CHARACTERIZING NOISE AND HARMONICITY: THE STRUCTURAL FUNCTION OF
CONTRASTING SONIC COMPONENTS IN ELECTRONIC COMPOSITION

John A. Dribus, B.M., M.M.

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APPROVED:
Jon C. Nelson, Major Professor
David Schwarz, Minor Professor
Joseph Klein, Committee Member and Chair of the Division of Composition Studies
Graham Phipps, Director of Graduate Studies in Music
James Scott, Dean of the College of Music
Michael Monticino, Dean of the Robert B. Toulouse School of Graduate Studies.

This dissertation examines the role of noise in shaping the form of several recent musical compositions. This study demonstrates how the contrast of noisy sounds and harmonic sounds can impact the structure of compositions. Depending on context, however, the specific use and function of noise can vary substantially from one work to the next.

The first portion of this paper describes methods for quantifying noise content using FFT analysis procedures. A number of tests on instrumental and synthetic sound sources are described in order to demonstrate how the analysis system may react to certain sounds. The second part of this document consists of several analyses of whole musical works. Works for acoustic instruments are examined first, followed by works for electronic media. During these analyses, it becomes clear that while the use of noise in each work is based largely upon context, some common patterns do exist across different works.

The final portion of the paper examines an original work which was written with the function of noise specifically in mind. The original work is put through the same analysis procedures as works seen earlier in the paper, and some conclusions are drawn regarding both the possibilities and limitations of noise analysis as a compositional tool.
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CHAPTER 1

INTRODUCTION TO TERMS AND METHOD OF RESEARCH

The primary method of research employed in this critical essay is to analyze the form of several works, taking into account large scale and small scale formal features that will shed light on the structural function of noise in each work. All works analyzed in this study have been composed within the last fifty years, but represent a mix of compositional styles and approaches, and a mix of electronic and acoustic sound sources. The analysis of noise is presented alongside other types of analysis (harmonic or timbral) in an attempt to gain an understanding of the function of noise as it relates to the work as a whole. For purposes of this discussion, noise is referred to, in its absolute form, as the furthest point from a perfect sinusoidal consonance on a linear continuum extending from pure sinusoidal tones to a completely random distribution of sonic energy across the audible spectrum (white noise). The level of noise present at any given time has nothing to do with expectations associated with the sound source or its volume, even if the source is generally considered “noisy.” (This is particularly important to remember in electronic compositions making use of recorded sounds.) Instead, the level of noise can be determined through an analysis of the sound’s spectrum, revealing the proportion of harmonic partials to random distribution of energy. Although the noise level in a sound often has a direct bearing on its timbre, the analytical and objective approach mentioned above is more accurate than simply discussing a sound’s timbre, which can be thought of as the subjective effect of the distribution of partials and noise on a listener. For example, an analysis might demonstrate that sounds recorded from city traffic (a source which is normally considered noisy due in part to its high volume)
actually has underlying harmonic partials and therefore may contain less noise content than expected, in spite of its noisy affect or “timbre.”

In pieces using traditional instruments that produce primarily harmonic sounds, the distinction of the more and less noisy sounds can be more subtle than in electronic compositions. Two considerations must be taken when analyzing sounds produced by traditional instruments. One consideration is timbre, which must be analyzed in the fashion discussed previously, just as it would be in an electronic composition. Instruments that produce more variant energy outside of harmonic partials are considered noisier. Although perceived timbre seems to be an obvious indicator of instrumental noise content, test data on certain instruments indicate that the level of noise is not always easy to predict, leading to interesting conclusions on how noise may function and how it may be understood, even in completely instrumental works.

The second consideration for instruments is more subtle, but is crucial in analyzing the first two works considered in this study. Based on the methods of noise analysis used, where timbre of the instruments remains primarily constant, the relative number and distribution of partials of different chord tones and the proportions of their distance apart may affect the noise content. Although one might assume that a dissonant interval such as the tritone would contain a higher level of noisiness over the “perfect” intervals that have symmetrical distribution of partials, this is not always the case, as the distance between fundamentals will also play a large part in the interaction of constituent chord tones. The number of tones in a given chord also affects its level of noisiness, with more chord tones generally yielding more noisiness, dependant, of course upon other factors including harmonicity and timbre. A full description of the
interactions of different chord tones in dyads and triads, as related to their level of noise production, will follow shortly in this chapter.

Methods to Analyze Noise

Throughout this paper, several considerations are made relating to the description, identification and quantification of noise in the works to be analyzed. In situations where the notes, sounds or passages being compared have obviously different levels of noise (i.e., flute choir vs. percussion ensemble), a simple acknowledgement of that fact is made, with no further analysis required. Consequently, for works containing acoustic instrumental sounds, timbre is the first consideration when quantifying the level of noise at any given point. Given the fact that timbre as perceived by the ear (without electronic analysis) can be subjective and does not always reflect the actual noise content of a sound, test data from electronic analysis of common instrumental sounds can inform discussions of timbre when full electronic analysis of a section of music is not available, or when the characteristics of a specific sound needs to be discussed separately from the soundscape in which it exists. Test data for common orchestral instruments is found later in this chapter.

In cases where the sounds, chords or passages differ in character but seem similar in balance between pitched and noisy content, a spectrograph can be used to visually portray the content of different blocks of sound. The spectrograph can be useful for relating electronic sounds to instrumental sounds. The fast Fourier transform (FFT) based spectrograph in Audiosculpt can be used for these purposes. Although some spectrographs were made for portions of music discussed in this dissertation, they proved to be not very useful when looking at large scale formal features or the
general contour of musical works, in part because interpretation of spectrograms can be very subjective in this context. Also, although the visual representations from a spectrograph can be beneficial for understanding a sound’s content, the presence and distribution of harmonic partials alone do not account for all the noisiness present in a given sample. Therefore, spectrographs are not included in the analyses here, although they did inform some of this research in its early stages, and in a different setting, the visual representation of partials in this way could be informative as well.

While the spectrograph presents a subjective view that can indicate noise content, another FFT based approach can be employed to quantify noise levels for more objective comparison of sounds and sections of compositions. This objective type of noise analysis can be accomplished by using FFT objects in MAX MSP. The analyzer~ object from the Tristan externals\(^1\) was used with its default settings in a MAX patch I wrote to generate a noise factor for any sound that runs through it. The noise factor is represented as a positive floating point value with 0 being the least noisy (perfect sine tone) and 1 representing randomly distributed noise. In this essay, the analyzer patch is primarily used to analyze the form of entire pieces, although sections of music will also be discussed. It is also used to demonstrate some general principles of noise content in relation to the interaction of pitches, instrument tessitura, etc. The tool I created using the analyzer~ object samples its sound input 20 times per second. For long portions of music, values were averaged and one value was released per second. Although this does produce some rounding off, the level of detail provided was more than sufficient for looking at the large scale formal implications of noise content,

\(^1\)Tristan Jehan’s analyzer~ object downloadable from [http://cnmat.berkeley.edu/downloads](http://cnmat.berkeley.edu/downloads), (accessed July 17, 2008)
and the rounding feature makes the data sets shorter and easier to represent. For test data and calibration described below, the sample averaging feature was turned off to yield more detailed data for short input samples.

Figure 1.1. Analyzer~ tool in MAX MSP
Analyzer Tool Testing and Calibration

Although the analyzer tool was designed to look at large scale formal features through noise distribution over time, numerous smaller-scale tests were done with the tool prior to analyzing full pieces. The goals of the testing were to describe the noise contour of instrumental notes from attack to decay, to understand the range of noise typical of different sources, and to describe how the noise output was affected by the interactions of different pitches in dyads, especially for consonant vs. dissonant chords, and for chords with small ranges vs. chords with large ranges. For testing the interaction of dyads, horn tones and sine tones were used in order to examine the differences in noise output from combinations of synthetic pitches versus the combination of acoustic pitches. Individual instruments tested during the analyzer's calibration included the flute, piano, cello, horn and violin. All instrumental samples were taken from University of Iowa's website, recorded by Larry Fritz in the university's anechoic chamber.²

Summary of Test Data

For all samples tested, the typical instrumental noise content range for single pitches was around 0.4 - 0.7, with higher values at attacks and decays. Several factors influenced noise level, including pitch level, instrument tessitura, volume, and playing technique. In general, lower pitches from the same sound source yielded higher noise levels. This was most noticeable and consistent at mezzo forte volume levels. Louder and softer tones often revealed unpredictable irregularities in pattern. One thing that became clear, however, was that register alone does not account for the noise level in a given instrument. For example, figures 1.2 and 1.3 represent the horn and flute (both

thought to produce generally “pure” tones) playing at different registers. Although both instruments showed an increase in noise as register decreased, the flute actually tended to contain more noise across its range, in spite of its higher general register.

Figure 1.2. Flute noise over time in different pitch registers

Figure 1.3. Horn noise over time in different pitch registers
Further analysis of other instruments showed similar patterns, where noise increased as register decreased, with many harmonic instruments displaying a similar variation in the noise factor from low to high pitches, in spite of the fact that some had a much wider range than others. A good example of this fact can be seen in comparison of the flute and the piano. In the piano the noise difference across its range between C1 and C7 was about 0.2, as seen in figure 1.4.

![Piano Noise Levels in Different Octave Registers](image)

Figure 1.4. Piano noise over time in different octave pitch registers

The flute (figure 1.2) also displayed a noise factor difference of about 0.2 across its range from C4 to C6, even though this range was less than half the piano’s. The horn (figure 1.3) displayed a noise difference of about 0.3 from C2 to C5, which was greater than the piano’s or flute’s difference, even though the horn’s sampled range was similar to the flute’s and much narrower than the piano’s. Finally the cello (figure 1.5), which displayed a somewhat irregular pattern, had a noise difference of only about 0.1 in
corresponding parts of its envelope on different pitches, in the range from C2 to C5. It is important to note that for the cello samples, pitches were played in relatively the same place on the string, meaning each pitch was played on a different string to match similar tessitura of each string and eliminate some variables relating to string length and tension. All these facts support the notion that although pitch has something to do with the noise level in the instrument, the relationship of that pitch to the instrument's tessitura makes a greater difference than the absolute pitch itself.

![Figure 1.5. Bowed cello noise over time in different pitch registers on different strings](image)

More evidence for the importance of tessitura was found through further analysis of the cello. In figure 1.6, C2, C3, and C4 were all played on the C string, revealing an expected peak in noisiness around the attack of the lowest pitch. When the same pitch (C4) was played on all four strings in succession (figure 1.7), the lowest noise levels
were observed in the C string, with an incremental increase in noise with each higher string.

Figure 1.6. Cello noise over time in different pitch registers on the same string

Figure 1.7. Cello noise over time on the same pitch on different strings
These noise patterns indicate that tessitura is a very important factor in the amount of noise contained in a pitch; C4 is a relatively high note for the C string, and high notes carry less noise. But on the A string, C4 is a relatively low pitch, and therefore the resultant noise level is higher. The data shown here backs up the general principle that the lower the pitch is relative to the string's range, the noisier the resulting signal will be. The combination of figures 1.6 and figure 1.7 indicate that there are two factors in the difference in noisiness on a given instrument, one being the actual pitch, and the other being the pitch relative to the range of its source.

One final test was done to try to determine whether range itself played a factor in the noise content of sounds. Two sine tones were played simultaneously into the analyzer to determine what effect register would have on similar grouping of tones. Since there is no tessitura to be considered in an artificially generated tone, and single sine tones carry no noise, all the noise sampled came from the interactions of the sine tones at their different registers. The numbers displayed are the sums of all noise detected in 80 samples. Sine tone chords where tested at 5 different octave ranges, and the groupings of the tones were tested in octaves and perfect 5ths. Octaves and fifths were tested separately in order to eliminate any individual patterns associated with a specific interval. Table 1 shows the results of the test. There seems to be no conclusive evidence that pure register had any predictable effect on these results; in fact, the variation from octave to octave seems very random. The differences between the octave and the fifth will be considered in the next section when pitch interaction is discussed in more detail.
Table 1.1. Noise factors in intervallic relationships

<table>
<thead>
<tr>
<th>Octaves</th>
<th>Fifths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bass note</td>
<td>Noise Factor</td>
</tr>
<tr>
<td>A110</td>
<td>0.528289</td>
</tr>
<tr>
<td>A220</td>
<td>1.687366</td>
</tr>
<tr>
<td>A440</td>
<td>1.931866</td>
</tr>
<tr>
<td>A880</td>
<td>1.352265</td>
</tr>
<tr>
<td>A1760</td>
<td>1.904128</td>
</tr>
</tbody>
</table>

Throughout the testing, playing technique also had an important effect on the noise level of an instrument's output. Figure 1.8 can be compared to figure 1.2 to show the flute's noise output when being played with and without vibrato. Not surprisingly, although the average noise output in both cases ranged from about 0.4 to just over 0.6, the tones containing vibrato tended to vary by a noise factor of 0.1, while the tone without vibrato tended to remain very steady.

Figure 1.8. Flute noise over time, vibrato playing technique
All of the tests done to this point (excluding the sine tests) were on single pitches. The horn was used to test whether the interaction of different pitch combinations would effect the noise content of dyads and chords. The horn was chosen because it tended to be less noisy (0.28 to 0.43 noise factor in these tests) than many other instruments, and the purity of the tones should allow their interaction to be seen more clearly. It is tempting to assume that consonant intervals would show less noise in the output than dissonant intervals. Figure 1.9 shows the noise plots for the individual pitches tested. They fell in the middle range of the instrument, and were close enough together (all fall within one octave) that individual differences in each tone did not display the typical trend of increased noisiness with lower pitches. The overall difference between the noisiest and least noisy pitch was a factor of about 0.15.

![Horn Noise Factor on Different Pitches](image)

Figure 1.9. Horn noise over time, individual pitches
Figures 1.10a-h display the noise output of each dyad, including the noise output for each individual tone (broken lines) and the noise output for the chord itself (solid lines). Each tone is shown with part of its decay, but for comparison purposes all sample sets have been cropped at 45 samples (2.25 sec) in order to show interaction of tones without the variability which comes with the ending of different decays on different pitches.
Table 2 shows numeric averages of the 45 samples of noise data from each individual pitch and dyad tested. The noise factor of the bottom note of each dyad (C4 at 0.407) and the other note are shown as Note 1 and Note 2 averages, respectively. The noise factors of both individual pitches were averaged together and are shown as the “average of notes.” This calculation was done to account for any variability in noise level in particular notes due to outside factors such as playing technique. The “dyad average” is the average of the noise samples when both pitches were analyzed simultaneously. This figure shows how the interaction of the pitches affects the noise
content of a chord. Because the noise factors of each “Note 2” necessarily varies, the “interaction sum” was used to show the difference between the average of notes and the dyad average, in an attempt to isolate the additional noise created by the interaction of pitches. Not surprisingly, the interaction sum of the octave was among the lowest (0.41). However, the dissonant minor second and the major seventh also had very low interaction noise levels. More surprising still was the fact that the most noise created by the interaction of pitches was found in the perfect fourth, tritone, and perfect fifth.

