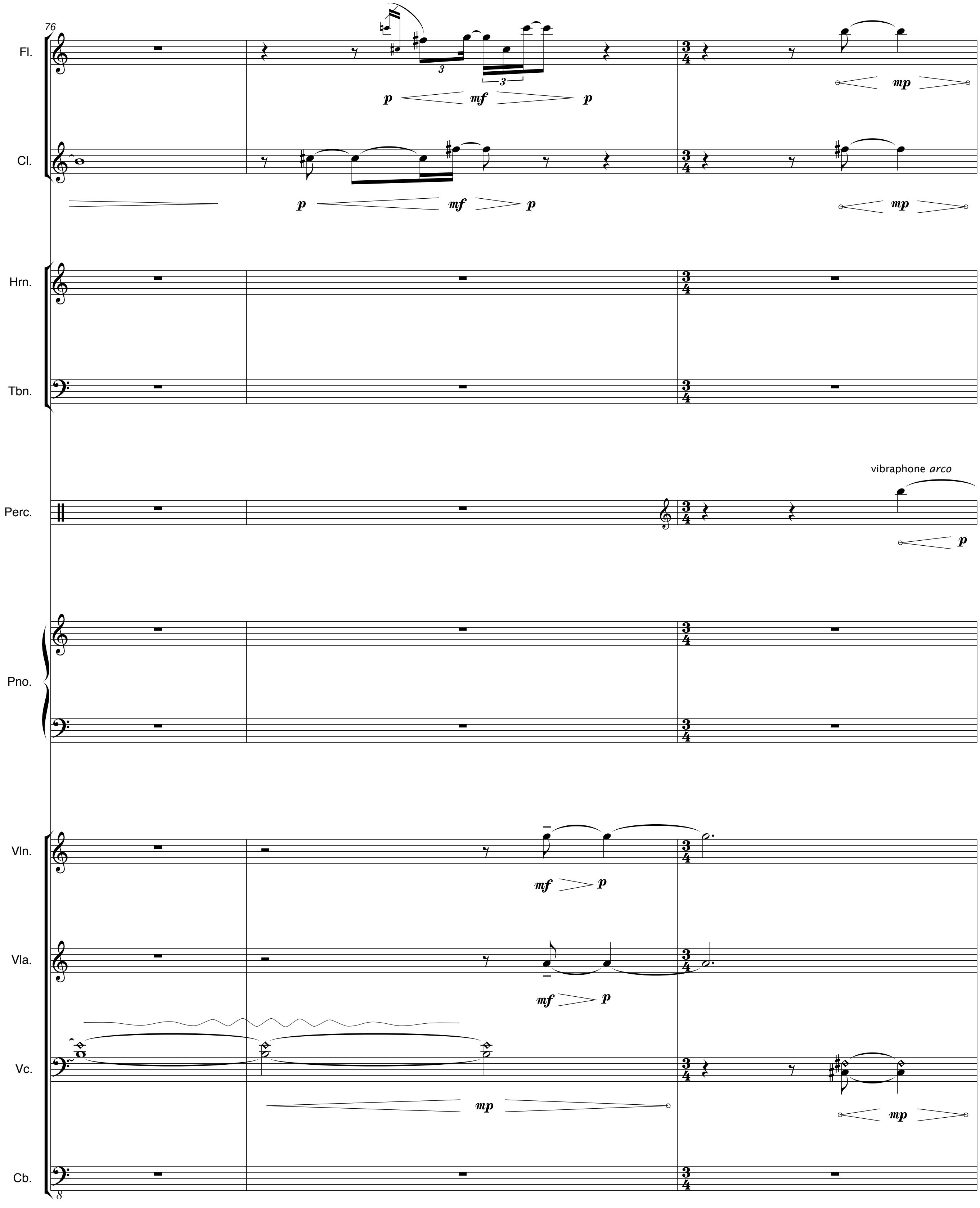

60
Fl.
Cl.
Hrn.
con sord.
(harmon mute)
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.


63
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
pp
mp
mf
p
bass drum


66
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
snare drum
large cymbal
f
mp
mf
p
ff

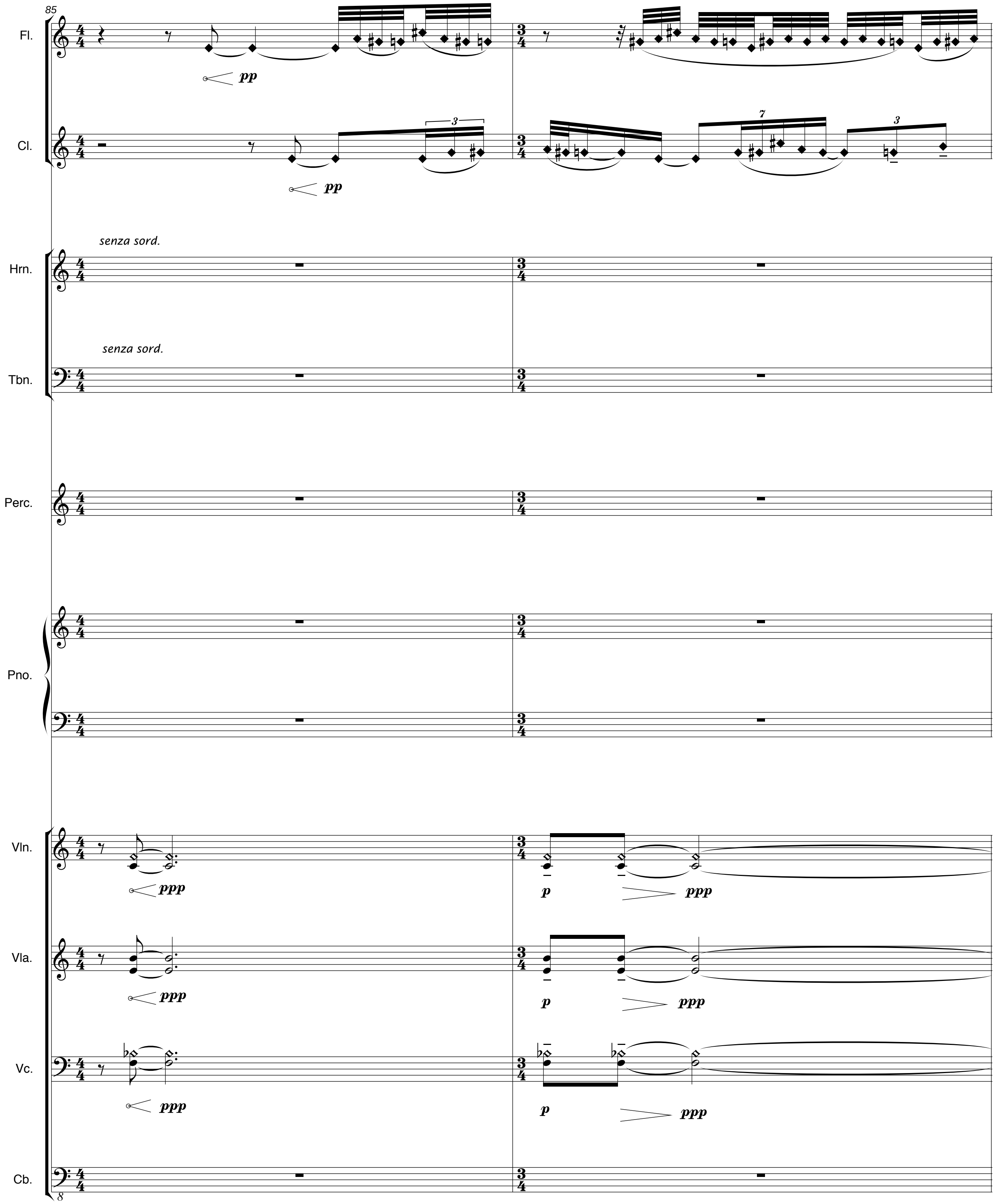

69
Fl.
Cl.
Hrn.
Tbn.
bass drum
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.


72
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
pp
pp
mf
sul pont.
ord.
mf
mp
pp
pp
mp
ppp


76
Fl.
Cl.
Hrn.
Tbn.
vibraphone arco
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.


79
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
sul pont.
ord.


82
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
con sord.
(straight mute)
con sord.
(straight mute)
sub. p
pp
p
mp
mf
f
ff


85
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
senza sord.
senza sord.
pp
pp
ppp
p
7
3


87
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
p
ppp
pp
mf


90
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
mp
p
mf
pp


93
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
sul pont.
ord.
ricc.
sul pont.
col legno


96
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
ord.
Vc.
Cb.


99
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
p


102
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
sul tasto
sul tasto
ord.
ord.
pp


105
Fl.
Cl.
Hrn.
Tbn.
vibraphone arco
Perc.
ppp
pp
3
5
ppp
p
pp
ppp
Pno.
Vln.
Vla.
Vc.
Cb.

108
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
p
pp
mp
p
mp
ppp
ppp


112
Fl.
Cl.
Hrn.
Tbn.
Perc.
p
Pno.
Vln.
p
Vla.
p
Vc.
p
Cb.


115
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
p
pp
ppp
ankle bells
(roll gently in hands)

119
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
5
flautando
sul pont.


timbral variations
122
Fl.
Cl.
Hrn.
Tbn.
small cymbal
arco
Perc.
Pno.
sul pont.
ord.
Vln.
Vla.
ord.
Vc.
Cb.


125
Fl.
Cl.
Hrn.
Tbn.
snare drum
vibraphone
snare drum
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.

128
timbral variations
Fl.
Cl.
Hrn.
Tbn.
crotales
arco
Perc.
Pno.
ricc.
Vln.
Vla.
Vc.
Cb.