Table 1.2. Dyad interactions

<table>
<thead>
<tr>
<th>Interval</th>
<th>Note 1 average</th>
<th>Note 2 average</th>
<th>Average of notes</th>
<th>Dyad average</th>
<th>Interaction sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>m2</td>
<td>0.407</td>
<td>0.383</td>
<td>0.395</td>
<td>0.429</td>
<td>0.034</td>
</tr>
<tr>
<td>M2</td>
<td>0.407</td>
<td>0.391</td>
<td>0.399</td>
<td>0.446</td>
<td>0.047</td>
</tr>
<tr>
<td>M3</td>
<td>0.407</td>
<td>0.371</td>
<td>0.389</td>
<td>0.435</td>
<td>0.046</td>
</tr>
<tr>
<td>P4</td>
<td>0.407</td>
<td>0.367</td>
<td>0.387</td>
<td>0.460</td>
<td>0.073</td>
</tr>
<tr>
<td>TT</td>
<td>0.407</td>
<td>0.375</td>
<td>0.391</td>
<td>0.465</td>
<td>0.074</td>
</tr>
<tr>
<td>P5</td>
<td>0.407</td>
<td>0.421</td>
<td>0.414</td>
<td>0.496</td>
<td>0.082</td>
</tr>
<tr>
<td>M7</td>
<td>0.407</td>
<td>0.316</td>
<td>0.362</td>
<td>0.415</td>
<td>0.054</td>
</tr>
<tr>
<td>P8</td>
<td>0.407</td>
<td>0.319</td>
<td>0.363</td>
<td>0.404</td>
<td>0.041</td>
</tr>
</tbody>
</table>

In order to test whether these results were unique to the horn, sine tones were played into the analyzer to reveal their interaction results. The noise factors from the sine dyads exclusively represented the result of pitch interaction, as sine tones by themselves carry no noise. Two tests were conducted with sine dyads to test interaction of different harmonic structures. The first test using octaves and fifths has already been presented in Table 1.1. There is no clear pattern revealed here, as the fifth was noisier three out of five times, and the range of noise produced varied greatly.
A second test using sine tones was designed to look for continuous patterns through linear pitch shifts, in case an interaction pattern was missed by using only selected discrete intervals in previous tests. A fixed pitch (A110) and a moving pitch were combined so that the second tone would climb in a glissando from A110 to A220 in 24 seconds. The results can be seen in Figure 1.11. The most noise sampled was found between 4 and 5 seconds, in the area of the major second to minor third. There was a notable dip in the plot in the area of the perfect fourth to perfect fifth (opposite from the increase in noise in this area seen in the horn testing), with a slight spike in noise around the area of the tritone, but no definite or predictable overall pattern in the development of noise.

![Noise in octave glissando from A110 to A220 over 24 Seconds](image)

Figure 1.11. Noise in octave glissando from A110 to A220 over 24 Seconds

A similar test was repeated with two sine tones, this time starting an octave higher on A220, with the changing tone ascending two octaves over 48 seconds (figure
Although at initial examination, there seems to be a similar peak in noise content near the beginning of this test, the peak actually happened earlier (around the 2 sec., or Db mark) and the following area of less noise content was also early, centered around Eb. By the time the separation of the component tones exceeded an octave, the noise levels become more even, but are still random. The sine tone dyad tests not only showed little similarity to the patterns displayed in the horn, but they also displayed little consistency among themselves.

![Figure 1.12. Noise change in glissando from A220 to A880 over 48 seconds](image)

Figure 1.12. Noise change in glissando from A220 to A880 over 48 seconds

After testing dyad interaction, one more test was performed using sine tones and horn samples. This time, triads were tested. The first triad was a C major chord, and the second was a dissonant chord including C4, Db4 and B4. The sum of 80 samples of noise for each chord, produced by combining sine tones, is shown in table 1.3. Each
The chord was tested twice since interaction tests on combined sine tones tend to vary a bit from test to test. In both cases, the consonant chord produced at least twice as much noise as the dissonant chord.

Table 1.3. Noise in consonant versus dissonant chords with sine tones

<table>
<thead>
<tr>
<th></th>
<th>C4, E4, G4</th>
<th>C4, Db4, B4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1</td>
<td>2.455898</td>
<td>1.184817</td>
</tr>
<tr>
<td>Test 2</td>
<td>2.518225</td>
<td>1.145454</td>
</tr>
</tbody>
</table>

The results for the horn were not as dramatic, but still similar. Using the same testing method as was used for dyads, it was determined that the interaction sum for the major chord was higher than the sum for the dissonant chord. Results are found in table 1.4. Figures 1.13-1.14 show the noise produced by each individual horn tone and chord for both the dissonant and consonant chords. Figure 1.15 shows only the noise levels of each chord for comparative purposes.

Table 1.4. Noise in consonant versus dissonant chords with sine tones

<table>
<thead>
<tr>
<th>Chord</th>
<th>Avg. of tones</th>
<th>Avg. of Chord</th>
<th>Interaction sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>C4E4G4</td>
<td>0.4</td>
<td>0.503</td>
<td>0.103</td>
</tr>
<tr>
<td>C4Db4B4</td>
<td>0.369</td>
<td>0.45</td>
<td>0.081</td>
</tr>
</tbody>
</table>
Figure 1.13. Individual and cumulative noise plots for major chord on French horn

Figure 1.14. Individual and cumulative noise plots for dissonant horn chord
Figure 1.15. Comparison of cumulative noise plots of major and dissonant chords

The overall results of the analyzer tool testing led to some interesting conclusions regarding the capability of the tool, and regarding the behavior of noise in different settings. 1) Instruments tend to vary in their noise content in a manner rather easily predicted based upon their timbre, or perceived noisiness, but significant exceptions can occur. 2) Instrumental tones (especially for instruments bowed or struck) tend to vary significantly in their noise content based upon where the sample occurs in the attack or decay of the tone. 3) Noise content varies significantly and predictably based upon the range of the tone in relation to the tessitura of the instrument. 4) Consonance or dissonance of a given chord has little predictable effect on the noise level of the chord, except that chords with more pitches do tend to exhibit more noise. 5) Sine tones do not always behave in the same way as instrumental tones in cases where interaction between tones creates noise. However, enough patterns are similar that the
fundamental principles of noise analysis should be applicable to both acoustic and electronic works.

Perhaps the most interesting finding of the testing was item 4, especially in the sense that some works may display more noisiness in areas of greatest dissonance. Given the testing, this fact must often be attributed to other factors such as volume, playing technique, etc., that coincide with the creation of dissonance, and not upon the presence of dissonance itself.

In the testing of the tool much focus was given to the topic of pitch and harmony, with the understanding that only some of the works presented in this paper contain significant pitched elements. However, since pitch and harmony has typically been regarded an important factor in describing the form of works, the emphasis is appropriate here. As I analyzed works that contained pitched elements, I took a close look at how the noise content supported or opposed the formal features defined by pitch and harmony. In those works that do not contain significant pitched elements, I examined how other factors including timbre and noise define musical form in place of harmonic elements.

Definitions of Important Terms and a Note on Analysis

Before the works are discussed, a few terms need to be defined. The term “quality” is used only in the traditional sense when referring to chords (mainly triads) from the common practice tradition. For sounds outside of this tradition, the term “character” is used instead, to refer more broadly to the affect of a particular sound or set of sounds.
The term “chord” is reserved for use with sounds that are primarily harmonic, whether they are instrumental or electronic. The separate pitches in each chord are simply be referred to as chord tones. For vertical structures that contain more than one sound or sound source (excluding different pitched instruments), the term sonority is used instead. The component parts of such structures are referred to as sonic constituents while the term “partial” is used to refer to any single (sinusoidal) harmonic component found in a chord or sonority.

The notion of tension and release is important, especially when dealing with the resolution of inharmonic sounds to harmonic sounds. However, given the specific connotations of this phrase, and its association with common practice tonal music, it is avoided in most cases. Instead, terms including stability, instability, stasis, and repose are used to describe situations in which the music seems to require a subsequent event (instability) or it does not (repose). In some cases, the concept of stability was shown to have more to do with context than sonic content when dealing with chords.

My analyses of five works took into consideration many of the typical elements of musical analysis, including pitch, timbre, and form. Each analysis focused on how these elements can be represented and understood through use of the noise analysis tool. While elements of more traditional types of pitch-based and formal analyses were referenced or carried out on a small scale in the following chapters, none of the descriptions of these works were intended to be full harmonic or formal analyses in a traditional sense. Rather, elements of past analysis techniques were utilized and referenced to assist in describing each work in terms of the structural function of noise.
CHAPTER 2

LIGETI’S LONTANO: CONSONANCE AS REPOSE IN A SOUNDMASS COMPOSITION

Lontano was chosen as the first work in this study because of the unique position it fills in the repertoire with respect to its treatment of timbre (and more specifically noise content) in relation to form. It was also fitting to consider Lontano in a paper that focuses primarily upon electronic compositions, because while the work is entirely acoustic in nature, the influence of electronics on its compositional process has been acknowledged by the composer and noted by other writers. In addition, the work’s historical position is significant because it displays structural links to traditional musical processes in its canonic structure and pitch organization, both of which can be studied in light of common practice tradition. In so doing, it was evident that work is also related to historical musical practice in the way that it controls the use of noise, both in terms of timbral manipulations and in terms of the control of dissonance.

Much of Lontano’s appeal stems from the fact that in structure and sound it is new and radical, while simultaneously it is filled with traditional internal structural links to common practice. When heard alongside other repertoire from the same period, Lontano can be thought of as a stark departure from traditional instrumental writing due to its focus on timbre, minimal treatment of melody, slow formal development, and micropolyphony. However, the implicit influence of some traditions of earlier Western music is unmistakable even at first listen, especially in Lontano’s tendency to use pure

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harmonic structures to create repose at important formal junctures, and for its implicit references to the traditional tonal harmonic practices, including references to triads and other traditional functional chords or intervals such as the tritone. The references to traditional harmonic practices are especially fascinating in light of the fact that the so-called functional elements seem to uphold the traditional approach that more stable harmonic structures are found at important formal junctures, including the beginnings and endings of large sections of the form. If a non-traditional work such as Lontano can be shown to behave according to the implicit common practice rules that more harmonically stable vertical structures must appear in strong structural positions, and if the noise contour of the work parallels the dissonance level of harmonic features, the work could shed some light on the question of the perception of the function of noise (commonly viewed as musically unstable) as it relates to other twentieth-century compositions, including electronic works.

The fact that the work appears to blend the sound of the late twentieth-century avant-garde with numerous references to past styles presented the first challenge when analyzing Lontano. The composer himself has mentioned the influences of early contrapuntal music on his micropolyphonic style, while downplaying the assertion that his work could be considered to be purely derived from past styles. His conclusion was that in the micropolyphonic works, “tradition and experimentation are both there side by side.”³ His apparent attempt to side-step the dominance of any particular influence on his style—“I am, of course, influenced by everything that is happening today in music… but I am not overpowered by it; I seem to be weighted so as to stand upright

³ Gyorgy Ligeti, 31.
again, however much I am rocked\textsuperscript{4}— is supported by Lontano’s synthesis of traditional and innovative elements, which has contributed to its general reception as something of the avant-garde. However, the composer’s downplay of obvious features possibly derived from earlier harmonic practice, such as the emphasis of the octave and the unison in \textit{Lontano},\textsuperscript{5} could lead one to question some of those claims. In fact, the composer’s assertion—“I do shun major triads”\textsuperscript{6} is true in \textit{Lontano} only as long as the [037] set of the major triad is not manifest in its minor triad form, as will be shown in the harmonic analysis which follows.

Whatever ties to the past do exist in \textit{Lontano}, the primary analytical challenge created by the dichotomy of tradition and experimentation in this work was the fact that there seems to be no clear and effective method of analysis agreed upon by scholars. For this research, I simultaneously undertook three approaches including a pitch-based analysis using some Schenkerian principles, a timbre-focused analysis, and a fast Fourier transform based electronic analysis of recordings of the work. The pitch-based analysis was linear in nature and stressed the progression towards more dissonant background scale motion as the work moves from its beginning on a unison pitch to its conclusion on a dissonant sonority. The timbral and FFT analyses demonstrated that the structural function of noise in various verticalities in the work was parallel to the linear progression of dissonance in the composition, and suggested that a noise-based analysis can provide a sometimes contrasting, yet often complementary method to analyze the large-scale formal structure of compositions. This analysis can also shed

\footnotesize
\begin{itemize}
\item \textsuperscript{4} Gyorgy Ligeti, 30.
\item \textsuperscript{5} Gyorgy Ligeti, 27-28.
\item \textsuperscript{6} Gyorgy Ligeti, 30.
\end{itemize}
some light on the role of traditional methods of harmonic resolution used in the piece, as they relate to noise.

*Lontano*, along with *Atmospheres*, *Apparations* and other Ligeti works of this period, has often been noted for its dependence upon timbre. Since there is no comprehensive pitch-based analysis of *Lontano* in published literature, Amy Bauer’s timbre-based discussion of the work found in *Indiana Theory Review* was considered before taking a closer look at the composition itself through my own analysis. Although Bauer’s work is more concerned with timbral considerations than it is with the overall form of the work, it provided a helpful point of reference for understanding some of the linear points of progression as well. It also addressed somewhat indirectly the role of pitch in a work dominated by timbre, setting the stage for my more detailed description of *Lontano’s* pitch and harmony.

In reference to the style that Ligeti employed in his micropolyphonic compositions, Bauer states “That new language has much to do with an ironic reversal of the traditional relationship between primary and secondary parameters: the elevation of timbre, articulation and dynamics over pitch and rhythm as determinants of musical structure.” This reversal is most evident in the music’s foreground layer, where surface melodies exist of two or three notes, and internal rhythms are covered up through the interpolation of many voices, blurring the normally analyzed parameters of rhythm and pitch, and pointing to timbre as a defining factor in the work’s structure. Even though I will later argue that the large-scale form of *Lontano* behaves (to some degree) according to traditional harmonic conventions through the control of dissonance and

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8 Bauer, 2.
placement of noisy timbres and dissonant chord structures in formal junctures that require motion or energy, the progression of surface features is most often marked by contrasting timbres. And although the structural significance of the background level harmonic motion may seem to conflict with Bauer’s claim that “the movement of one texture to another distinguishes form,”⁹ the truth is that both harmonic and timbral elements work in tandem to produce compelling forward motion throughout the work.

The bulk of Bauer’s essay focuses upon important features of the textural and timbral structure of the music. She breaks timbre down into several component parts (spectral structure, temporal envelope, sound pressure level and loudness) in an attempt to move towards a theory of timbre. However, difficulties are encountered with this approach because “attributes of auditory sensation—such as spectral shape and energy distribution (the intensity of specific partials), sound pressure, and the frequency location of the spectrum—contain subjective components that frustrate objective analysis and comprehension…. A comprehensive theory of tone color would have to surmount these difficulties, and reconcile empirical data with the intricate and often paradoxical responses of our auditory system.”¹⁰ This challenge was evident in my research as well, as my FFT based analysis tool revealed that dissonant intervals often contain less noise than do consonant intervals. However, this particular difficulty can be partially overcome by acknowledging that the composer used the affect of both the dissonant structure (perceived to increase intensity even without containing more noise) along with instrumental timbres that do indeed contain more noise content to contribute heightened energy to certain sections.

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⁹ Bauer, 13.
¹⁰ Bauer, 16-17
Without acknowledging the interplay of real noise and perceived noise in the form of harmonic dissonance, it is difficult for a timbral analysis to move beyond small blocks of the music. In Bauer’s essay, the largest section of the work graphed out using timbre-based analytical principles is 45 measures, and there is no reference to the larger formal function of this section.\(^{11}\) In other words, a timbre-based analysis fraught with subjective elements (effective as it may be in describing small scale events in the work), can be much more effective in describing the large scale background features that govern form and progression in the music when coupled with a tool that analyzes the presence of noise. Nonetheless, even Bauer’s account does begin to point to some of the important large-scale formal features of the work, if not describing them explicitly. One such example includes the dense vertical structures at points of intensity that resolve to cadential patterns marked by perfect consonances or even unisons. These patterns are able to punctuate larger formal gestures through the control of noise as a source of musical energy. Bauer mentions these features as determinants of form and refers to them as “a harmonic progression from dark to light and near to far.”\(^{12}\) She goes even further, when in reference to Ligeti’s requiem she observes that “instrumentation and articulation enhance and, at several points, provide mobility and closure in lieu of the primary parameter of pitch.”\(^{13}\)

To form a clearer picture of the interaction of timbral elements and large scale form, it was necessary to take a moment to divide the surface level of timbral detail from the background levels of formal progression. When this division was made, Ligeti’s compositional process, which could be referred to as a restructuring of musical

\(^{11}\) Bauer, 21.  
\(^{12}\) Bauer, 5.  
\(^{13}\) Bauer, 7.
expectations through the articulation of form in large sections by the manipulation of timbre in large formal blocks, actually seemed bound by the traditional harmonic conventions, implying that dense or dissonant chords ought to resolve to pure or consonant sonorities. The difficulties that Bauer encountered in “theorizing about timbre”\textsuperscript{14} in \textit{Lontano} can largely be circumvented by realizing that while timbre is often interpreted based upon the spectral content of sounds or chords (a subjective measure), it can be readily described by analyzing the level of noise therein (an objective measure). The rules that govern Ligeti’s transformations of timbre in the so-called soundmass works rely partly upon his ability to control the level of noise present in a vertical structure at any given time, and also upon the noise levels implied through prolongations of prominent pitches associated with noisy or dissonant sonorities. In \textit{Lontano}, Ligeti’s pitch language is structured using the idioms of the later Twentieth Century, but it allows the arrangement of his timbral transformations to progress in much the same way that unstable chords and tendency tones were expected to resolve to consonant chords in common practice tonal music. The correlation between these two drastically different styles is only possible because of the underlying principle that sounds with a greater degree of inharmonicity in their spectrums have traditionally resolved to more harmonic sounds. The harmonic analysis that follows demonstrates that on a continuum from perfect harmonicity to complete noise, the perception of pitch and timbre should not be separated, but rather flow into each other just as the contrasting sections of \textit{Lontano} collide and dissolve simultaneously.

\textsuperscript{14} Bauer, 3.
Lontano Analysis

The purpose of this harmonic analysis in Lontano was not to fully describe the workings of a soundmass composition, but rather to provide a formal analysis referencing pitch to address some of the challenges unsolved by other forms of analysis, including Bauer's timbre-based approach. Pitch-based analysis was appropriate in light of the composer's own claim that "intervals, definite pitches, really do play an essential role here in the whole basis of the form and also in the image of the music."\textsuperscript{15} In fact, this look at the pitch organization of the work reinforced the premise that many of the so-called secondary parameters related to timbre referenced by Bauer are significant primarily on the foreground level, and that in this work, pitch maintains a primary significance in the formal structures seen in the mid-ground and background layers of the music. The composer discussed this relationship in detail in his interview with Josef Hausler:

I believe that Lontano is the example that demonstrates most purely the crystallization of corner-stones or pillars that are specific intervals or single notes or harmonies. They provide a kind of contrast to the prevalent neutrality and tone-color transformation, that is to say, on one level of the work there are tone-color transformations, but there is another, harmonic level which, I would almost say, is behind it: that is also an aspect of Lontano, of being distant. At certain moments in the work there are single pitches or groups of intervals. To give you one example: at the very beginning I proceed from a certain note—an A flat. This A flat plays a role in the work as a whole. If you then look for similar corner-stones later on, you find that all twelve notes emerge as pillars. That has nothing to do with twelve-note music—there is no note-row.\textsuperscript{16}

The following detailed discussion of pitch and harmony as they relate to form was possible with Lontano while it would have been much more difficult in earlier soundmass

\textsuperscript{15} Gyorgy Ligeti, 94.
\textsuperscript{16} Gyorgy Ligeti, 96.
works such as Atmospheres or Volumina.\textsuperscript{17} This is due to the way that Lontano’s form is dictated by Ligeti’s so-called corner-stones, and the way that they affect the sense of progression in Lontano. In one of the earlier soundmass works, a timbre based analysis would have been more likely to be able to stand alone, but here harmonic considerations are also necessary, because form is determined to a large degree by harmonic factors. The relevance of this discussion in a paper about the treatment of noise in modern composition grows out of the premise that timbres containing more noise are often used alongside dissonant chords to create more energy in certain sections of a work. Since Lontano clearly displays both consonant and dissonant chords in important structural junctures, it displays a sophisticated formal use of noise-related progression and resolution, and is therefore more appropriate for this paper than other soundmass compositions.

In spite of the significance of the pitch-based analysis, this approach was challenging when considering Lontano. Although the so-called “primary parameter” of pitch was eventually shown to retain “primary” significance in this work (if at a background level), the dense and complicated nature of Lontano’s texture often rendered the pitched factors difficult to interpret. The presence of thick clusters and wide range can lead to differing interpretations of which specific pitch is most significant in any harmonic structure. However, through repetition of certain pitches and chords, a background of notable pitch relationships does emerge in the work. The composer’s assertion that all twelve tones emerge as corner-stones at some point must not be taken to imply that all twelve are equally significant; in fact the composer upheld this fact by mentioning that this work is not governed by dodecaphony. Rather, each pitch

\textsuperscript{17} Gyorgy Ligeti, 91.
assumes a function when it emerges as a corner-stone pitch, and some function in more structurally significant roles than others. As the structure of the work unfolds, the function of each corner-stone pitch evolves and changes, shifting the harmonic focus from one center to another.

The opening A flat that emerges as a primary pedal tone at the outset of the composition functions as the first structurally significant corner-stone pitch. In fact, the articulation of this and other important corner-stone pitches (reinforced by the development of timbral gestures) breaks the work up into several large formal blocks. The first block extends from measures 1-41, and is marked by this entrance on the unison Ab and a conclusion on an octave C. In spite of the composer’s adamant rejection of the major third as a harmonic interval,\(^\text{18}\) it serves an important function in the linear motion here. In fact, the canonic development of the melodic lines establishes less of a progression from the Ab to the C, and more of a prolongation of Ab under C, creating a consonant major third interval throughout the first 3 minutes of the work. As already mentioned, Ab is the primary opening pitch of focus, and although its meaning has changed in light of the harmonic motion around it by m. 11, it is still present until the last cello voice finishes its first iteration of the canon motive in m. 15.

A detailed look at the first 14 measures illustrated the function of a corner-stone pitch. For the first 25 seconds of the work, it is the only pitch present (all timings used in the analysis reference the Ligeti Project II recording.)\(^\text{19}\) The functional significance of pedal notes and their ability to transform into melodic notes with a propensity for progression is evident in the first 11 measures of the work. At the end of the first

\(^{18}\) Gyorgy Ligeti, Four Interviews, 29.

\(^{19}\) Gyorgy Ligeti, 2002, Lontano, The Ligeti Project II. Teldec Classics, OCLC 50157160.
melodic statement of the canon theme in the first flute (Ab, Ab, Ab, G, Ab, Bb, A nat., Bb, Ab) the concluding Ab no longer sounds like a melodic center as it did in the first few measures of the line. Rather, by measure 9, A natural has been established as a center instead by the downward resolution of Bb. The reemergence of Ab as a dissonant non-pedal tone in m. 11 indicates the important function and progression (and even hints at modulation) in the development of canonic texture in the work.

The unique role of the Ab at the work’s opening is established at least in part by traditional means; the repetition of the tone is further enforced by the voice-leading of the main canon-melody. Although most of the significant structural pitches do grow out of the canon motives, there are two other structures that reinforce pitch significance. These include the perfect fourth-based counter-motive first seen in the double basses after Rehearsal Letter A, and the structurally significant octaves, unisons and tritones which tend to start or conclude important melodic statements. (The composer mentions the significance of these verticalities in his interview with Josef Hausler.)

By the point that the last voices of the first canon fade completely by measure 13, the second wave of canon motion (mm. 12-19) has already begun to dominate the texture. The overlap of the first canon’s conclusion in the flutes with the beginning of the second canon in the oboes and violins creates a short transitional space that leads to a seamless joining of Phrases 1 and 2. This new set of micropolyphonic entries associated with the second canon motive points to a different (and much weaker) pitch center of E, which is actually first implied in the secondary voices associated with the first canon through the resolution of the double bass F#-B motive in m. 11 to an E-F#-A-B tetrachord by m. 13, and then is reinforced in canon 2 by the oboes with their

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20 Gyorgy Ligeti, György Ligeti in conversation, 28-29.
emphasis of B in mm. 14-15. The entries of the second main canon motive on E in the bassoons (m. 13) and flutes (m. 14) is echoed at the fourth (on A) in the strings in the following measure. This represents a fourth-based departure from the temporary pitch center of E, which is further reinforced by the flute entry on A in m. 16. The second wave of micropolyphonic motion fades away around m. 18 on a D#, only to be followed by a second set of entries on C# and D# beginning in mm. 17-19, and a third set of entries around Rehearsal Letter D in m. 22. Together, these three short polyphonic sections comprise Phrase 2, which runs until the C entry in the flutes in m. 31.

This second phrase of the music has a curious function in light of the music that precedes and follows it. Although the shift to a weak implied E center from the work’s opening Ab seems at first to do everything but reinforce Ab as an important pitch, it does provide for a somewhat more motile second phrase, creating energy towards the resolution of section 1 to C. During Phrase 2, the importance of Ab is never lost. In fact, the tendency of the temporary E center in Phrase 2 to descend (directly or indirectly through polyphonic motion) a half step to D# allows a return to Ab (enharmonic G#) in the flute’s third canon entrance in mm. 19-20 through a downward movement by a fifth. The quasi-tonal fifth-based D# to G# descent helps to prolong Ab as the clear primary pitch in the opening section of the work (mm. 1-41). Throughout the transitional second phrase, Ab remains as a point of repose, with an important function in the opening of the third part of that phrase through the polyphonic entries in m. 22. Its significance is retained through prolongation until C emerges as a very important new corner-stone pitch in the flutes in m. 31. However, the overlap of Ab and C around the beginning of the third and final phrase of section one (around Rehearsal Letter E), along with the
implication that C is the third of the Ab major triad, facilitates the prolongation of Ab through C until the first section ends in m. 41. The noise content of the first section of the work mirrors the harmonic development in the first 41 measures. Figure 2.1 shows the noise content graph of this section of the work. The horn is chosen as the opening instrument, one that according to noise content testing tends to produce a relatively low level of noise when compared to other instruments. In fact, the entire first phrase of the work, in which Ab is introduced and developed, remains the least noisy portion of the first section, averaging a noise factor of about 0.53 for the first 49 seconds. Because the instrumentation does not change much during the phrase, there is relatively little change in noise content throughout the phrase, with a total change of .17. The noise produced in phrase one is consistent with the character of the phrase, which remains static throughout. It is more or less a directionless statement of harmony; an exhibition of the first corner-stone pitch.

![Figure 2.1. Noise graph of Lontano, Section 1](image)

Figure 2.1. Noise graph of *Lontano*, Section 1
In contrast to the static nature of the first phrase, the second phrase is shaped more by timbre, and consequently, the noise profile differs. Lacking the clear central Ab, the harmonic motion of Phrase 2 works to prolong Ab while moving clearly towards its goal of C. Each sub-section of the phrase has a different noise contour, beginning with the transitional material in mm. 11-13, which shows an increase in noise over the material of Phrase 1. The first sub-section of Phrase 2 (mm. 13-18), shows a slight but steady increase in noise production, caused primarily by the slow emergence of the strings, and accented by the thick vertical cluster chord around m. 17. The second section of Phrase 2 (mm. 18-22) actually shows a decrease in noise content, but the final section shows a dramatic increase in noise, further spurred on by higher dynamic levels in the strings, culminating at the important entry of Phrase 3 on C at m. 31. The meandering path towards higher noise content and the eventual goal of C reflects the nature of Phrase 2. Without clear harmonic direction for much of the phrase, the composer keeps timbral intensity in check as well, only ramping up the energy and noise content when the trajectory towards C emerges. Overall, Phrase 2 does show an increase in noise content over Phrase 1, with an average noise output of 0.7. Overall, the total change in noise level throughout this phrase is higher at 0.25 than either other phrase in Section 1. This contrast reflects the eventual motion from Ab to C through transition and prolongation.

The final phrase of Section 1 clearly emphasizes the importance of corner-stone pitch C. Once this emphatic arrival opens the third phrase at m. 31, there is nowhere to go but down to a point of repose, and the noise contour outlines this motion. However,
the composer keeps the noisier instrumentation including strings at high volumes for some time, affecting a decay with some peaks and valleys, and relatively high noise content until the final arrival on octaves at C in m. 40. The total change in noise content for Phrase 3 is 0.24, and the noise average is 0.72, slightly higher than the previous phrase.