131
Fl.
sub. p
5
3
Cl.
p
3
Hrn.
sub. p
Tbn.
Perc.
Pno.
p
3
Vln.
p
Vla.
sub. p
3
Vc.
p
Cb.
8
p
3


134
Fl.
cresc.
mf
Cl.
cresc.
5
3
mf
Hrn.
Tbn.
Perc.
Pno.
cresc.
Vln.
cresc.
mf
Vla.
cresc.
mf
Vc.
cresc.
mf
Cb.
8
cresc.
mf


137
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
sub. p mf p
large cymbal
arco
mf
mf
sub. p mf
p
f
p
sub. p mf
p
mf


140
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
cresc.
mp
p
cresc.
cresc.


143
Fl.
Cl.
mf
Hrn.
Tbn.
Perc.
8va
Pno.
mf
Vln.
Vla.
Vc.
Cb.


146
Fl.
Cl.
Hrn.
Tbn.
snare drum - rim
- head
- side
Perc.
mp
8va
Pno.
Vln.
Vla.
Vc.
Cb.


149
Fl.
Cl.
Hrn.
Tbn.
Perc.
(cover snare)
f
8va
Pno.
ff
mp
Ped.
Vln.
mp
Vla.
mp
Vc.
mp
Cb.
mp
pp
pp


152
Fl.
Cl.
Hrn.
Tbn.
snare drum (covered)
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.


155
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
ppp
p
pp
mp
con sord.
sul pont.
ord.


159
Fl.
Cl.
pp
senza sord.
Hrn.
senza sord.
Tbn.
large cymbal arco
Perc.
p
Pno.
sul pont.
Vln.
mp
sul pont.
Vla.
mp
Vc.
sul pont.
ord.
Cb.
f
pp
p
mp
p


162
Fl.
Cl.
Hrn.
Tbn.
crotales
arco
Perc.
small cymbal
(soft mallets)
Pno.
ord.
Vln.
ord.
Vla.
Vc.
Cb.


165
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
pp
p
bass drum
mp
mf
sul pont.
ord.
3

168
Fl.
Cl.
Hrn.
Tbn.
ankle bells
(roll in hand)
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.

171
Fl.
Cl.
Hrn.
Tbn.
vibraphone
Perc.
Pno.
Vln.
Vla.
Vc.
sul pont.
ord.
Cb.
sul pont.


174
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
tr
tr
ankle
bells
(shake)
large cymbal
ord.


177
Fl.
Cl.
Hrn.
Tbn.
Perc.
mp
Pno.
Vln.
Vla.
Vc.
3
Cb.
3
sub. mp
f

180
Fl.
Cl.
Hrn.
Tbn.
snare drum (uncovered)
- rim
- head
- side
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
arco


183
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
p
mp
pp


186
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
mp
mf
p
f


189
Fl.
Cl.
Hrn.
Tbn.
snare drum - rim
- head
- side
Perc.
Pno.
Vln.
sul pont.
ord.
Vla.
sul pont.
ord.
Bartok pizz.
arco sul pont.
Vc.
ord.
Bartok pizz.
arco
Cb.


192
Fl.
Cl.
Hrn.
Tbn.
vibraphone
arco
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
pp
mf
mp
p


195
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
pp
mf
tr
mf
mp
pp
p


198
Fl.
Cl.
Hrn.
Tbn.
vibraphone ord.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.


201
Fl.
Cl.
Hrn.
Tbn.
crotales
Perc.
Pno.
cresc.
Ped.
Vln.
Vla.
Vc.
Cb.


204
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
mp
f
p
mf
pp
low tom
sul pont.
ord.

206
Fl.
Cl.
Hrn.
Tbn.
vibraphone
Perc.
Pno.
Vln.
sul pont.
ord.
Vla.
Vc.
Cb.


209
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.


212
Fl.
Cl.
Hrn.
Tbn.
small cymbal
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.


215
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
sul pont.
ord.


218
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.


221
Fl.
p f
Cl.
p f
Hrn.
mf f
Tbn.
mf f
Perc.
Pno.
f
6
3
5
3
mp
Vln.
5
f
Vla.
5
f
Vc.
3
3
mf f
Cb.
3
mf f


224
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.


227
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
f
mp
f
p
p
mp
mp
mp


229
overblow
Fl.
Cl.
Hrn.
Tbn.
snare drum - rim
- head
- side
Perc.
Pno.
detache
bow with excessive pressure
sul pont.
Vln.
Vla.
Vc.
arco
Cb.


232
Fl.
Cl.
Hrn.
Tbn.
Perc.
Toms: - high
- low
Pno.
Vln.
ord.
Vla.
ord.
Vc.
Cb.

235
Fl.
Cl.
Hrn.
Tbn.
Perc.
ff
Pno.
ff
f
3
5
Vln.
sul pont.
p
mf
6
Vla.
sul pont.
p
mf
Vc.
sul pont.
p
mf
Cb.
Bartok pizz.
ff
p
mf


237
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
ord.
ord.
ord.
sul pont.


239
Fl.
Cl.
Hrn.
con sord.
(harmon mute)
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.


242
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.


245
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
mp
pp
mp
pp p pp p
p
mp
p
mp
p
mp p
flaut.
p
p
mp
p


248
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
p
pp
ppp


250
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
mp p mf p
mp
p mp p
mf p


252
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
mf
mf


254
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
p
mf
Vln.
sul tasto
Vla.
sul tasto
Vc.
sul tasto
Cb.


256
Fl.
Cl.
Hrn.
Tbn.
Perc.
vibraphone
Pno.
Vln.
ord.
sul pont.
Vla.
ord.
Vc.
ord.
Cb.
ord.


259
Fl.
Cl.
mp
Hrn.
Tbn.
Perc.
Pno.
ppp
p
Ped.
ord.
Vln.
p
Vla.
Vc.
Cb.


262
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
"te ke
ankle bells
(roll in hand)
(shake)
sul pont.


265
Fl.
te ke"
Cl.
Hrn.
Tbn.
egg shaker
crotales
arco
Perc.
Pno.
sul pont.
ord.
Vln.
Vla.
Vc.
Cb.


268
Fl.
pp
Cl.
p
Hrn.
Tbn.
vibraphone
Perc.
p
Pno.
pp
Vln.
mf
sul tasto
Vla.
p
mf
Vc.
Cb.


271
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
pp
mf
"te she ke te"
p
mp
p
ricc.
mp
p
mp
p


274
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
ord.
pizz.
arco


277
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
sul tasto
sul tasto


279
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
tr
p
pp
mp
ord.


282
Fl.
" she ka te ke ta fe"
mf
Cl.
Hrn.
Tbn.
Perc.
Pno.
ord.
Vln.
pp
Vla.
pp
Vc.
pp
Cb.
pp


285
Fl.
pp
p
Cl.
pp
p
Hrn.
Tbn.
Perc.
Pno.
3
mp
3
Vln.
sul tasto
Vla.
3
p
3
pp
sul tasto
6
6
6
Vc.
sul tasto
pp
Cb.
sul tasto
8


288
Fl.
mf
"she te ke she fe te"
p
Cl.
mp
mf
mp
mf
p
con sord.
Hrn.
p
mp
pp
con sord.
Tbn.
p
mp
pp
small cymbal (soft mallets)
Perc.
Pno.
Vln.
p
ord.
Vla.
p
mf
ord.
Vc.
p
mf
Cb.


291
Fl.
"she fe"
Cl.
Hrn.
Tbn.
ankle bells
(shake)
Perc.
Pno.
sul pont.
ord.
Vln.
Vla.
Vc.
ord.
Cb.


294
Fl.
Cl.
Hrn.
Tbn.
vibraphone arco
Perc.
p
Pno.
ricc.
Vln.
p
Vla.
mp
Vc.
pp
p
ricc.
Cb.
pp


296
Fl.
mf
"she ke te ke"
"fe te"
Cl.
pp
mp
pp
Hrn.
Tbn.
small cymbal
(soft beater)
egg shaker
Perc.
pp
Pno.
pp
Vln.
p
ricc.
sul pont.
Vla.
sul pont.
pp
Vc.
ricc.
pp
Cb.


299
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
p
p
mp
sul pont.
3
6
3
3


302
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
mf
"te ke te she ke"
vibraphone
arco
pp
large cymbal
pp
sul pont.
sul tasto
pp
mp
p
mp
pp
sul tasto
ord.
ppp
p
ppp
p
pp
mp


305
Fl.
Cl.
Hrn.
Tbn.
Perc.
vibraphone
arco
Pno.
Vln.
ord.
Vla.
Vc.
Cb.


308
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
vibraphone - soft mallets
sul tasto
ord.
sul tasto
ord.


311
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
p
pp
mf


314
Fl.
Cl.
Hrn.
Tbn.
Perc.
Pno.
Vln.
Vla.
Vc.
Cb.
whisper (without instrument)
"te te ke she se te ke fe ke te ke te ke fe she ke"
"she te ke se fe te"
"ke se she te fe ke"
ankle bells (roll in hand)
small cymbal
damp cymbal
whisper
"se ke fe she ke"
"se ke te she se"

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Appendix I: Spectral Sources - Derivation Process and Results

The first part of this Appendix details the process by which the spectral data used in *Elucide* was extracted from sound files, and the second part lists the data obtained through this process.

Process of Extracting Spectral Information

After creating a digital recording of a selected sound, I use the program "AudioSculpt" to generate an FFT analysis of the sound. A further analysis is performed with AudioSculpt to identify the most significant and stable partials in the sound file. Although OpenMusic is capable of performing spectral analyses, AudioSculpt's clear visual representation of FFT data facilitates the adjustment of analysis parameters while gathering spectral data. Figure 9-1 shows a visual representation of an FFT of PnoHrmBC#, in which the x axis represents time, the y axis represents frequency, and the contrast values of points in the graph represent the level of energy. The horizontal lines on the graph in Figure 9-1 thus represent the constituent partials of the PnoHrmBC# spectrum; dark lines that extend throughout the sample represent the most prominent and stable partials, while the light lines that appear only near the beginning of the sample represent weak, transient partials. A waveform representation of the sound file appears at the top of the AudioSculpt window, aligned with the FFT depiction; it can therefore be seen that the attack point of the sound generates an outburst of noise, shown as energy in all frequency regions, after which point the sound both decays in amplitude and settles into stable oscillation. That the prominent partials appear evenly spaced in this graph indicates that the sound is harmonic (the frequency of each of the stable partials is an integer multiple of the fundamental frequency); however, since many of the upper partials appear darker than would ordinarily be expected in an ordinary piano note, it can be seen that the natural spectrum of this piano string has been altered to reveal higher components, a result of touching a node on the string.

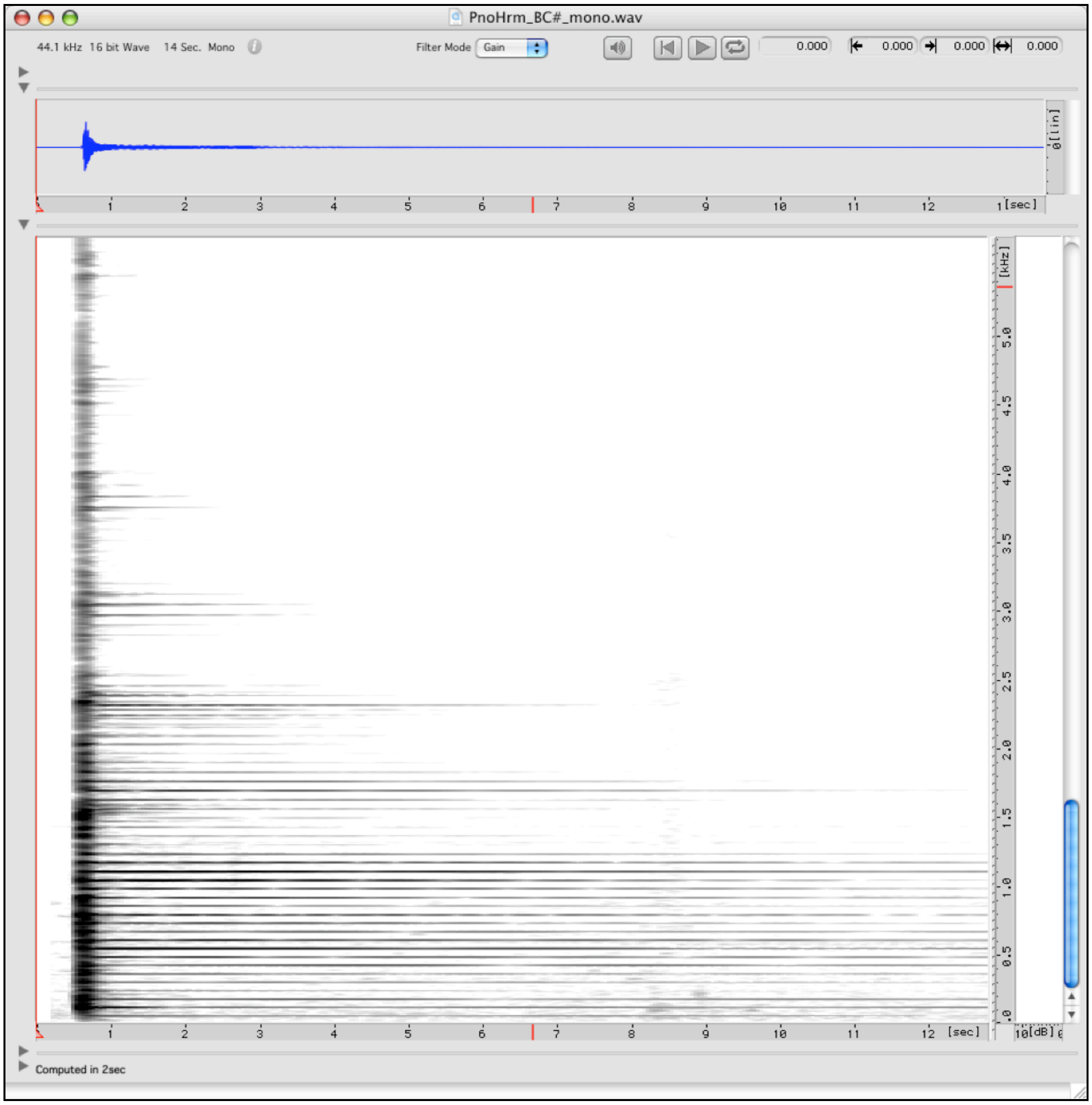


Figure 9-1. A visual representation of an FFT of PnoHrmBC#.

Figure 9-2 shows a partial tracking analysis that has been performed on the FFT in Figure 9-1. Analysis parameters can be adjusted in order to produce an analysis that is sufficiently detailed, yet removes data concerning components that are too weak or transient to be useful.

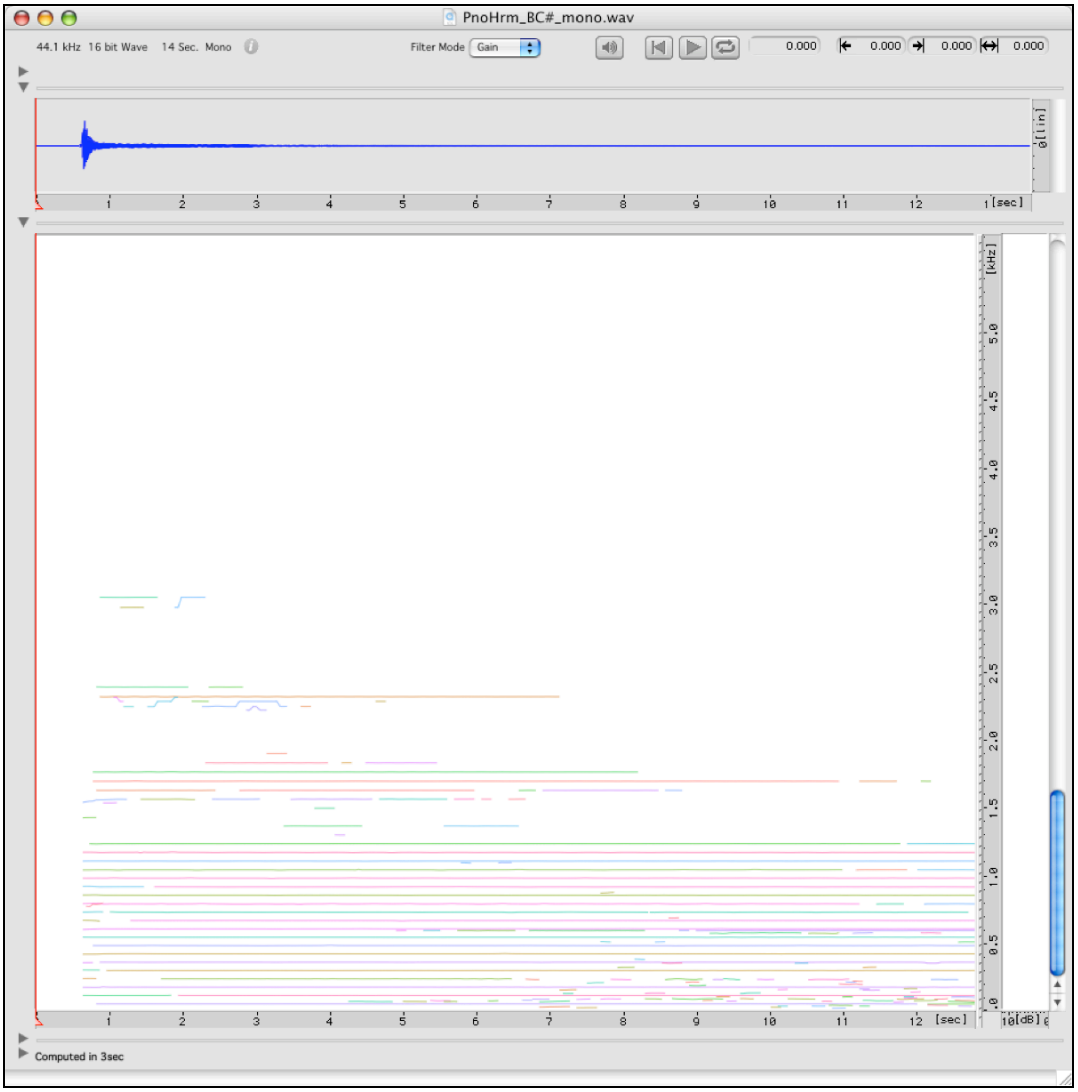


Figure 9-2. A partial tracking analysis applied to the FFT in Figure 9-1.

Once a suitable partial tracking analysis has been performed, the data is exported from AudioSculpt using the SDIF file format. Although these files can be structured to represent a wide variety of analysis data, the partial tracking analysis files used here are structured as three-dimentional matrices that contain the frequency, amplitude, and phase data for each of the partials at a series of temporal positions (as described in section 2.4 above). At each position along the Z axis of the matrix is found a two-dimensional matrix (called a frame) that represents a small temporal segment of the sound file. Each frame contains an n by 4 matrix, where n represents the number of partials that are found in that frame, and each of the four columns contain the partial numbers, frequencies, amplitudes, and phases.