In the absence of such clearly defined linear motion as was found in Section 1, much of my focus in the rest of the work turned in more detail to considerations of vertical incidences of consonance and dissonance, beyond simply focusing on points of pure unisons and octaves, as were seen in measures 1 and 41. The benefit of considering vertical structures alongside noise was caused by the fact that thick dissonant sonorities can add perceived intensity to musical textures, in much the same way that noisy timbres can. The danger in correlating vertical dissonance with noise was large, however, as test data showed conclusively that dissonant chords often contain less noise than consonant chords played by the same instrument at a similar register. Fortunately, this apparent contradiction was overcome in cases where the composer increased intensity by coupling dissonance with other factors (such as extremely high dynamics, or timbre) that do tend to increase the physical presence of noise. In other cases the contradiction was emphasized in situations where dissonance is coupled with timbres containing relatively low noise, creating a somewhat static dissonant fabric that served well in places such as transitions where there was little need to change the level of energy present. The interplay of dissonance and noise content became increasingly evident throughout the rest of Lontano, as the composer distanced himself from the vertical consonances presented in the first section.
Since octaves, unisons, and clear corner-stone pitches are increasingly less clear in much of the music after measure 41, the importance of contrasting harmonic structures with varying degrees of dissonance becomes more evident. This is clearly the case in defining the function of sonorities in the fifteen-measure transitional section beginning at m. 41. The transition is marked by a progression from dissonance to consonance through minor second-based chromatic fabric in the bass voices at the beginning of the section to a clear open fifth between the trombones and tubas by measure 55. The emergence of consonance from dissonance is then quickly pushed to the back of the memory by the tritone-based chord opening the second main section in m. 56.

Figure 2.2 presents the noise graph of the transitional section from m. 41 to m. 55, ending where the consonance of the perfect fifth is most noticeable and pure. With the exception of the clear dip in noise content with the consonance at the very end of the transitional section, the trajectory of noise content does not correlate as clearly with specific points of dissonance and consonance as it did earlier in the work. Instead, the noise levels stay relatively static while the harmonic development unfolds. This trend is different from the tendency, seen in Section 1, of noise content to grow towards important formal junctures, but since the function of this transitional section is to be a relatively static bridge between sections, the consistency of noise is appropriate. Although the amount of change in the noise factor is similar to the change in the last two phrases of Section 1 (at 0.23), the trajectory is not clearly directed towards a particular point, and the overall average noise levels here are relatively low at 0.66, keeping any energy created by the opening dissonance and the progression to consonance in check.
In fact, all of the required forward motion is provided by the harmonic features of the transition, and the relatively constant noise content provides some stability, keeping the section from moving forward too quickly.

![Graph](image)

**Figure 2.2. Noise levels in *Lontano’s* first transition**

The ability of this part of the music to halt any notable change or progression in noise content while simultaneously undergoing one of the most obvious harmonic progressions from dissonant to consonant found in the work makes the new entry of Section 2 on the tritone at m. 56 all the more noticeable. Almost as though the change from a minor second to a perfect fifth was not enough to move this music forward, the strongest transitional interval from common practice was called upon to push this music into the next section.

The use of the tritone to open Section 2 is as significant as the resolution of previous sections to a consonant octave or fifth. As if the tritone were being used as a signifier of harmonic tension to be established through dissonance to come, the “devil’s interval” ushers in the longest and most dense section of the work. This second section
of Lontano runs from m. 56 to m. 120. There is not such a clear linear progression based upon interval found here as there was in the first 41 measures as many pitches come to the forefront for a brief period of time, and often the density of the sonorities prevents clear single pitches from sounding out in the fabric of the composition. This is emphasized through contrast when at the very end of the section F emerges suddenly from the fabric as the only pure octave pitch heard in over four minutes of music. Unlike the C resolution of the first section which was clearly prepared and approached for some time m. (mm. 31-41), the preparation for the resolution to F in m. 120 starts at the beginning of the section, and is swept under the surface texture of the music for many measures while the timbral affects of the dense chords are pushed to the forefront. The tonal implications of beginning the section on the Bb-E tritone in m. 56 and ending it on F by m. 120 are not obvious to the casual listener, but are better revealed through analysis. Also, the descent to F by fourth in mm. 73-75 in the horns, does not immediately reveal its structural significance in the big picture of the section, although it does provide a moment of melodic clarity.

After m. 75, the music is dominated by thick chords created by the micropolyphony of the melodic lines. Although there are no more trademark unison arrivals until the F resolution in m. 120, the melodic lines themselves are designed to provide some harmonic continuity in light of their starting and ending pitches. For example, in m. 88, the first solo violin arrives at C, and commences its next line on G, two octaves below. Although this moment is blurred by the fact that the different lines all arrive here at different times, this melodic reference back to the C of the first section, and the implication of C’s continuing importance in this section has some structural
significance. Although C is not used in a context here that would allow it to serve as the dominant fifth of F, the fifth based relationship of C and G echoes other points of emphasis for this interval found in the work, and sets the precedent for the background level progression of the C resolution of the first section to the F resolution at the end of the second section.

Perhaps the most notable harmonic/melodic feature of the second section comes about 30 seconds before the eventual resolution to F. As the directionless sweeping lines of the seventh minute of music slowly fade, an Fb at FFF dynamic levels momentarily appears in the double basses around 7:40-7:45. Enharmonically, this is the same E that comprised the top note of the opening tritone for the section, and functions as a leading tone for the resolution to F at the end of this section. But even this clear harmonic symbol is blurred. Instead of a strong resolution to the final pitch of the section, the Fb is allowed to fade, and when F slips to the forefront around 8:15, it is more as a dissonant minor second overlapping with a fading Fb, than a resolution by half step to a pitch center F.

As the longest and most complicated section of the work, Section 2 displays a clearly directed contour towards the final F around 8:15 to 8:20, without approaching it as definitely or decisively as C was approached in m. 41 at the end of Section 1. In fact, in keeping with the long, indirect, and somewhat unfocused approach to F in this portion of the music, the noise graph of the entire section shown in figure 2.3 displays less defined contours towards specific formal junctures than do the noise graphs of Section 1 or Section 3. To some extent, the approach to F in this second section marks a departure from the clear emphasis of pitch in the linear motion of Section 1, and this
departure is reflected in the less obvious noise contour as well. Although the eventual movement to a pure octave is clear marker of Ligeti style in this and other works, the large-scale progression here is away from clarity and towards obscurity, perhaps a reference to the work’s title. The end of Section 2 marks the last time that a unison or octave is heard in the work.

Figure 2.3. Noise in Lontano, Section 2

Given the progression of the music to this point with the ever-increasing programmatic implications of the title Lontano, there appears to be a continued decrease in harmonic focus at the opening of the third and final section, which is not progressing towards a single pitch-class resolution. Instead of opening with a unison or even the recognizable tritone found in previous sections, Section 3 starts out with a D-
G-F-Bb cluster—hardly a strong dissonance—but certainly less focused in the sense that the sonority provides neither repose nor an urgent need for resolution. However, on top of this non-descript and distant musical fabric, there are important melodic entrances on D at m. 122 and on G at measure 127. These points of entry are notable because the separate voices enter simultaneously at the octave as they introduce the motives used for contrapuntal development in this last section. This presents a contrast in approach from earlier sections where lines started separately and eventually joined together at a focal pitch in octaves at the end of a section. Here, the voices start together and then the music unravels into thick polyphony, establishing a new function for the octave in this section. While the octave was previously used as a point of repose, here it functions as a point of departure heading towards the increasingly dissonant and noisy climax of the work found from about m. 137 to m. 145. Figure 2.4 shows the noise graph of the third section.

![Noise graph of Section 3, with the octave openings of phrases marked](image-url)

Figure 2.4 Noise graph of Section 3, with the octave openings of phrases marked
Each entry is marked by an increasing noise levels creating a dissonant decay of consonant beginnings. The overall effect is a powerful departure from organization and order as the octave—the single vertical structure that had served as a point of repose for previous sections—is allowed to evolve into dissonance and noise. As the symbolic function of the octave dissolves and the music continues to unfold, it becomes clear that unisons, octaves, and consonant chords no longer have a place in the musical fabric. In fact, as noise increases towards a point of saturation at m. 137, the composer adds more dissonance, leading to the climactic section of the work commencing with a chord containing 11 pitches and many noisy timbres.

After several measures of loud and dissonant polyphony, including the point of the highest noise level in the work (0.86 at m. 139), the composer makes one last symbolic approach towards an octave D# in the highest voices at m. 145. However, the previously established function of the octave has been destroyed, and the lower voices are not compelled to join in the consonance. The composer further de-emphasizes the function of the octave as a point of repose by using noisy timbres here contributing to an overall noise factor remaining in the range over 0.8. The D# of measure 145 is allowed to decay for the next several measures, finally disappearing by m. 154. The failure of this octave sonority to accomplish any sense of repose signals the coming end of the work. The remaining minute and a half of polyphony is unfocused, quiet and generally inconsequential. The music finally disappears into dissonance with a cluster on B, C# and D at the very bottom of the clarinets’ register, supported by the bass clarinet. Strikingly, the composer chooses instrumental timbres with little noise here, somehow
creating a point of uncertain, static repose in spite of the lingering dissonance as the
music fades into the distance.

Programmatic considerations aside, Lontano’s form represents a departure from
order and consonance. By carefully controlling the musical parameters of timbre and
dissonance that govern the development of most of his works, Ligeti created a
compelling journey which moves from near to far. The noise graphs for the entire work
shown in figures 2.5 and 2.6 give one perspective regarding how this motion is
achieved. Figure 2.6 is the plot from a second recording of the work, demonstrating that
noise contour can be similar between different performances of the same work.21

Summary of Noise in Form

Both graphs visually present a compelling summary of the Lontano’s form. The
first section represents a motion towards the C octave in measure 31, which can be
considered the clearest crystallization of consonance in the entire composition. In spite
of the fact that this is a consonance, the composer used timbre, instrument range and
playing technique at high volume to increase the noise level and energy at this point.
Representing the second highest area of noise content in the “Ligeti Project” recording,
this preliminary destination of the work provides the point of departure needed to
articulate the rest of the form. The second section of the work is longer, and shows a
well-rounded arch-shaped contour. As mentioned before, this section does not contain
any clear formal signals that rival the importance of the C octave from mm. 31-42, But
because this section marks the main development portion of the work, the composer
kept the noise level relatively high. Coupled with the dense polyphonic development and
rich timbres, this noise keeps the motion going forward in the work’s longest section.

The third section represents a reversal in the meaning of the octave, leading to the climax of the work. While the octave C in Section 1 represents the highpoint of the section after which the energy and noise levels necessarily had to decrease, the octave entrances at m. 122 and 127 mark relatively low energy entrances, which simultaneously develop and decay into magnificent polyphony. As the octave’s meaning is redefined at this point so that it can no longer function as a point of repose, the climax builds to its noisiest and most dissonant point at the work’s climax after m. 137. Once the octave no longer serves as a point of resolution, noise and dissonance slowly fade, but never to a clear ending as the work fades into the distance.

Noise plays an important role in the form of Lontano, working alongside consonant and dissonant sonorities as they shape sections and sub-sections. There is a complimentary relationship between noise level and types of sonorities, as each helps to define the function of the other, simultaneously reinforcing allusions to past practice, while creating an overall sound which is altogether new. Likely listener assumptions about the propensity of consonant sonorities to lead to resolutions are complimented by equally likely assumptions that noise must create tension, and the lack thereof leads to repose. The slow unfolding of Lontano allows for gradual interpretation of noise on a large scale, allowing noise to often take a background level role in defining the form of the work. The next work I analyzed (Chain 1) presents a contrasting use of noise, pushing it to the foreground level almost immediately. Also the role of noise in the resolution of tension is handled differently in Chain 1, with a more radical approach to its possible function, and little reference to past styles.
Figure 2.5. Noise in *Lontano*, full work, from the Ligeti Project recording
Figure 2.6. Noise in *Lontano*, from the Wien Modern recording
CHAPTER 3

LUTOSLAWSKI’S CHAIN 1: NOISE AS REPOSE

In Lontano, the focus of analysis was on how noise content aids in defining large-scale form. As previously noted, while the mix of new and traditional compositional elements in Lontano made some aspects of analysis difficult, the tendency to close sections with cadential patterns, often carefully prepared and followed by clear transitional material, helped the work retain some semblance of traditional musical form. And while the dense micro-polyphony present in Lontano rendered the individual characteristics of single lines and notes largely inconsequential, the reference to canon and layering of similar lines in contrapuntal fashion was more an extension of older practices than a departure from them. As I considered the nuances of Lontano, the composer’s careful noise control on the large scale coupled with cadential patterns resolving to less noisy material made it easier to understand the form of this long and complex musical work.

In Lutoslawski’s Chain 1, the composer’s control of noise also relates to the overall form, but noise interacts with smaller formal features of the work in ways not seen in Lontano. The following pages examine the function of noise in defining a form that bears less obvious similarity to forms from past musical times. This is not to say that the formal constructs of Lutoslawski (in this work or others) were not influenced by tradition, as there are in fact some implicit references in Lutoslawski’s works to Western musical tradition. Particularly important to this analysis is the fact that in the corpus of Lutoslawski works written before Chain 1, the composer relied heavily upon the

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“expectation-resolution or implication-realization model of perception, so firmly entrenched in the traditional Western ways of making and receiving the musical experience, in contriving to elicit affective response.”

If applied to Chain 1 as well, this model of composition would link the structure of the work in an organic way with the structure found in *Lontano*, which clearly relies upon the arrival on a single pitch as that point of “resolution,” prepared through “expectation” that dissonance must come to rest on consonance.

But in many ways, *Chain 1* demonstrates at least a partial break from both the Germanic tradition of large orchestral forms which rely upon cadential division of sections (as seen in *Lontano*), and the concept of the “expectation-resolution model of perception” noted above. Although the work ultimately can be segmented into a few cadence-punctuated units, chain technique and aleatoric polyphony cloud the form of a work which is clearly moving away from a focus on closed sections towards a focus on compositional processes. While the work is similar to *Lontano* in the sense that both make extensive use of counterpoint and polyphony, Lutoslawski’s texture is sparser, relying upon the characteristics of each individual line more than the affect of the sum of the lines in directed cadential conclusions. Furthermore, Lutoslawski’s "chain" technique for linking musical ideas (if fully executed) would render the cadence (so important in *Lontano*) an unnecessary relic of the past. In *Chain 1*, there are still some cadential patterns, but many of those do not retain the same level of structural importance as the carefully prepared sectional cadences in *Lontano*. Instead, cadential patterns are used primarily at the end of short motives and signal only the cessation of a phrase or the

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transition between short phrases, rather than the completion of a section. Often, these phrase endings overlap with the beginning of the next phrase, obscuring the cadence.

In those few places where the lines do come together to form a dense vertical block of sound, the resolution of that sonority is key to understanding noise control as it relates to the overall form of the work. In these instances, the function of the “expectation-resolution” model (if present in the composition) should be readily identifiable. In this case, these vertical structures do serve as markers delineating the large-scale form in much the same way that resolutions of dissonance to consonance function in common practice music and in Lontano. However, the majority of the work is not focused on preparing for these culminations, nor is it focused on them. Instead, the listener’s attention is subsumed by focus on less significant internal cadences, series of repeated notes that fail to lead to a resolution, and juxtapositions of short motives or “chain links” that exist more to be appreciated in the moment than to develop into something larger. An analysis of noise function in Chain 1 must account not only for the contours that lead to resolution, but also for the noise patterns, or lack thereof, that exist in sections where process is key and resolution is not an obvious object or goal.