In the OpenMusic workspace SpectRes (developed by the author), the SDIF files can be imported into one of the patches contained in the folder "SDIF Tools." The patch “sdif_getdata” allows the user to examine the raw data contained in the file, however it is generally more useful to covert this data into musical terms. The patch “sdif_midicvel” converts the frequency and amplitude data in each frame into midics (OpenMusic’s representation of pitch, as described in section 2.4) and weighting value (represented by MIDI velocities). Using OM music editors, this data can be displayed in score notation; Figure 10 depicts the contents of the SDIF file containing the partial tracking data from Figure 9-2 on musical staves (the weighting values cannot be accurately displayed in this way, but remain attached to each pitch). Each chord in the sequence represents the contents of a single frame of the SDIF file; the passage in Figure 10 displays some of the 265 frames contained in the 14 second sound file. (In this editor, the top staff sounds two octaves higher than written, and the bottom staff sounds two octaves lower.)

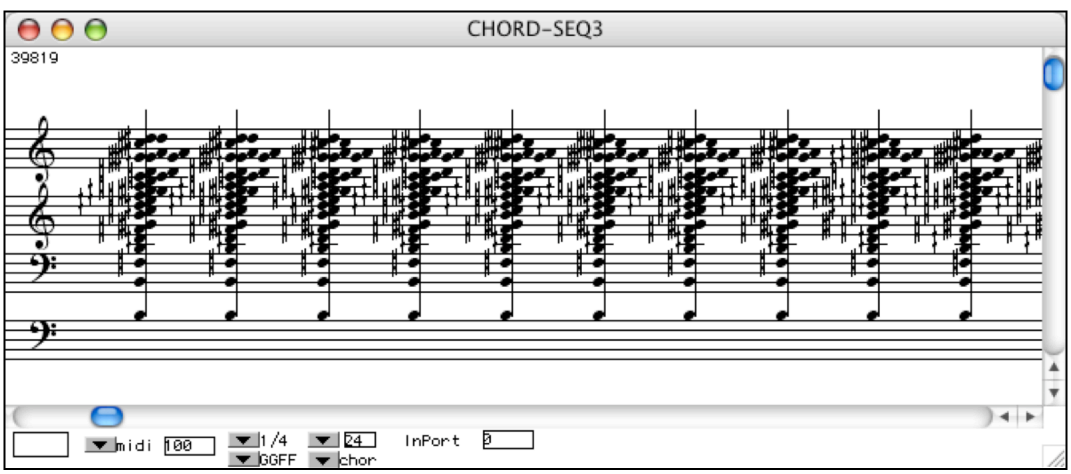


Figure 10. Partial tracking data displayed in musical notation.

In order to better visualize the contents of a particular frame, including weighting values, I developed the patch "sdif project," which projects the pitches into a measure such that the stronger partials appear closer to the left while the weaker ones lie to the right. This method of representation allows the spectral profile of a frame to be easily apprehended, facilitating the selection of suitable spectral materials. Furthermore, by viewing a series of frames in projected in this way, one can get an impression of the general evolution of the spectrum. Figure 11 depicts the projection of a single frame from the chord sequence in Figure 10.

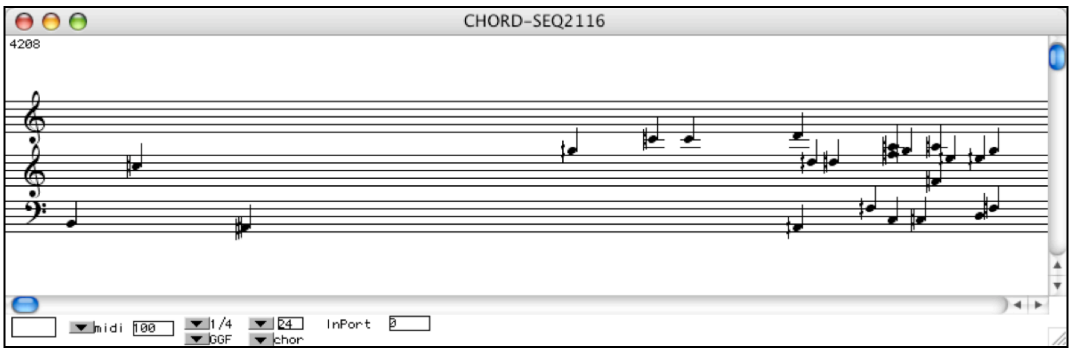


Figure 11. A projection of a single frame of an SDIF file.

Data Obtained from Spectral Sources

Since each partial tracking analysis used in this thesis contains a vast amount of data, it would be impractical to attempt to reproduce all of the information that may have been referenced during the compositional process. However, certain frames from these analyses were of particular focus in the work, and I have here provided a collection of SDIF projections that gives a general overview of the raw harmonic materials upon which the music is based. The abbreviations for source sounds used in Table 1 of section 2.5 above are also used in Table 3.

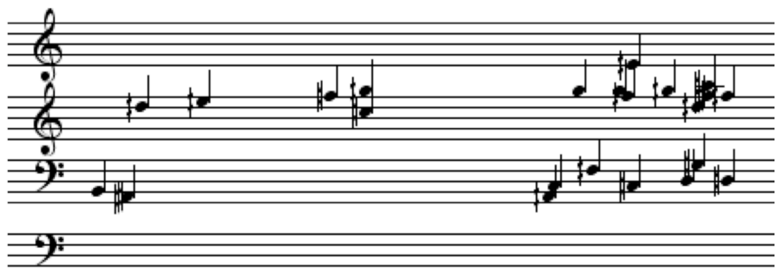
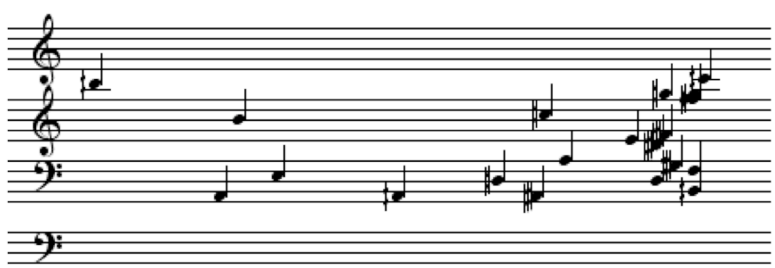
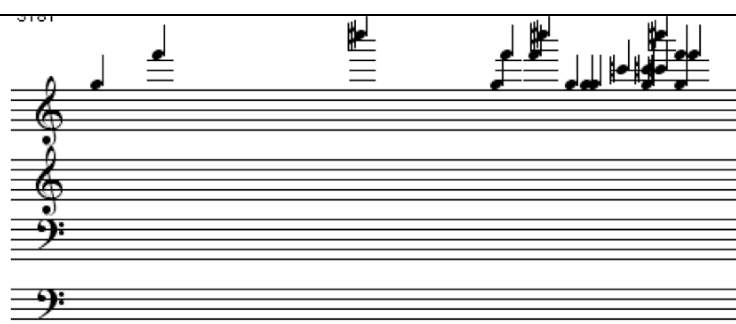
Source Sound	**Frame Projection**
PnoHrmBC#	(see Figure 8 above)
PnoHrmBD#	
PnoHrmAD#	
PnoHrmAB	
Crt	

Table 3. Data from spectral sources (continued on next page).

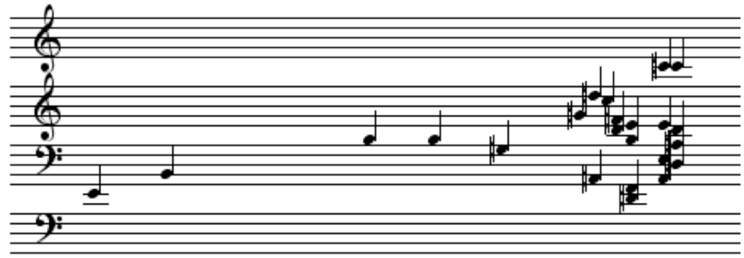
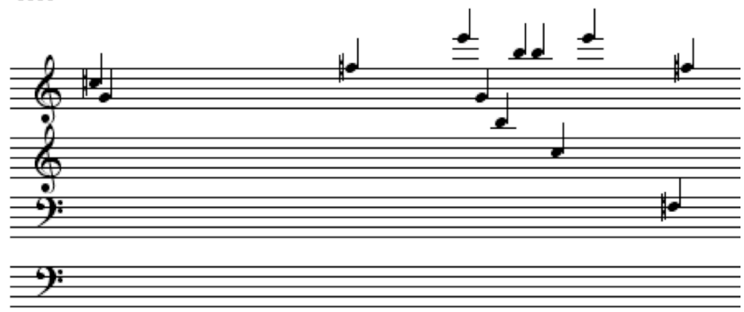
BassE1	
SngBwl	

Table 3 (cont.) Data from spectral sources.

Appendix II: Description of the OpenMusic Workspace "SpectRes"

In order to generate useful pre-compositional material from the spectral data detailed in Appendix I, I developed a modular set of patches that facilitate the inspection and manipulation of the partial tracking data produced by AudioSculpt; I have called the workspace containing these resources for spectral composition "SpectRes". In this workspace are six folders of patches, each containing a group of patches that perform similar tasks. These folders are named "SDIF Tools", "Interpolators", "Partial Extraction", "Chord Sequence Tools", "FHV filters", and "Projectors"; the patches contained in each of these folders are described below.

SDIF Tools

The operation of the patches contained in this folder are detailed in Appendix I above, however the appearance and structure of these patches and of OpenMusic programming in general have not yet been addressed. The outward appearance of the "sdif_project" patch is therefore shown in Figure 12, illustrating OpenMusic's graphical interface.

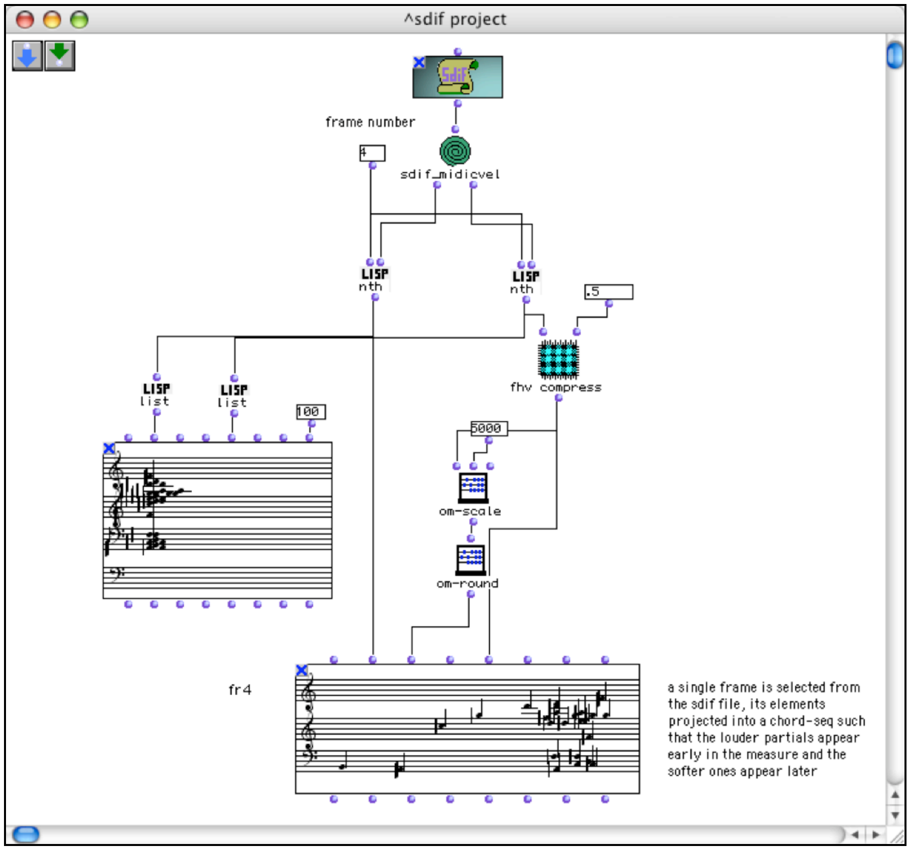


Figure 12. "sdif project": an OM patch from the set of SDIF tools.

In an OpenMusic patch, the programming code is represented by a group of objects that are connected to one another with lines, indicating how data is to be passed between the objects. The objects each perform a particular function on data that they receive, and pass the results of that operation on to other objects. In Figure 12, objects such as those labeled "LISP nth" and "om-scale" are instances of LISP and OpenMusic functions, respectively, and perform fixed operations ("LISP nth, for example, accepts a list of values in one inlet and an integer n in the other, selecting the nth value from the list and sending it to its output.) Objects such as the rectangles containing integers and those containing musical staves allow the patch to receive and display information from the user, respectively, and the rectangle labeled SDIF provides access to an external file. The remaining objects in Figure 12 (the circle labeled "sdif_midicvel" and the square labeled "fhv compress") represent sub-patches that encapsulate other levels of programming, containing other OM and LISP objects as well as other sub-patches. These embedded sub-patches can themselves contain other sub-patches, engendering a nested structure that can be extended as needed. This multi-layered system allows a patch to maintain a clear outward appearance by hiding much of its complexity, however the nested structures of these patches prohibits their complete representation in this document.

Interpolators

The patches in this folder interpolate a series of chords between individual frames of SDIF files and manually created chords. In these interpolations, intermediary amplitude values are generated, but the pitch content of the original chords is not altered. Any pitches that are common between the chords will therefore be maintained throughout the sequence with gradual changes in amplitude. Pitches that are unique to one chord, however, will fade to or from silence in the sequence. Figure 13 shows the patch "chordsdifchord", in which a single pitch was entered as the first chord in the sequence (shown in the rightmost staff), a frame from an SDIF file supplied the mid-point of the interpolation (in the middle staff), and a dyad was entered as the final sonority (in the leftmost staff). The number of chords to be interpolated is specified in the two number boxes found in the lower part of the window.

Two similar patches were created to generate interpolations between two SDIF frames or two chords, respectively. This set of patches was used to create HV sequences for a number of large passages in the piece: Figure 14 shows the HV sequence that was used in composing the texture at the end of Section I-iii (mm. 53-65), and Figure 15 shows the HV sequence that was used at the end of Section I-iv (mm. 128-150). (Since the amplitude values of each pitch cannot be displayed with the score editor, these depictions do not communicate the manner in which pitches gradually fade in and out over the course of the sequence.)

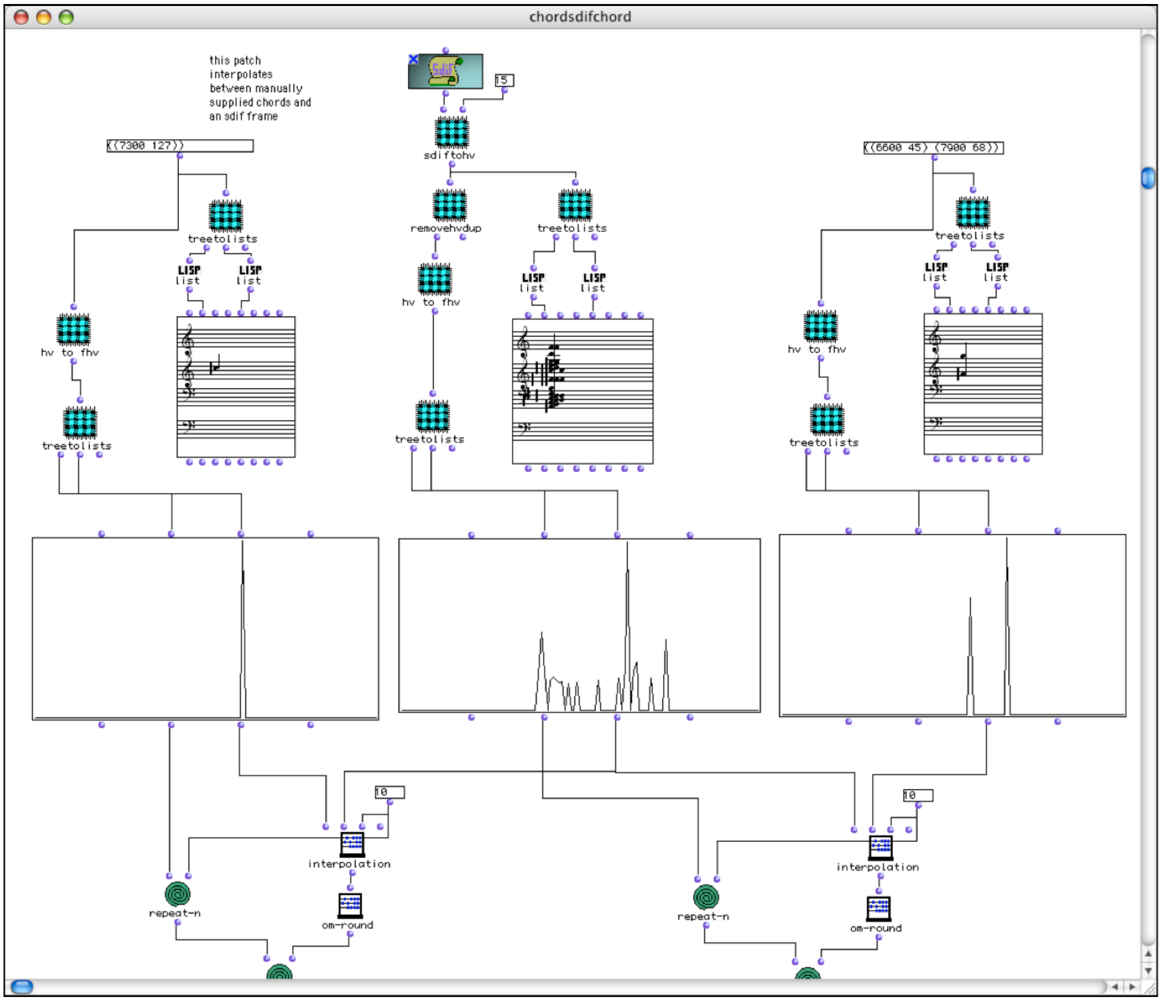


Figure 13. “chordsdifchord”: an OM patch from the set of SDIF tools.

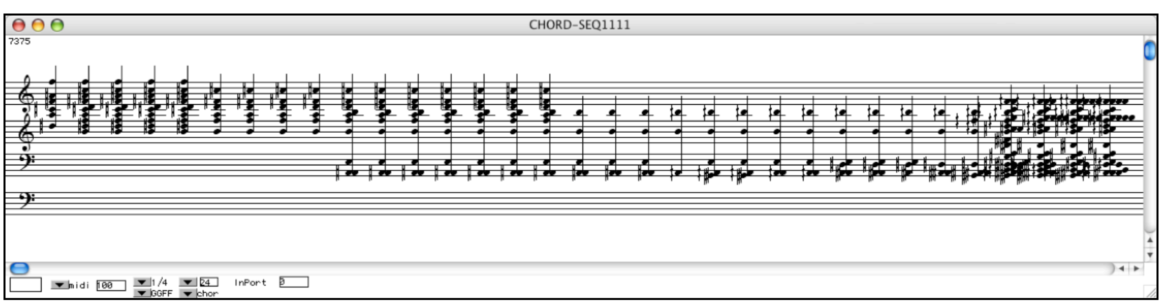


Figure 14. HV interpolation,
used at the end of Section I-iii (mm. 53-65).