To analyze Chain 1 using noise control as a formal principle, one must consider certain concerns not considered in Lontano. First, the timbre of individual instruments has much more impact on noise content at the surface level, as they often play alone or with sparse accompaniment. Second, held notes, attacks, and decays have much more significance in noise analysis in Chain 1, as they are most often exposed. Finally, a clear distinction must be made between the function of noise on the foreground scale, and its function within the overall form. In analyzing Lontano, an individual line would
rarely have been considered in detail, but here it is often necessary to do so. However, it is important to note that rapid fluctuations in noise level do occur because of the prominence of individual lines. When looking at large scale form, these fluctuations must be accounted for before the overall contour of the background level form, as revealed through noise content, can be understood.

The First 19 Seconds

Chain 1 opens with a gesture that immediately demonstrates a compositional approach different from Ligeti’s slow thematic development found in Lontano. The rapid opening sweep upward and downward to held notes is also atypical for Chain 1; in fact, it is one of those rare places where all instruments seem to work together towards a common goal in a single held chord. That is not to say that this gesture doesn’t fit in with the rest of the work; after all, each voice arrives on a held note at a slightly different time, consistent with chain technique. Nonetheless, this is a unified gesture, pointing to the opening anchor of the work.

While Ligeti’s tall vertical sonorities were carefully prepared consonant cornerstones, Lutoslawski’s idea of temporary repose displayed in this opening is a dissonant sonority comprised of an aggregate chord, prepared by a rapid, chaotic cascade of pitches and timbres. In Lontano, the “expectation-resolution” model could still be observed, because the corner-stone sonorities were often a consonant resolution of dissonant material. But in Chain 1, as evidenced by the opening sweep to a dissonant held chord, the resolution of dissonance to consonance is not present. Although one could argue that this is simply a reversal of the “expectation-resolution” model, with a
consonant unison opening up to a dissonant resolution, the twelve-tone chord at 00:06 just before Rehearsal Letter 2 does not function as an important sectional marker; and it can hardly even be called a cadence. The eventual return to the unison pitch at the end of the introduction doesn’t serve much functional purpose either, but is rather a simple regression back to where the music began. In fact, it could be considered a negation of any functional process already established in the work.

With traditional progression models not present, the noise analysis of the opening is key to understanding its construction and function. The aggregate chord at 00:06 carries a noise factor of 0.7, relatively high for a held sonority containing no attacks. The cascade of sound leading to this chord contains a noise level as high as 0.77, a level not found in Lontano until after more than two minutes of the work. The opening gesture of Chain 1 emphasizes the composer’s propensity towards rapidly changing movement and texture—a dramatic and chaotic affect marked by high levels of noise.

After a brief sustain of the aggregate chord, the next gesture ensues—another cascade of notes in either direction, this time towards a second aggregate chord. Noise content displays more variation here, with the opening cascade for the second gesture (at Rehearsal Figure 2) falling from 0.8 to 0.67 during the second held sonority. Finally near 00:11, near Rehearsal Figure 3, a repeated note on a single pitch begins to emerge from the texture. This B, first heard in the trombones and subsequently imitated by the other instruments, is repeated seven times and leads to the conclusion of the opening material, with noise levels falling to as low as 0.57 around 00:19. Rather than

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3 All timings for Chain 1 are based upon Witold Lutoslawski, 1989, Witold Lutoslawski, Volume 5, Polskie Nagrania Muza, OCLC # 12127698.
functioning to provide extended repose at the end of a section as might be found in Lontano, the unison pitch found here does as much to push the music into the next section through the rhythmic energy generated by repeated notes, as it does to close the section. This may be in part because the repeated note is not part of a prepared cadence, but more of a rhythmic development growing out of a dramatic gesture. Although lower noise content, a decrease in dynamics, and a reduction of dissonance is used by the composer to shape this section of music, the function of this repeated note (and others seen later in the work) carries less large-scale significance than similar gestures did in Lontano.

Several lessons were learned from the use of noise as it relates to form in the first nineteen seconds of Chain 1. The introductory material showed a compression of musical ideas unlike anything found in Lontano, but the importance of noise control in shaping the contour of this portion remained significant. Although defining only small scale form, the pause found at 00:19 was essential in closing off the introductory section in a work where points of closure such as this one are very few and far between. At the same time, the energy and continuation created by the repeated note patterns found here set the precedent for the incomplete conclusive function of the repeated pitch. In other words, although the unison was used to close the introduction, the repose was not complete, creating an uneasy energy that will be played out later in the composition.

While Chain 1 makes few if any allusions to common harmonic practice, the patterns exposed in the introduction demonstrate elements of formal control that are used throughout the work. In fact, the aggregate chord and the single repeated pitch are the two most important pitch-based formal markers found throughout the rest of the
work, although they seldom can be found in such close proximity again as the form unfolds. Charles Rae argued that the symbiotic relationship between these two markers demonstrates a principle of expansion and contraction which defines the form of the work. This argument is helpful in understanding why the single pitch as a repeated note does not function to create the same level of repose that it would have generated in *Lontano*. Standing at opposite ends of the pitch density spectrum, neither the aggregate nor unison is able to function as a static or final ending point. Rather, each represents an extreme of the possible degrees of density, where the natural progression of either is to move towards the opposite and neither is more important than the other. This relationship sets up an engine to create textural change and forward motion, but neither the unison nor the aggregate is capable of functioning as an ending in and of itself. Instead the two mark the outside limits between which the pendulum of musical generation swings, and neither is able to close the work, but instead both create a sense of perpetual motion, as each are defined as needing to proceed to the other.

Figure 3.1 shows the small-scale noise control in the opening gesture of *Chain 1*. The intricate shaping of noise content corresponds perfectly to the shaping and intent of the introduction, providing a general downward trajectory toward the unison. Each attack or cascade pattern is very similar in its noise content, while each successive held chord or decay pattern is slightly lower in noise, leading to the eventual repose of the unison repeated pitch. Here the small-scale use of noise shapes the form of a very short section, in much the same way that noise shaped large sections of *Lontano*.

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The opening of *Chain 1* is an unusual portion of the work in the sense that it is comprised of very clearly shaped phrases punctuated by large tutti attacks; the chain technique and aleatoric polyphony that define the rest of the work are not very prominent here. Aside from the introduction, the work can be divided into two main sections. The first begins directly after the introduction and runs until Rehearsal Figure 40, where the second section begins and runs up to the climax, which is punctuated by the tam-tam at rehearsal 47. The first main section makes extensive use of Lutolawski’s so-called “chain technique,” while the second is marked by dense aleatoric polyphony. After the climax, the music concludes with some sparse closing material, which briefly recalls features of both chain technique and aleatoric polyphony, balancing the overall form in light of the introductory material seen at the beginning. Figure 3.2 illustrates the division of the full work into sections as seen through noise contour. The marked difference in compositional approach between the two main sections is demonstrated.
through noise analysis, revealing a more variable first section contrasting with a second section which remains much more static until the climax near the end.

Figure 3.2. Sectional Division of Chain 1

Section 1: Chain Form

The chain technique that dominates compositional process and form throughout the first half of Chain 1 has been described by Lutoslawski as a method that achieves a departure from traditional sectional form, or an “alternative conception of leaving one musical thought for another… [through] asynchronous superimposition of two layers passing on to another section independently.”5 In this portion of Chain 1, many of the defining features of the work can be found in the independent lines comprising links of the “chain.” The method of creating links varies throughout the work, and while it is possible for a musical idea to flow seamlessly into another, there are many times when one phrase may end abruptly and the listener’s attention is snatched away by a new

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musical idea growing out of accompaniment to the previous motive. Also, different links of the chain may take on different functions such as melody or accompaniment, and the function of an individual link of the chain may change based upon the context in which it is heard.

Overall, it was clear from the noise analysis alone that as the "chain" of musical ideas was developed throughout sections of the work, the composer exploited the possibility of using widely varying timbres and textures, even making allusions to musical material from the introduction as each independent line became woven into the fabric of the chain. Although the concept of “chain” seems relatively straight-forward in the composer’s description, the unconventional fragmented texture created in Chain 1 raises an interesting question about the technique. If the form was in fact designed to create long and continuous portions of music without the interruption of important cadences or other sectional divisions, was that goal of continuity actually achieved? A cursory look at the noise graph for this section would indicate this not to be the case, unless the constant variety and flux of the different musical ideas and timbres actually became the unifying concept providing musical cohesiveness to this section. In fact, one scholar has gone so far as to liken the chain form found here to Jonathan Kramer’s concept of the highly discontinuous “moment form,” eventually rejecting that idea in part because musical ideas in Lutoslawski’s chain are in fixed order. Instead, Chain 1 can be considered to employ a "discontinuous chain technique" where continuity is

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6 Nikolska, 308.
7 Rae, 178.
8 Klein, 314.
9 Klein, 315.
achieved through the expectation of flux in both timbre and thematic character throughout the first section. This pattern of flux is clearly illustrated by the noise contour plot.

In spite of the disjunct nature of the surface texture in Section 1 of the work, further analysis showed that this is no simple or randomly conceived conglomeration of short themes; instead, the first section is comprised of a carefully ordered and crafted progression of events leading to a stark contrast to the highly continuous texture of the aleatoric polyphony in the work’s second section. The means to this end involves a gradual increase in variety and discontinuity, leading up to the junction between the two sections. The understated nature of the musical strand commencing after the introduction serves as a starting point to develop this progression, while also providing a contrast to the extreme swings of dynamics, timbre, and noise content in the introduction.

The noise contour present in the first part of Section 1 demonstrates the composer’s effort to start the section in a manner that displays little variety, and then to slowly depart from this as the thematic discontinuity of the compositional technique becomes more pervasive. When the clarinet enters after the unison decay at the end of the introduction, it ushers in a section without the dramatic peaks and valleys of the opening. This subsection of the work is marked by solo or sparsely accompanied entrances by instruments whose timbre is generally pure, complimented by playing technique and dynamic levels which do not introduce much noise. In fact, it is not until the 1:37 mark (after Rehearsal Figure 13) in the music that a noise level as high as the .8 factor seen in the opening 19 seconds is found, and only at the 2:53 mark (Rehearsal Figure 24) does the noise level finally dip lower than the 0.57 found in the
introduction. This initial leveling off of musical contour plays well into the composer’s concept of form; now that the drama of the introduction has run its course, the “chain” can be developed in line with the composer’s conception of systematically linking together its musical parts.

It is not long, however, until the larger formal scheme begins to reveal itself, as noisier musical material is inserted into the texture. However, even this is done in a subtle manner. When the xylophone enters just before Rehearsal Figure 14, its timbre along with the cembalo’s, pushes the noise towards the highest point heard thus far (0.882 at 1:40), yet the affect is neither dramatic nor forceful. Instead, the brighter timbres set the stage for more musical variety to come without disrupting the serene nature of the music currently being heard. This point displays the highest noise level found anywhere in the work except for the climax. This subtle point of intensity ushers in a pattern of alternating focus on solo and ensemble chain links, with initial focus on the solo lines. This focus is prevalent in the ensuing 92 seconds which mark a slow fall in noise levels from the 0.882 down to 0.486, showing more variety in thematic content, timbre, and noise level change than previously seen in the work. Once this low point is reached, the focus slowly shifts toward ensemble sections of the music, building the noise levels back up in the fourth minute of music to average levels higher than have been seen in most of the work. But the alternation of solo and ensemble continues, contributing to a continued disjunct texture in an area of higher intensity, where the constant flux between different links of Lutoslawski’s chain becomes more prominent. This continues to be the case until the section nears its end at 5:03 (Rehearsal Figure
40). By this point it is clear that the increase in rate of flux in noise levels is part of the large scale formal scheme in preparation for the transition to the second section.

One other key feature of the first section is the continued emphasis on repeated unison notes. While the repeated note, the octave, and unison iterations of the same pitch served in *Lontano* to indicate the end of a section and pointed to some sort of pitch centricity, here their function is limited to the very small scale. Instead of being carefully prepared markers of important formal junctures, the repeated notes in Section 1 serve often to abruptly conclude individual links of the chain, as seen in the clarinet after Rehearsal Figure 5, or in the cello after Rehearsal Figures 34 and 37. Although the repeated pitch is a B natural in both the end of the introduction and in the clarinet passage immediately following this point, the pitch class used in subsequent repeated note passages seems to vary in an unpredictable way, doing away with any semblance of centricity that may have been implied. Instead, the repeated unison pitches serve two simple functions. In addition to articulating the end of individual chain links, they also serve to help vary the noise content in line with the composer's large-scale formal plan. This is possible in part because the repeated notes create enough rhythmic momentum to propel the music while allowing the timbre of individual instruments to be displayed. In the case of the clarinet’s relatively pure timbre after Rehearsal Figure 5, repeated notes here contribute to a decay in noise content, but when a similar repeated note pattern is found in the xylophone after Rehearsal Figure 14, the repeated notes actually serve to prolong the high noise content and tension contained in the percussion instrument’s timbre. Therefore, the repeated notes play well into the composer’s concept of musical flux while emphasizing the differences in individual instrumental
timbre. The energy of change which moves the disjunct Section 1 forward is punctuated by the repeated note.

Section 2

One notable omission of a repeated note pattern is found directly before the transition to Section 2 around Rehearsal Figure 40. As if to emphasize the lack of large scale function given to the repeated note pattern, none are used here at one of the work’s most important sectional breaks. The music that follows is radically different from the chain-inspired content of the first half of the work. Dominated first by the strings, this second section represents a musical conception opposite to that of the beginning of the work. Instead of moving quickly between chain links of vastly different character, the aleatoric polyphony here is characterized by multiple repetitions of the same theme, varied slightly in different instrumental voices. The slight variations lead to eventual development, moving towards the introduction of a new solo line with new accompaniment in the trombone 6 minutes and 11 seconds into the work at Rehearsal Figure 42. At 6:45, just after Rehearsal Figure 43, this solo material is marked by new, more accented accompaniment, leading to new material in all instruments at 7:12 (Rehearsal Figure 43), and a long section of repeated notes starting at 7:37 (after Rehearsal Figure 45) and carrying (with some variation) through to the climax at 8:27 (Rehearsal Figure 47). In other words, five musical ideas are able to sustain nearly three and a half minutes of music in the second section, where as many ideas would have occupied less than a minute in Section 1. The economy and consistency of parts shown here in the second section not only provide a strong contrast to the discontinuity
of first section, but also allow the composer to create larger continuous gestures not yet seen in the work through careful thematic development and manipulation of noise.

A look at the noise contour of Section 2 confirmed that the constant musical flux of Section 1 is absent here. In fact, in spite of the much thicker texture, not only does the flux in noise levels even out, but the noise levels settle at a moderate level, seldom reaching the level of 0.8 seen at many instances in Section 1. Part of this is a direct result of playing technique; certainly it is not due to instrument choice, as most all instruments present in solo settings in the opening sections are playing in ensemble here. The smooth contour found from 5:03 to around 8:20 is not without its variation, but the overall plot of the noise graph is generally flat. The variations that do exist present themselves first as subtle waves from 5:03 to around 6:11, with a shift to a more uneven, meandering pattern afterwards, but even this portion is smoother and moves in a narrower range than the music of the first section.