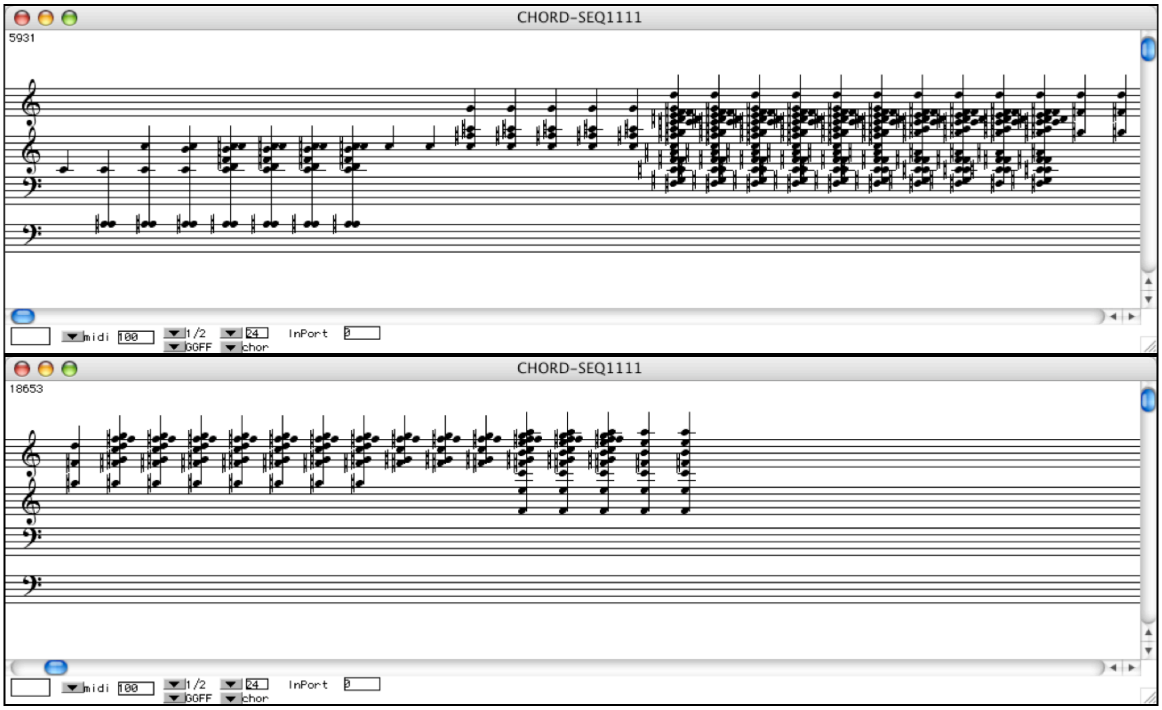


Figure 15. HV interpolation,
used at the end of Section I-iv (mm. 128-150).

Partial Extraction

While the SDIF format encourages a harmonic interpretation of a spectrum, it can be useful to track the evolution of a particular partial over a period of time. Two patches were developed to facilitate a more "horizontal" perspective: "partfrondur" and "partdisplay". The former patch displays the relative onset and duration times for all partials, as shown in Figure 16, whereas the latter patch plots the amplitude envelopes of selected partials. Figure 17 displays a portion of the "partdisplay" patch, in which the curve editors at the right represent the amplitudes of the partials whose pitches are represented in score notation.

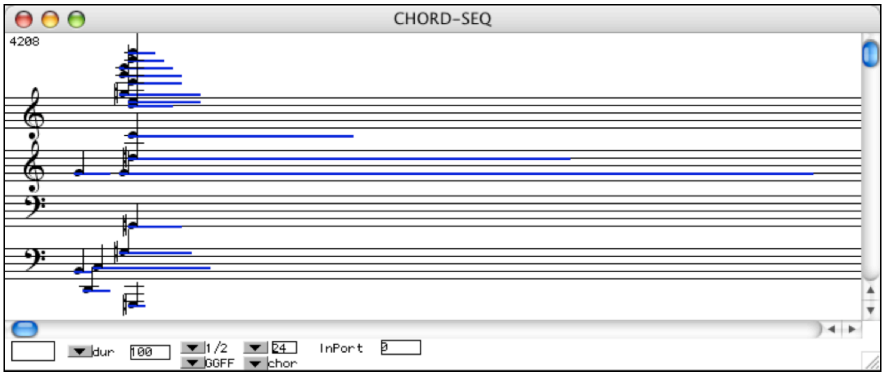


Figure 16. A display of the relative onset and duration times for each partial

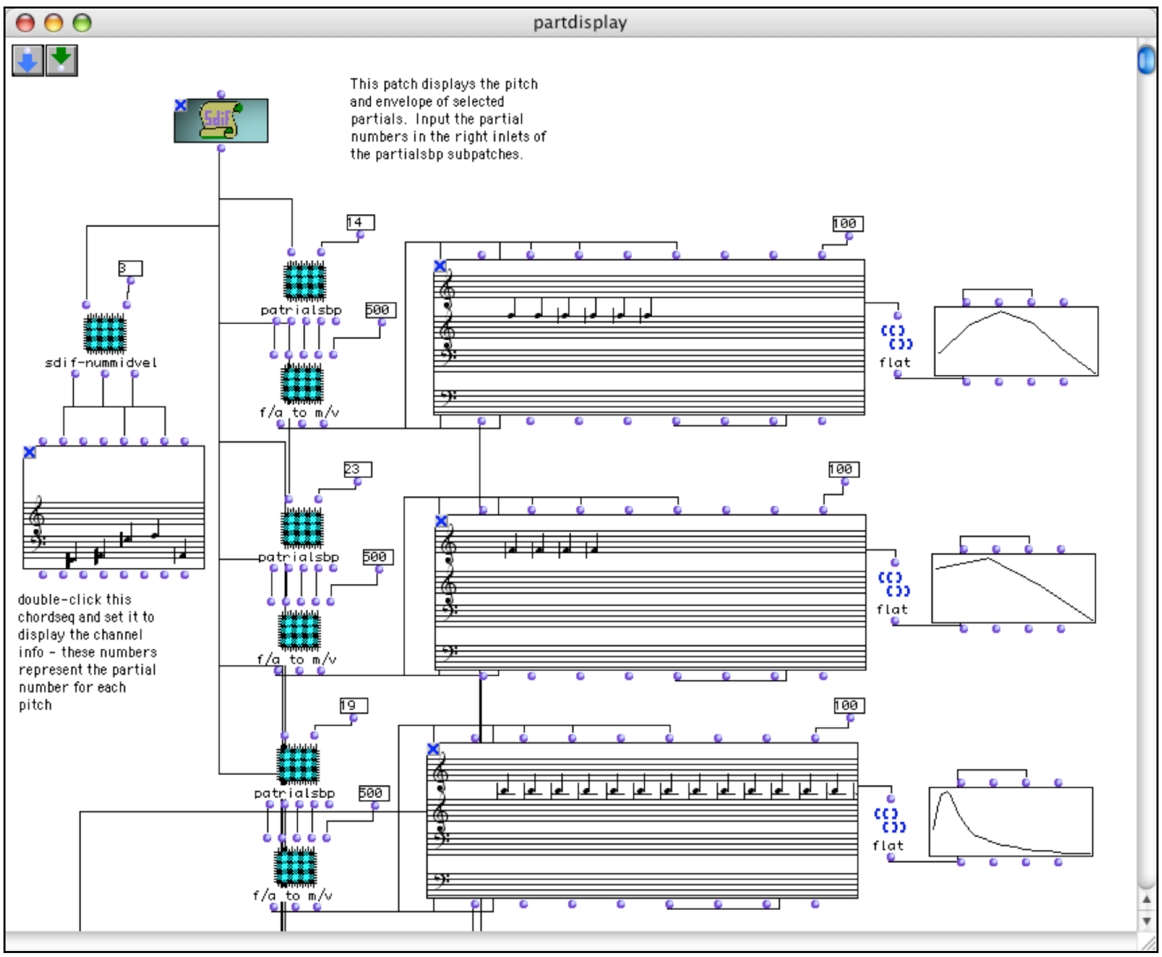


Figure 17. Display of amplitude envelopes for selected partials.

Chord Sequence Tools

A set of tools for manipulating chord sequences have been provided, in order to facilitate the handling of the materials produced by other patches. These tools enable the user to crop and combine sequences, or to thin verbose sequences by removing all but every nth chord. A patch called “chordseq project” performs the same function on chord sequences as “sdif project” does on SDIF frames, and “chordseq gain” is used to adjust all velocity values in a sequence.

FHV Filters

As described in section 2.4 above, HVs can be parsed according to their weighting values. A set of patches called “FHV filters” will repeat a single HV a specified number of times, applying a dynamic filter to the series according to curves set by the user. ("FHV" stands for "full hierarchy vector", and is a re-formatting of an HV so that it can be expressed as a single list of numbers; every MIDI note value is given a weighting, with zeros holding the places of notes that don't appear in the set. Hence, the 60th number in the list represents the weighting for middle C.) Figure 18 depicts one of these patches, in which an HV (in this case taken directly from an SDIF frame) is filtered to remove elements whose weighting values do not fall within the parameters set by the curves set in the editors labeled “low curve” and “high curve.” This process enables the generation of a varied chord sequence, such as that shown in the score editor at the bottom of Figure 18, from a single HV. The other patches in this set are designed to filter HVs and HV sequences from other sources, such as chord sequences generated by other patches. The material found in Figure 2 above was generated using one of these patches.