One of the most curious features of Section 2 is that the composer chose to build towards the climax of the work with a section that does not elevate the noise content towards its conclusion. Given the patterns seen in *Lontano*, and the fact that playing techniques and dynamic levels often characteristic of approaches to climaxes found in common practice music do raise noise levels, one would expect some similar pattern to be found here, especially in a work where the climax is so dramatic. But since this is a work where the “expectation-resolution” model does not operate, any large scale formal function must be understood through other means. One explanation is that the contrast itself between the first and second sections may be sufficient to build energy to the climax. Although this is partly true, this explanation does not account for the fact that in
spite of a lack of increased noise, there is a marked increase in perceived volume and intensity towards the end of the section.

The answer to the problem lies in the unconventional usage of the repeated note and aggregate chord. Throughout common practice, the repeated pitch often signified a point of repose or centricity; and even in works like *Lontano*, where tonality was primarily lost, the simple allusion to a pedal tone with the potential to possibly establish a tonal center was enough to aid in the release of tension or an approach to a cadence with decreased noise levels. But by this point in *Chain 1*, the repeated note has already been robbed of its traditional ability to resolve tension because of the way it is used in Section 1. In fact, despite the stark contrast between the two main sections of the work, it is the precedent of non-functionality of the repeated note established in the first section which allows for its surprising use in the second section. In other words, in Section 1 the use of the repeated pitch was marked by the fact that the composer was not using it in a way that could create centricity or provide repose, even though in a different context, such a function would have been possible and (in a different work), musically appropriate. Here in the second section, however, tension is created by the repeated note’s total inability to provide closure, because any context which would allow it to resolve has been removed by the first section. The percussive explosion of the climax marks the culmination of this tension.

In large part, the success of *Chain 1* is based upon the rejection of centricity and functionality, not only in the area of pitch, but also in the realm of traditional musical form. As *Lontano*’s many allusions to common practice form and harmonic practice provided a frame of reference in which it can be understood, so the adamant rejection of
common practice devices observed in *Chain 1* provides a similar, if antithetical, context for its interpretation. Two elements of the long repeated-note approach to the percussive climax illustrate this concept well. The first occurs around the 8:00 minute mark (after Rehearsal Figure 46) where all instruments approach a Bb while playing rapid repeated notes. In *Lontano*, this might have been enough to establish some sort of formal marker or pitch-based point of reference, but here it is almost immediately swept away as a meaningful but futile reference to practices of the past. Six seconds later, the instruments spread out to form an aggregate chord (minus an F natural). This gesture has the potential to accomplish two things. First, it is in many ways a mirror of the opening gesture of the work, which also took six seconds to expand from a unison to a 12-tone chord. If some functionality based upon musical patterns had been established in the work, perhaps this gesture could have led to some finality. Second, as important as the 12-note chord is in this work, perhaps its near re-emergence here in this context could have established it as some substitute for a tonic chord; perhaps a resolution to a point of “equal centricity” of all twelve pitches could have been created. But neither the allusion to the opening nor the re-establishment of the near aggregate chord is enough to calm the music or conclude the section, as the barrage of repeated notes ensues again.

At this point, the irony of the work becomes complete. The allusion to the aggregate is now finally present, and all instruments are frantically playing repeated notes. At the same time, the noise levels do not increase because the repeated notes allow the music to hold a relatively stable and moderate noise level around 0.7, in spite of the perceived increase in intensity. Clearly unable to reach a conclusion at this point
with all musical devices established in the work now in full play, there is no chance for resolution without introducing something new. That new element is an obliteration of the established musical texture, which is handily accomplished by an infusion of noisy timbres contributed by the percussion instruments, sending the noise levels to an unprecedented high of 0.93 at 8:27. In many ways, the percussion attack at the climax delivers the opposite of the “expectation-resolution” model, with precisely the same effect. Here Lutoslawski demonstrated, through contextual pointers over the last 8 minutes, that traditional expectations can be reversed; that actually a barrage of noise can create closure as effectively as a perfect consonance.

This climax is a fitting end for a work which was composed using chain technique as a vehicle to create form in a new and different way. Certainly the unconventional execution of the climactic material complements this goal. The concluding material which follows is inconsequential, alluding to the short thematic material of the chain portion of the work and the repeated notes and aleatory polyphony of the second section. *Chain 1* fades into the distance much as *Lontano* did, but with a very different affect. While *Lontano*’s ending was a reference to moving away from common practice devices utilized extensively in the work, the ending of *Chain 1* is a reiteration of the adamant rejection of tradition found throughout the composition.

This discussion of *Lontano* and *Chain 1* has illustrated the usefulness of using electronic analysis techniques to understand structural and formal element of works written for acoustic instruments. Although when compared with electronically produced sounds, the sounds produced by acoustic instruments are often characterized by a relatively limited noise range; still, the electronic analysis of these works provided
unique insights into their construction. After establishing the relevance of this type of analysis through consideration of these acoustic works, I applied the same analysis techniques to music composed electronically, illustrating both the similarities and differences in noise contours which exist in works for the computer. By using the same analysis techniques for acoustic and electronic works, I placed the electronic compositional techniques now possible into context with the acoustic works of the late 20th century. To do so, I considered two electronic compositions: *Chreode* (1984) by Jean Baptiste Barriere, and my work *Urban Structure* (2002).
CHAPTER 4

BARRIERE’S CHREODE: INCIDENTAL NOISE IN ELECTRONIC COMPOSITION

As I began my study of Chreode, I was fortunate to have not only the composer’s own account of the formal and programmatic considerations of the work, but also a detailed description of the computer programs and synthesis models used to create the work. The composer’s description of the work “Chreode: the pathway to new music with the computer” provided many details about the process-oriented unfolding of the work. My analysis took a look at the processes that drive the work and showed how noise contour works through the development of musical ideas to shape the large-scale form. I used this analysis to describe some of the challenges and idiosyncrasies encountered while using noise analysis on electronic compositions, and to suggest how an analysis program such as this one could inform the compositional processes for a new work.

Chreode is a nine-minute stereo tape piece composed entirely through synthesis, using FOF technology to model (among other instrumental timbres) the timbre of the human voice. While my analyses of Lontano and Chain I focused not only on using noise to describe the form of a work but also on the perceived meaning of noise in a musical work, the analysis of Chreode had to go a step further to also consider how noise can be related to a synthesized vocal and instrumental models, and how the perception of a synthetic voice or instrument can impact our understanding of other components of the work, including form and noise content. In other works analyzed, I

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1 Jean-Baptiste Barrière, Chreode, found on Computer Music Currents 4, Mainz: Wergo, 1989.
have addressed the question of whether noise content is necessary to create tension, and how the lack of noise can lead to a sense of repose, based either upon the physical characteristics of the sound itself, or the perceived meaning of noise in a society conditioned to hear pitch in music. In considering Chreode, I also observed if and how the noise profile of synthetically modeled sounds was similar to or different from what could be expected from traditional instruments, and what effects any differences may have on the perception of these modeled sounds. The noise analysis of this work shed some light on human perception of these different timbres, and also helped address the question of whether or not our auditory systems are capable of objectively detecting the noisiness of a specific sound or timbre, especially when it is linked perceptually to a familiar instrumental or vocal sound.

A quick look at the form of Chreode reveals a work in two sections or cycles, split just after the chronological half-way point around 5:20. The trajectory of each cycle is defined by large-scale, slowly developing algorithms affecting different musical parameters. Each half of the form is further partitioned into two somewhat balanced sections, the first of each being dominated by vocal timbres, and the second of each being driven by instrumental sounds which occasionally are transformed into or layered with vocal-like timbres. Each cycle is further partitioned into sub-sections (more evident in the first half of the work), which are defined by a constantly evolving ostinato pattern. The transformations of this ostinato provide the backbone for the development of rich timbres which define the character of the each section, and ultimately, the work as a whole. Figure 4.1 illustrates the overall form of the work.
The opening of *Chreode* begins with a sparse texture, and the granular nature of the FOF synthesis process can clearly be heard in the single line which introduces the work. At first glance, the noise graph of the work shows a relatively low starting level for noise content, implying that the opening should be harmonic and clearly pitched in nature. In fact, the first seven seconds of the work carry an average noise factor of only 0.48, about the same as the noise level carried by the solo horn at the beginning *Lontano*. But the auditory effect is different, and surprisingly, the opening of *Chreode* is abrupt, noisy, and fragmented. A closer look at the line reveals that it contains granular bursts of low pitch, and while the attack envelopes are abrupt, they are still produced by sine waves, making them harmonic in nature. Therefore, what could be perceived as
noise at the opening is in fact produced through cyclic patterns, and the resulting noise
level at the outset remains low.

Ushered in by this innocuous but unique opening, the first section of *Chreode* immediately begins the ostinato process that slowly evolves from the opening murmurs into the timbre of the human voice. This is accomplished through a slow expansion or “invasion”\(^3\) of the narrow pitch space used at the beginning of the section, along with a smoothing out of the abrupt enveloping function around 00:28, allowing the underlying vocal timbres to become more pronounced. The noise contour of this section, which runs until 00:49, reflects the musical processes being employed. The thickening of timbre from the outset to 00:28 results in an increase of noise peaking at 0.57 around 00:14, but the removal of the harsh enveloping function at 00:28 serves to reduces the noise factor to as low as 0.38 at 00:41. At this point, another enveloping function similar to the one employed at the beginning, but more narrow and rapid, and not harsh enough to obscure the vocal timbres, is added back in, raising the noise factor back up to levels around 0.5, before the cycle begins again with the first variation of the ostinato pattern around 00:49.

The second and slightly compressed reiteration of the opening material runs its course until 1:22. This ostinato cycle is marked by a richening of timbres and a journey higher into the pitch space, with the modeled vocal timbres resembling the tenor voice rather than the bass voice heard previously. Although timbres in this section can be described as richer, they are not necessarily thicker; in fact, noise levels here do not exceed those seen in the first section. However, it is clear from listening to the music

\(^3\) Barriere, 186.
that this section demonstrates the composer’s scheme to enrich the material with each repetition. It seems that the movement into higher pitch space here cancels out the potential or need for increased noise to create energy and motion in this particular instance, however, as the work continues, the enrichment of material does produce an increase of noise. It is a place like this that clearly demonstrates the interdependence of so many different musical factors on the listener’s perception of intensity. Although elevated noise could have been here to enrich the material, it was not, and the effect did not suffer. Perhaps the composer was simply holding out high noise content as an additional tool to enrich the music until it was deemed to be the right time.

At 1:22, a third iteration of the ostinato material begins, but soon it becomes clear that this section will be marked by further development of the musical form and the modeled vocal timbres. After the typical opening, which moves towards more clearly pitched vocal sounds around 1:43, the ascent towards higher pitch, volume, and intensity begins. This ascent is also marked by an increase in noise by the time the two-minute mark is reached. A higher set of voices in the alto range is added around 2:12, and at 2:18, a soprano layer joins in, further thickening the sound. The intensity created here leads to the climax of the first half of the work; the formal processes that created the increases in timbral richness, volume, and speed reach their “apex” at 2:29, and according to the composer the processes are inverted as a descent off of the first cycle’s climax ensues.

A fascinating consideration for this third ostinato section of the work was the question of noise as it relates to tessitura. In the case of the instruments sampled and

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4 Barriere, 186.
5 Barriere, 188.
referenced in the introductory chapter of this dissertation, instruments played in similar fashion at similar dynamic levels tended to be noisier towards the lower end of their ranges. In the case of the ascending pitch patterns in this part of the work, along with the clear imitation of specific timbres associated with different voices (bass, tenor, alto, soprano), factors other than tessitura contributed to the increase in noise if the vocal synthesis model handles noise content correctly. These factors included dynamics, attack type (parallel to playing technique in traditional instruments), layering of voices, or other factors. Given the number of variables, it was not possible to conclude which factors were primary contributors to the noise increase here, or whether this passage revealed any inaccuracy in the vocal model as noise relates to tessitura. However, this instance did demonstrate one possible compositional use of this noise analysis tool. Understanding of noise content through this type of analysis could conceivably inform a different vocal synthesis model in a case where variables were isolated, and it was determined that a different treatment of noise would lead to more realistic synthetic vocal timbres.

At the beginning of Section 4, the inversion of processes that created the form of the first two-and-a-half minutes of music begins with a substitution of instrumental timbres for vocal timbres. According to the composer, this shift was designed to “break up temporarily the extreme homogeneity of the material.” In practice, the change is short lived, with layers of vocal timbres reemerging around 3:23. The formal development of this large section of the work roughly mirrors patterns of the first 2:29, with the exception that the ostinato patterns are not as easily recognized although they

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6 Barriere, 187.
do remain as the formal underpinning of the work. Instead, sections with dissimilar beginnings containing dramatic timbral contrasts define this portion of the work, which runs until just past the five-minute mark with sectional breaks at 3:23, 4:16, and 4:42. Each successive sub-section in this portion of the work starts and ends at a lower noise level than the previous section, resulting in a slow but steady decrescendo of noise, while dynamic levels stay strong until the fourth sub-section begins to thin out in texture around 5:00. In this sense, the noise contour reveals the inverted mirroring of the first section better than does the audible presentation of the work.

The other notable feature of this instrumentally dominated section is the relatively low level of noise contained overall. Beginning with a noise factor just over .7, the section steadily loses noise as it progresses, in spite of the presence of some percussive sounds in the instrumental timbres in a texture complemented by thick layering. This is surprising in light of the fact that the listener's ears have been conditioned to expect more noise in percussive settings (even in subtle cases such as the xylophone passage previously noted in Chain 1), but here the audible effect of the percussion is effective, even though the higher noise level is absent. One explanation for this is that the synthesis model in use was primarily coded to create sustained sounds (vocal phonemes), and instrumental and vocal attacks are not properly modeled to contain an onset of noise such as a fricative, chiff, or mallet hit. Instead, harsh but sinusoidal enveloping simulates instrumental attacks, giving a rapid spike in dynamic level, but little associated noise.

Another explanation for the relatively low noise level here may be the sample rate of the work. Although it would have been possible to use a sample rate of 44.1 kHz
in 1984, it would have been computationally expensive, and there is no documentation
to indicate what rate was actually used. The FFT analysis of Chreode indicated that
the highest partials present are somewhere in the 12-13 kHz range, found about two
minutes into the work where the soprano vocal part is layered in. But other sections of
the music, including percussive sections, do not contain frequencies much over 10 kHz.
If a lower sample rate was used, that would explain the lack of higher partials. One can
speculate that perhaps the missing higher partials are responsible for the lower than
expected noise levels; but regardless, the low noise level does not spoil the affect of the
percussive sounds. Once again, the noise analysis of the work provided information
about the modeling techniques employed in the work, and again the analysis could be
used to inform a subsequent synthesis model if a composer so desired.

Another difference between the noise content in this electronic work and what
might be expected in the analysis of a recorded acoustic work becomes evident as the
first cycle winds down around 5:17. In his description of the work, the composer pointed
out that the inverted formal process accented by instrumental timbres leads to the “only
point of repose in the work”\(^7\). Exactly where this point lies is impossible to ascertain; in
fact, the overlap of the waning instrumental sounds and the new vocal timbres which
usher in the second part of the work run from 5:17 to 5:27, preventing any point of
silence or true repose. However, what is easily seen from the analysis is the fact that
the noise levels drop to as low as .19 at 5:12 into the work, marking the lowest noise
ratio found in any of the works analyzed thus far in this paper. Although this part of the
music could be used as evidence that low noise combined with harmonicity do resound

\(^7\) Barriere, 188.
with our conditioned ears as a signal of repose and cessation of energy (as the composer seems to have intended), there is an alternate explanation in this case. As the density which was present for most of the second section is peeled away by the inversion of the formal processes, and the choirs of instruments disappear in favor of solo voice, the clear harmonicity of each instrumental timbre is easily heard. In a synthesis work using a modeling process focused on the sustained portion of sounds, the harmonicity of each instrumental timbre is clearly reflected by the analysis, and easily perceived by the human ear. Moreover, the ambient noise that is commonly present in recordings of works can greatly reduced or absent in a synthesized composition. Although the affect of this point in the music is similar to the end of the first section of Lontano where the unison C fades into the tuba’s pianissimo D-flat, the analysis indicates the noise levels here in Chreode are much lower.

As the instrumental sounds fade into the background, the second half of the work begins at 5:17. Barriere described this section as being composed with “defined” lines and “variable” points, as opposed to the first half of the work, which was marked by “defined” points and “variable” lines. The effect is a much more homogenous beginning to the second half of the work. Also, because the defined lines provide more continuity to the texture, the vocal timbres are more easily heard at the outset of the section. Otherwise, the second half moves along a trajectory similar to that of the first section, beginning with sparse textures and lower pitches, moving gradually up through the vocal pitch range and the related vocal timbres. Another similarity to the first section is the level of noise present at the beginning of the section, generally in the range of 0.45.

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8 Barriere, 186.
However, there is somewhat less rapid variation due to the more linear nature of the
algorithms that drive form, as opposed to the algorithms emphasizing defined points of
the previous section. Figure 4.2 shows a slightly more linear nature at the beginning of
the second cycle, as opposed to the disjointed non-linear nature of the first. The linear
nature of the algorithms also results in less obvious iterations of the underlying ostinato
pattern, although it is still present.

![Figure 4.2. Comparison of noise levels in the beginnings of Sections 1 and 2](image)

Aside from the smoother progression along defined lines, the primary factor that
sets the outset of second half of the work apart from the first is the method used to
accumulate complexity. In the early vocal sections of first half of the work, complexity
was increased by enriching the timbre of successively higher vocal parts, while slowly
revealing and developing the vocal timbres. In most cases, the layering of different
vocal parts (such as tenor and alto parts around 2:12) was limited to transitional
features, with most focus being on one vocal part at a time, even in cases where several pitches were sounding simultaneously. Aside from the clearly audible shifts from vocal part to vocal part, the switching off of different vocal registers in the first section of the work broke it into multiple sub-sections, which were often marked by noticeable changes in the noise contour. However, the more constant, level trajectory of the noise graph from 5:27 to about 6:45 indicates that a different approach is in play in the second half of the work. While pitch levels do rise throughout this section, the richness of the timbres (indicated by noise levels on the graph) remains relatively constant. This is accomplished because the composer begins with vocal sounds that are recognizable and fully resonant even at the lowest of pitch levels. The constant level of noise for more than a minute of this section is created by the dialog of vocal timbres at different pitch levels, but relatively constant richness. The musical development here is driven not by a slow development of vocal timbres, but instead the slow unveiling of a serially organized four-part choir.\footnote{Barriere, 189.} Around 6:45, the noise levels begin increasing through a thickening of the choral texture, and as more voices in multiple layers are piled on, the trajectories of pitch, noise and tempo all trend upward. This accumulation of intensity is manifest by an increase of noise by more than 0.1 to around 0.6 by 7:30.

At about this point the choral texture been fully developed and has reached a point where it cannot become much thicker, and an intriguing shift begins to push the music towards its final climax. The analog to this point in the first cycle is around 2:12, where the vocal timbres (the primary means of development for the first section) are almost fully developed, and the composer turns to increased density and tempo to push
intensity upward. Here, density and tempo (the primary means of development for the second section) reach their maximum around 7:30, so the composer turns to timbre in order to push the piece towards its climax. However, some further transformation must occur to keep the divergent paths of the two sections from ending in a similar place of both density and timbre, so the composer pushes the timbral richness of the vocal sounds to a breaking point, resulting in a “high and rich shearing of the spectrum.”

The composer described this point of the music as follows:

In the domain of pitch, the result is an intervallic and intonational structure in constant change, which generates intense and expressive emotion. In the timbral domain, the extreme values of frequency formants result in a total bursting of the spectrum, in parallel with numerous rules of correlation, and at the end of the process produce an extraordinarily rich and extended sound which evokes the image of bowstrokes on living vocal chords.

What the composer is describing here is actually an extension and transformation of vocal timbres away from the vocal formant configuration, towards something that is a type of hybrid between instrumental and vocal sounds. The extreme richness in timbre allows for a very rapid thinning of the texture around the eight-minute mark, where the hybrid alto/viola and soprano/violin timbres are showcased in solo form. In spite of the thinner texture, little intensity is lost because the richness of individual timbres is markedly increased, and the noise content (0.55 to 0.68) of these sounds reflects this fact.

At this point, the timbral possibilities of the FOF based synthesis model have been largely exhausted, and with other available techniques to increase intensity (tempo, density) extended to their limits, the music seems as though it is about to grind

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10 Barriere, 189.
11 Barriere, 189.
to a halt, at a very anti-climatic ending place indeed. In fact, there is as much a sense of repose here as there is at the middle of the work where the noise levels are almost a factor of 0.5 lower. But this is an unsatisfactory and intense repose, a breaking point akin to the incessant unison just before the climax of *Chain 1*, which could only be diffused by a wash of noise in the form of percussion. Barriere described the musical event at 8:05 which shatters and diffuses this uneasy resting place. “This ascent is rounded off by material which begins with an extremely high gong stroke and quickly dissolves into a distant choir.”

There are several curious characteristics associated with the gong stroke. First, it is the only place in the entire work where a very noisy attack is applied, quickly pushing the noise levels here up to 0.8, the highest mark seen yet in the work. This is accomplished in spite of the previously noted fact that very high partials above the level of 11-12 kHz are not present. Nothing was said in the composer’s account regarding the high noise level of the gong, except that this and other instrumental sounds are used to “break up the extreme homogeneity of the material.”

But there is no reason given that this particular hit would need such a noisy attack, when other percussive sounds employed near the middle of the work had no such emphasis. Also, the very rapid decrease in noise from 0.8 to 0.5 over only three seconds of decay is much more rapid than would be expected in a real instrument (the percussive attack at the climax of *Chain 1* lost a noise factor of 0.23 over eleven seconds). Even more surprising is that the rapid noise decrease seen in the analysis graph is not readily apparent to the human ear. The composer mentioned that the gong attack “dissolves into a distant

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12 Barriere, 187
choir,” noting that the resultant sound contains some of the timbre of the gong along with the voices. But the decay is smooth, and the mix of timbres covers an extremely rapid drop-off in noise content.

It could be argued, in a work relying on perceived associations between electronic sound models and their acoustic counterparts where the capabilities of the vocal sounds are pushed beyond their natural limits, that it is only fitting that the percussive climax also extend beyond the normal capabilities of acoustic percussion. The dramatic climactic gong hit, although pushing the capabilities of the sounds it is modeled after beyond their natural limits, actually provides a perfect balance for the eight minutes of music preceding it.

The rest of the work serves as a further decay of musical ideas already presented. The hybrid gong/voice sounds finally disappear around 9:06, where vocal patterns alluding to the initial vocal ostinato reappear momentarily before fading into the distance. One final and interesting feature is evident on the noise graph at the very end of the work. Unlike the point in the middle of the work where thin texture and points of silence were marked by artificially low noise levels, the noise chart indicates the presence of ambient noise in the final fade-out of the vocal material, starting around 9:15. This feature has no impact on the perception of the work’s ending but does stand as an intriguing contrast to the middle section. Again, this is a point where the noise analysis tool could actually be used to aid a composer who was seeking consistency throughout the work.

\[\text{Barriere, 189.}\]

\[\text{Barriere, 189.}\]
There is no reason to believe that the composition of *Chreode* was in any way informed by a study of *Chain* 1, but the parallels between the two works are undeniable. Each work, through its form, created a system of rules whereby recognizable, pitched instrumental timbres (whether acoustic or electronic) were pushed to their limits in a way that neither their musical characteristics, nor the form of the work, nor even silence itself, could create closure. So something else was required—in this case noise—to break down the pattern and move each work towards its end. But the question remains: why noise? In *Chain* 1, it is easy to rationalize that given the limited number of acoustic timbres available, percussive noise provided the biggest possible contrast to the other sounds in the work, making it an appropriate way to move towards closure in a formal, timbral, and harmonic system that had exhausted its potential. But this is not the case in *Chreode* or in any other electronic work, where anything including a pure sine tone is available to the composer to create contrast, even with the potential to create a contrast much greater than the rapid change of 0.3 noise factor seen in the work. Perhaps the instrumental and vocal modeling in *Chreode* made it more appropriate contextually to use a "gong" rather than something else; for consistency sake a modeled instrument was required. Or was it the conditioning of the human ear, and perhaps the expectation that *Chreode* would work in a way the other works before it had functioned, that made this the right way to reach a climax?

In conclusion, it is clear that at least in the case of *Chreode*, despite the infinitely expanded palette of sound available to the composer, rules appropriate to the use of noise in acoustic works can function as effectively in the electronic realm, at least when typical acoustic timbres and modes of composition are referenced by that electronic
work. In the following analysis of *Urban Structure*, I explored a work of my own that does not rely on modeling and instrumental context in the same way that *Chreode* does, and I examined how noise can function differently in an acousmatic setting.
Figure 4.3. Noise graph of Chreode
CHAPTER 5

URBAN STRUCTURE: NOISE AS A STRUCTURAL MARKER IN AN ORIGINAL COMPOSITION

In contrast to Chreode, which was marked by process-oriented form and synthesized sounds, my work Urban Structure relies on a more traditional sectional form that is informed by contrasting musical parameters including timbre, tempo, and pitch level. This acousmatic work reveals a different application of noise content as it relates to form than was found in Chreode. In Urban Structure, a work that relies primarily upon the juxtaposition of opposites and rapid shifts of timbre and texture to create forward motion, the presence of noise in different settings does much to push the work onward from one section to the next. At first listen, Urban Structure is strikingly different from Chreode in presentation and approach. Perhaps most striking is the use of timbral markers to create variety and define form. The contrast of different timbres (as acknowledged by Barriere in reference to the juxtaposition of instruments and voice)\(^1\) is present in both works. But the two primary types of markers in Urban Structure are defined not only by timbre, but also by harmony and pitch. Most often found at the end of sections and also in transitional material, these markers are bursts or washes of white noise, and the minor chord.

In light of previous discussions defining noise and harmonicity as existing on opposite ends of the musical spectrum, along with the consideration of Hindemith’s categorization of harmonic sounds, it is easy to understand the profound potential for contrast between pure noise and the minor chord. But the juxtaposition of these two

\(^1\) Barriere, 187.
diametrically opposed musical signifiers also presents a compositional problem; the contrast between the two (in theory at least) is so dramatic that careless use of these sounds as formal markers could rapidly become predictable and melodramatic. A musical form defined by sectional divisions based solely upon wide swings from pure noise to pure harmonic consonance would do little to create a compelling composition. A work cannot stand on contrast alone, and without careful manipulation and control of noise, a compositional model based upon contrast of noise and the minor chord could be ineffective.

At first glance, the noise chart of *Urban Structure* indicates both widely contrasting swings from noise to harmonicity, and also a good bit of irregularity and nuance in structure, belying the conception that a form based on the juxtaposition of musical opposites must be predictable or uninviting. Figure 5.1 demonstrates the basic overall form of the work, displayed on its noise chart. Although most sections transition from one to the next in areas of very low noise, this trend is not a rule. In fact, most sectional breaks are slightly before the lowest point in noise content. The transition between the third and final section contains the lowest noise level in the work right near its midpoint; what would seem to be an important formal marker is imbedded in a place that is non-functional to the form. And, although most sectional breaks are defined by low noise levels, moderate levels exist at the two most important formal junctures of the work—the beginning and the ending.
Given the fact that so much compositional emphasis was placed upon juxtaposition of harmonic sounds and noise, the wide swings in noise content during short periods of time was no surprise. Although such a noise profile would be impossible in a work written for traditional instruments, the computer made these wide contrasts possible and easy to execute. What was challenging during this analysis, however, was that the peaks and valleys in the noise chart did not always coincide with musical events that sounded clearly noisy or harmonic. In fact, some points in the music which have decreased noise on the chart actually sounded noisier when listening to the work, including the section starting around 00:57, which is discussed in the analysis below.

The beginning of Urban Structure possesses a noise profile similar to that of the opening measures of Chain 1, where a relatively high level of noise content rapidly gives way to more moderate levels. But there is little associated affect with this noise decrease; instead of a dramatic sweeping gesture similar to the opening of Chain 1, the
0.1 decrease of noise during the first 16 seconds of *Urban Structure* seems more coincidental and related to phrasing than intentional and related to gesture or form. The difficulties of interpretation continue in the span of 00:24 to 00:31 in *Urban Structure*, where the noise level decreases by a factor of more than 0.5, with no associated affect; again, the change is incidental and related to the sampled sounds, not programmatic, intentional, or related to musical gesture. Finally, by 00:57, there is a noticeable gesture comprised of building sound growing out of an accumulated reverb, which lasts until about 1:13-1:15 where there is a door slam which reaches the maximum noise level of 1.0, followed by a reiteration of an equally noisy hit around 1:25.

But there is a problem with the accumulating reverb starting around 00:57 and the building intensity towards the first big dramatic hits in the work. In a totally counter-intuitive twist, the noise level actually decreases in the 16 seconds following 00:57. In fact, the decrease is dramatic and steady, amounting to the loss of a noise factor of .2 over that time period. Where the sudden dip to a factor of .25 at 00:31 could be passed over as a momentary anomaly, the entire gesture commencing at 00:57 cannot be ignored. The perception of increasing noise at this point adds great tension to a texture that so far had been comprised of short rapid shifts, short phrases and general inconsistency. But the increase in noise is a mirage, and an inconsistency in itself.