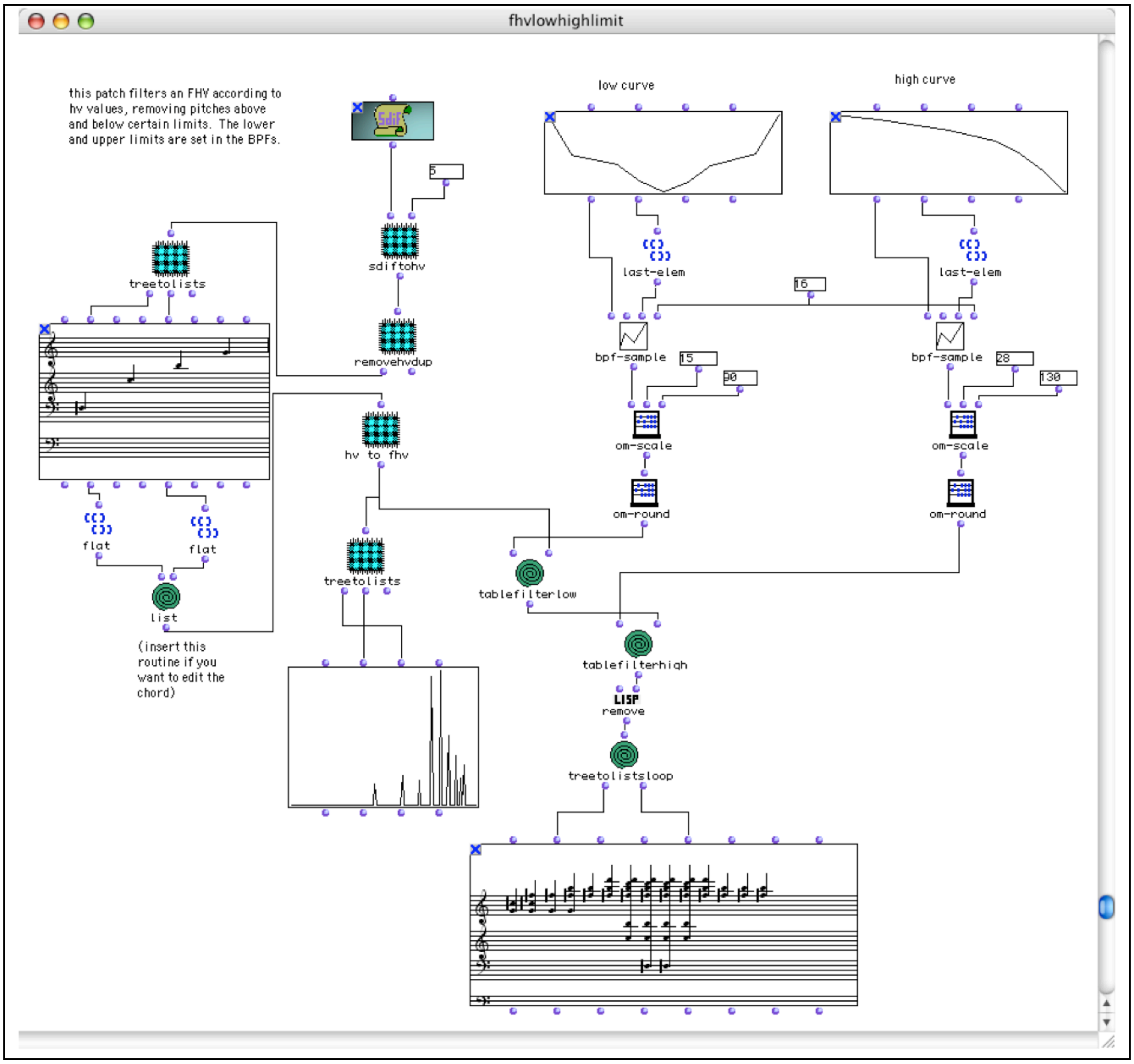


Figure 18. The "fhvlowhighlimit" patch.

Another method of filtering HVs is adopted by the "contourfilter" patch. This patch has a similar structure to that of "fhvlowhighlimit", however here the curves represent registral boundaries. This patch can be used in conjunction with the other FHV filters, affording the composer the ability to sculpt HV materials in a flexible and intuitive manner.

To facilitate the application of HV data in music for multiple instruments, I designed two patches that parse an HV series according to either weighting values or registral boundaries, dividing the series at multiple points to produce a number of separate "slices". Figure 19 shows the version of the patch that divides the sequence according to weighting values, called "HV slicer"; the chord sequence found at the top of the patch is thus divided into a maximum of five separate sequences, the weighting value boundaries of which are set in the number boxes at the left of the patch. In the registral version (called "lincontourslicer"), the dividing points are entered as single pitches.

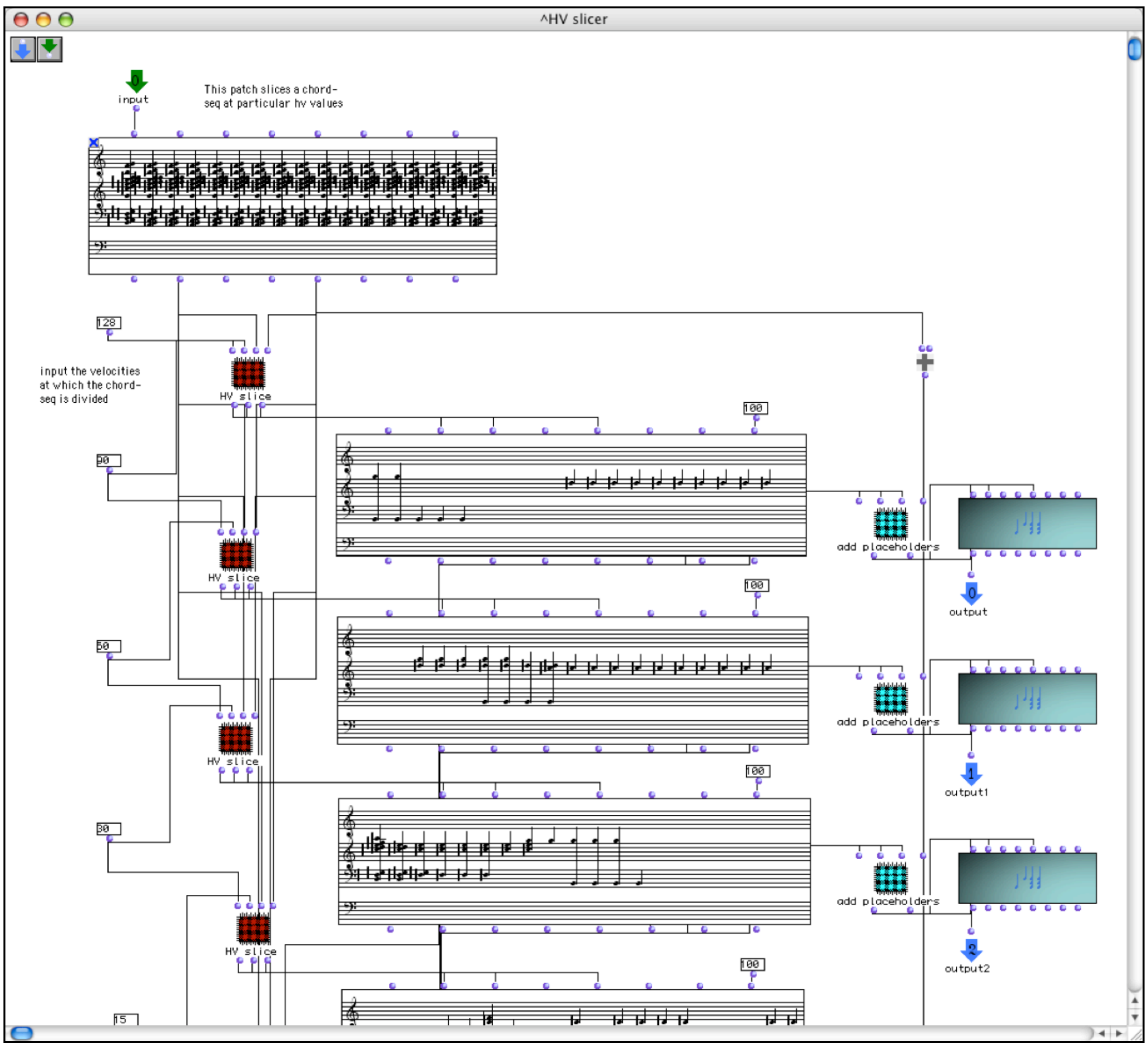


Figure 19. A chord sequence parsed according to HV ranges.

Projectors

Once the above-described tools have been used to generate chord sequences, these materials can be projected into measures for use as pre-compositional materials. As described in section 2.4 above, one of the methods of projection used in this thesis involves generating a monophonic line from an HV sequence, such that the prevalence of a particular pitch is relative to its HV value. The "melodyproject" patch produces such a single line according to user-defined parameters for resolution and porosity (the proportion of notes to rests); an example of the products of this patch was presented in Figure 3 above, whereas the patch itself is shown in Figure 20.

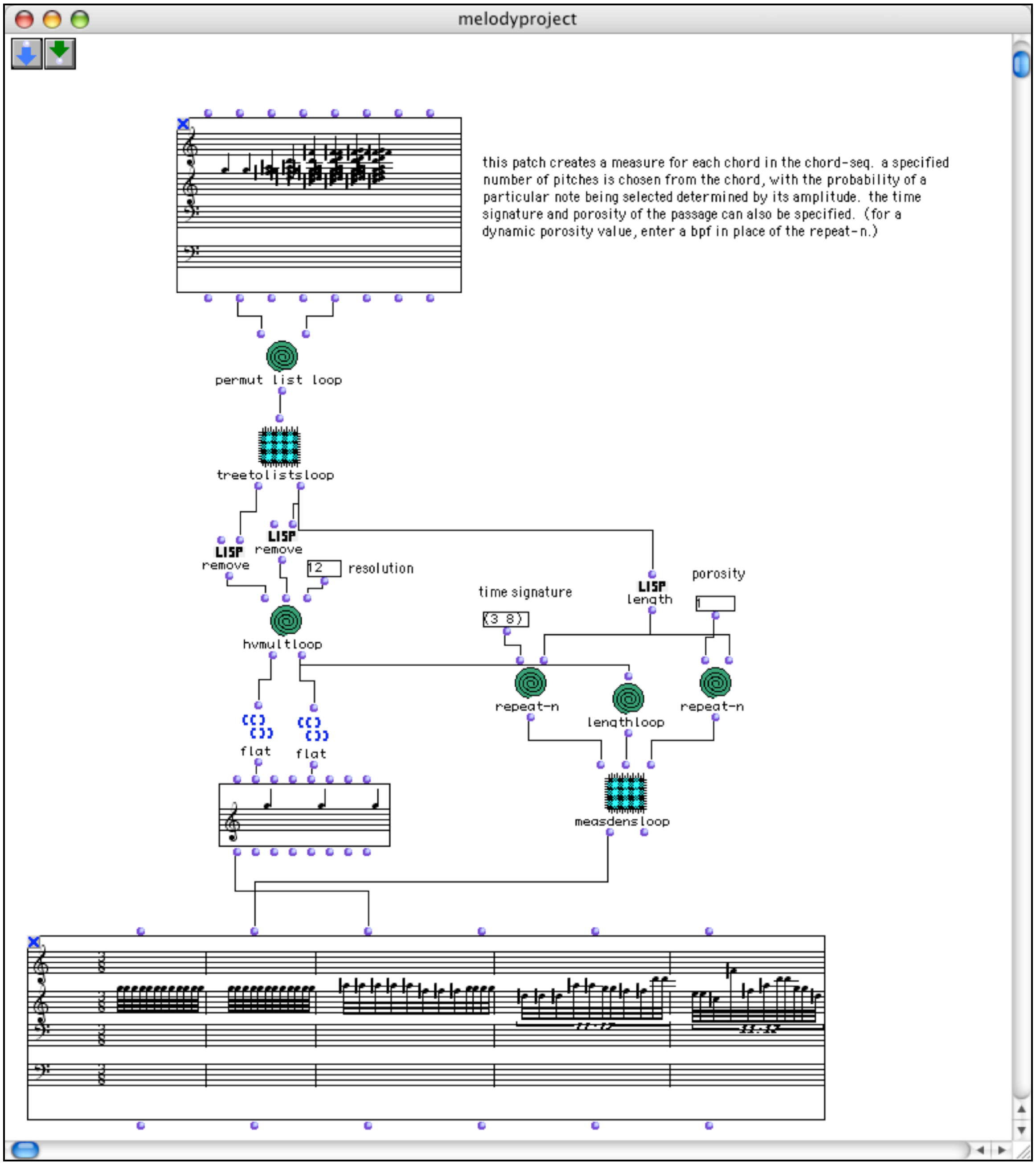


Figure 20. The “melodyproject” patch.

The collections of chord sequences generated by either “HV slicer” or “lincontourslicer” can be projected into a polyphonic texture using the patch “textureproject”. A portion of this patch is shown in Figure 21, which shows how each of five separate chord sequences are processed by the sub-patch “rhythm proportion” to generate multiple lines of activity. A polyphonic texture generated by this patch is shown in Figure 22; this material was used in composing the stochastic texture found in mm. 38-44.

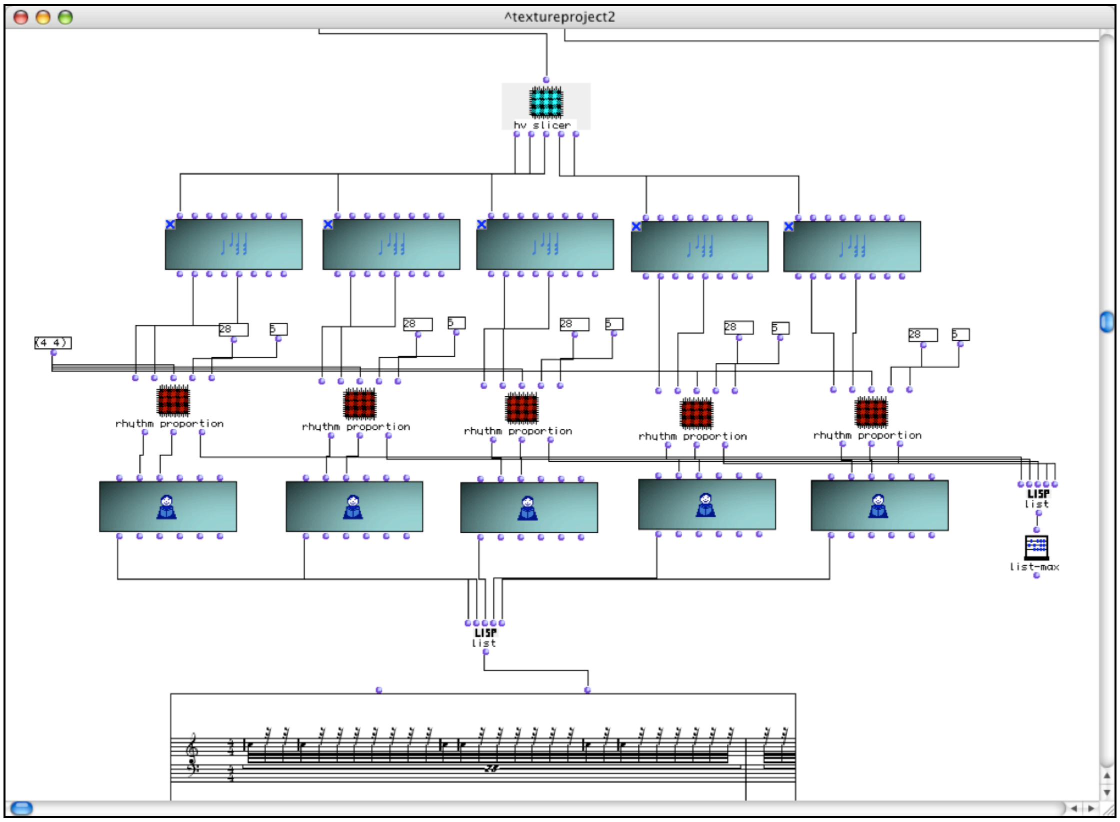


Figure 21. The "textureproject" patch.

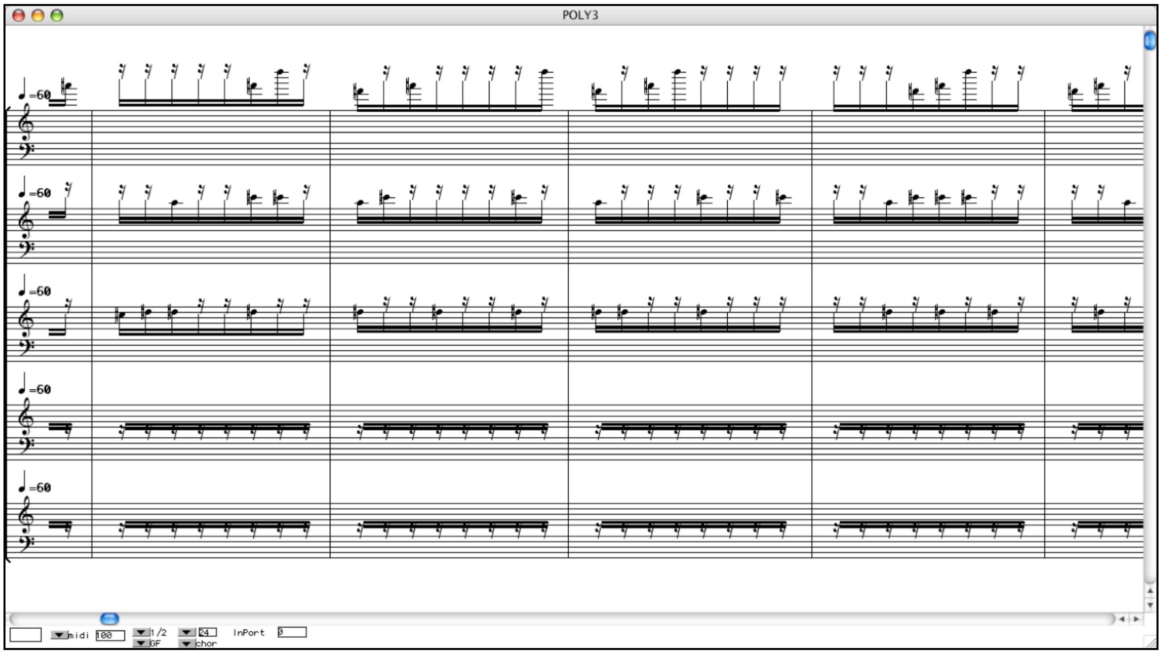


Figure 22. A polyphonic projection of a sliced HV sequence.