The opening section of *Urban Structure* makes clear the challenges of using noise-based analysis on acousmatic works possessing textures so riddled with rapidly shifting sounds and electronically generated complexities. Even the complexity of the algorithms used to generate *Chreode* does not rival the dense and often unpredictable nature of multiple layers of highly processed recorded sounds played simultaneously.
That is not to say that the seemingly contradictory and decreasingly noisy reverb is unexplainable; rather, it is clear from a technical standpoint that the filters comprising the reverb are in fact somewhat harmonic in nature, and as the reverb was repeated and layered, energy accumulated in certain areas of the harmonic spectrum, as evidenced by the use of the noise analysis tool. The fact that the accumulation of harmonic partials sounded noisy and not harmonic is as insignificant to the overall shape of the work as it is intriguing; in this case the composer unknowingly chose to use a musical device that actually accomplished the opposite in the technical realm of what was heard in the audible realm. But the affect of a perceived increase in noise still exists, and is effective as it is used, even though perception defies reality in this case.

The contradiction here in the first ninety seconds of *Urban Structure* does nothing to discredit the usefulness of the noise analysis tool, but instead demonstrates that its results must be interpreted with caution. The tool worked perfectly to describe what was going on acoustically throughout the entire early portion of the work, even if the section contained illusions perceived by the ear. However, fact that an illusion could be created in this setting reveals much about the nature of human noise perception in music. If there were something physically inherent in the noise patterns that forced a particular natural response, then the illusion would not have been able to occur. But the illusion demonstrated here actually seems to indicate that the typical conception that an increased sense of energy or chaos in music is associated with or driven by increased noise, is not actually predicated by physical systems or laws, but is really a conditioned response of the ear based on centuries of musical listening. While the arguments made here are compelling, it is necessary to acknowledge that the observations about noise
content and form are based off of a few musical events occurring on a relatively small scale. Through analyzing the rest of *Urban Structure*, it became clearer whether these observations could be corroborated by other similar instances.

After 1:25, the rest of the material in Section 1 takes on more of a transitional nature. Key elements from the beginning of the work, including heavily reverberated percussive sounds along with bursts of noise (already mentioned as one of the primary formal markers in the work) are mixed with the other important formal signifier: minor chords. The harmonic nature of the minor chord iteration in the second half of Section 1 comes more from processing and filtering than from anything present in the recorded sound sources. In fact, the minor chord textures found throughout the work were created by layering transposed samples of a rather noisy soundscape: city traffic. The introduction of the minor chord textures in Section 1 do not correspond to an immediate decrease in noise levels as might be expected from the introduction of more harmonic-sounding material. As it turns out, the high incidence of repeated noisy sounds keeps the noise levels here at least as high as they were in the first part of the section. Furthermore, in the one area where the minor chord is able to stand alone (1:47-1:49) without layering of any noisy material, the noise levels hover around 0.77, which is actually higher than the average of 0.72 for transitional material from 1:25 to 2:12. In similar but opposite fashion to the surprise decrease in noise content during the accumulated reverb previously discussed, here the introduction of harmonic material is not accompanied by a marked decrease in noise content. Though it is possible for other factors to contribute to the high noise level contained in clearly harmonic material, any conditioned expectation that harmonicity should be accompanied by decreased
noise or a sense of repose is again not satisfied. In fact, as the section winds to a close from the two-minute point onward, the amount of very noisy material (along with another accumulating reverb around 2:09) again contribute to increased perceived energy, even while the average noise levels drop. Therefore, the patterns observed on the small scale around the 1 minute mark, seem to continue through Section 1.

Overall, despite its various twists and turns, the first section retains a relatively high noise level, averaging just over 0.7. The expository nature of the material does not avoid larger scale gestures entirely, but the disjunct nature of the material, caused by the introduction of several different types of sampled sounds, does lend itself to short thematic ideas, which in this case tend to be noisy. Isolated areas in the section do display some harmonicity, and others are marked by relatively low noise levels. Overall, the section is characterized as percussive, discontinuous, and noisy.

Section 2, commencing at 2:12 and running until 3:53 stands in stark contrast to the first section. At the beginning of the section, noise levels begin and remain under 0.2 for several seconds, the longest stretch of levels this low seen in any work analyzed thus far. The sound here is not sinusoidal or without characteristic timbre as could be inferred from the noise graph, but rather it is high and brittle in nature with rapid pulses all on the same pitch. The main focal point of the music here is actually the spatialization achieved through binaural or eight-channel panning (depending on the version of the work being heard, analysis was performed on the stereo version), but the sounds, pure as they are, are not too simple to stand alone. This pitched backdrop slowly fades as different sounds, some pitched and others noisy, are slowly exposed in various layers. Section 2 is characterized by gestures of varying length which
emphasize the spinning sensation achieved through the panning. The progression of
sounds, which tend to move away from simplicity and towards complexity, is marked by
an irregular but persistent increase of noise approaching levels of 0.8 around 3:30, as
preparation for the final cadence of the section is made. Figure 5.2 demonstrates the
general contour of the section.

![Figure 5.2. Trajectory of noise in Section 2](image)

In general there are fewer surprises in Section 2 than were found in Section 1.
With an average noise content of only 0.44, the section emphasizes pitched elements
over noisy ones, with a clear linear progression towards its climax at 3:36. This
progression is characterized by an increase in noise, dynamic intensity, and frequency
of events. The contrast achieved between this section and the first is due in large part
to the lower noise levels and different treatment of gestures. There are also more
subtle features which set this section apart.
First, noise behaves intuitively as the previously stated assumptions about noise in common practice music suggest; there are not illusions here as there were in the first section. A prime example of this is the temporary peak in noise around 2:46 which momentarily disrupts the upward-oriented linear contour of noise for the section. This area, which runs an arch from 0.25 to 0.74 back to 0.28 in noise levels over 17 seconds sounds how it looks on the graph. A noisy, crackly pattern of noise is superimposed over more harmonic elements, slowly fading after reaching its peak. This noisy event serves to push the music forward, temporarily increasing intensity, but it does not disrupt the overall direction of the work.

Just as noise behaves intuitively here, so does the minor chord. Introduced in dramatic fashion at the section’s climax at 3:36, the chord does contain many noisy components, but its decay quickly sheds the noise, allowing the final 17 seconds of the section to fall to a point of repose at very low noise levels. The minor chord is a satisfactory resting point for our conditioned ears, allowing a generally harmonic section to end in a consonant place.

After assessing the two sections together, many of the anomalies in Section 1 were shown to possess only small-scale importance. Although the exceptions were striking in their occurrences, an assessment of the larger scale rendered them insignificant. In summary, what exists in the first four minutes of the work are two contrasting sections: the first is event driven, noisy and discontinuous, while the second is gestural and more harmonic. Whatever expectations seemed to have been ignored on the small scale in the first section, the form after two sections appears somewhat traditional in conception.
The work’s longest section begins at 3:53 and runs until 8:13, although the last 74 seconds of the section are transitional. Section 3 has some characteristics of both previous sections, containing a high level of noise similar to the levels seen in Section 1, but a generally linear upward trajectory to the beginning of the transitional material at 6:59, similar to what was found in Section 2. In many ways, Section 3 presents further development of material from Section 2. Much of the added noise that pushes the section’s average noise level up to 0.68 (from its beginning up to the transition at 6:59) comes from timbral materials similar to those in Section 2. This is accomplished through increased energy in the higher partials, and increased overlapping of sounds. Spatialization becomes even more pronounced here, first with sounds bouncing back and forth across the horizontal plane, eventually assuming a spinning pattern and slowly rising towards the azimuth. The material is, for the most part pitched, but layered more thickly and treated with more ample reverb. The very subtle beginning of the section is the only exception, mirroring the nature of the second section’s opening, while clearly incorporating the sonorities of the minor chord into the texture.

As far as noise content interpretation goes, there are no surprises here as there were in the first section, as the noise content effectively mirrors the contour of the work, and increasingly high noise accompanies the rising pitch patterns between the sixth and seventh minutes. One very effective use of noise occurs in this minute of music as the pitched material spirals upward towards one of the most important formal junctures of the work around 6:59. Towards the end of the last spiraling pattern which starts at 6:41, the pitch is so high that even increased volume can do little to increase intensity, and the timbre runs the risk of turning high and brittle in a fashion akin to the very passive
and non-dramatic opening to Section 2. But heavy reverb smears the texture and thickens the sounds enough to retain incredible intensity and increase the noise levels to over .9 in a section which is primarily pitched. Since the reverb here spreads energy into the lower partials, and the nature of the sounds being processed does not allow energy to be concentrated in specific areas, the reverb does not simply create an illusion of noise here as it did in the first section. Interestingly, however, this area retains a primarily pitched sound, in spite of the increasing noise.

The transitional section which follows from 6:59 to 8:13 provides a needed break from the intensity of Section 3. Referencing the percussive sound samples of Section 1, the section turns away from the gestural nature of the last two sections, focusing more on individual sounds and timbres. The transition is marked by primarily noisy percussive sounds placed within a very sparse texture, resulting in much lower noise levels than the previous section. The transition is a great example of how density can affect noise level in cases where sounds appear to be un-pitched. Beginning at 7:32, layering and higher contained frequencies in the percussive sounds result in a slow increase of noise to a point, and then a reverse process is commenced, leading to decreased noise by the time Section 4 starts at 8:13. Figure 5.3 shows the noise contour of the transition.
Aside from the clear upward noise trajectory created by increased density of events, the other notable feature of this section starting around 7:32 is the fact that noise levels range generally from 0.3 only to 0.6, in spite of the fact the sounds are percussive in nature. The reason is simply that the attacks are short and each hit has a clear resonant frequency. The noise contained in each crisp hit does not increase the intensity to the degree that a heavy reverb or a noise wash could. The result is a development of percussive material from the first section that clears the air without increasing intensity too much, allowing for the entry of the fourth and final section.

Section 4 commences in similar fashion to Section 3 with a harmonic background and low noise levels. As in Section 3, noise, which has proven to be such an important structural marker throughout the work, emerges on the surface level of the sound. This time there is no noise wash, but small bursts of noise which gradually increase in
volume and frequency. As the section progresses, other elements from previous sections are reintroduced in altered form. Around 8:49, the signature spinning pattern from Section 3 is heard in accelerated form, indicating again that this section is going to focus on developing material heard previously. The quick impulse caused by this gesture causes noise to shoot up quickly from about 0.6 to around 0.8. As more sounds derived from previous sections are layered in, including the minor chord sound and traffic noises modified to the extent that they sound almost like airliners at takeoff, the noise level is pushed close to 0.9 for an extended period of time (9:15 to 9:40). There are many pitched elements still audible in this sub-section; in fact, more sounds carry an obvious pitch here than did many sounds in the much less noisy Section 2. But the extreme layering, along with the large number of very high partials containing much noise, pushes both the noise meter and the intensity of the work near the upward limit.

Around 9:40, the layer of crackly noise which was introduced with the noise bursts about a minute before, fades, revealing the remaining pitched elements more clearly. Noise levels remain relatively high (not dipping below .67), as the traffic-turned-airline sounds are pushed to the forefront. More noise is reintroduced around 9:50, preparing for a series of noisy hits at 10:03, 10:05, and 10:07. These noisy punctuations of an already chaotic texture are cadential in nature, but not to the same extent that the hits around 1:15 and 1:25 were; these hits are not sufficient to complete the work. Perhaps this is because they carry less noise than previous hits, or because the events around them have occurred in such rapid succession. Whatever the reason, just as in *Chain 1*, the noise that is capable of signaling the end of the work is not able to actually conclude it.
After the third noisy hit there is a short period of silence (not true silence, as noise levels fall only to 0.4) followed by a diffuse scatter of short noisy bursts. It sounds for a moment as though this may be the ending—an ending marked not by pitch, but only by noise. However, a much more emphatic closing gesture ensues, with a final pitched “airline” sound marked by a glissando from high to low pitch, punctuated not by noise, but by a highly resonant, very loud minor chord at 10:12. This chord provides finality to the work, providing the sense of finality that was lacking in the previous cadential punctuations.

While noise and harmonicity both have important structural significance in this work, the fact that it ends on the minor chord and not on a wash of noise indicates something about the function of each. One could argue that there is in fact something inherent in the physical properties of the minor sonority, as perceived by the human ear, which would make it the appropriate resting place. Although this argument could clarify how centuries of common practice revolved around music based on major and minor chords, there is really little evidence to support this possibility in this twentieth-century setting. Instead, the structure of the work points to context as the reason that the most fitting point of repose comes with a minor chord. First, there is the issue of internal context within the work. Although both noise bursts and minor chords were used both within the texture as well as to end sections, noise is found in many prominent developmental passages throughout the work, including the beginning of Section 4, where noise actually is the catalyst to push the music forward. The repeated use of noisy bursts in these settings give noise its primary definition for the work as a developmental tool to increase tension, not to diffuse it. Although noise is used to
effectively end Section 1, its uses continue to become more developmental from that point forward, altering the context as the work unfolds.

As previously mentioned, the other contextual clue that cannot be ignored is the fact that in the tradition of listening to Western music, the minor chord was commonly used as a resting place at the end of a work. While this fact says little about the actual musical properties of the minor chord, it is unfair to assume that this large scale context does not still play a role in music composition and listening, even in a time when many works do not hold to the traditions as tightly as was found in the past. That which is common is often accepted, and in a musique concrete setting, it is certainly acceptable that the one element with historical connotations retain some of its traditional meaning.

The noise analysis of Urban Structure revealed a compelling mixture of the old and the new, the expected and unexpected. Throughout the work, noise used in both traditional and non-traditional ways establishes formal flow and direction. In spite of the irregularities mentioned in Section 1, the general utilization of noise in the work provides sectional contrast. The idea of contrast seen here is not unlike the cases studied in Lontano and Chain 1. Although these two works used noise in opposite ways, with Lontano using harmonic consonance to achieve repose while Chain used noisy dissonance to the same affect, both constructions worked logically and musically because enough contrast was achieved between sections of each work to guide the listener’s ear. In the case of Urban Structure, some of the opposing interpretations of noise function that were observed between Chain and Lontano actually occur and develop at different points in the same work. But because the sections are clearly segmented, and the significant markers (white noise and the minor chord) are clearly
defined in their contexts, the result is not a confusing jumble of different signifiers, but instead a compelling development of musical features.
CHAPTER 6

COMPOSITIONAL IMPLICATIONS FOR A NEW ELECTRONIC WORK AND CONCLUSIONS

In contrast to *Chreode*, which is marked by process-oriented form and a noise contour that grew out of fixed processes, *Urban Structure* displays a somewhat programmatic use of noisy and harmonic sounds to the extent that the minor chord, a relic from hundreds of years of common practice, became the key signifier of rest and repose. While the methods to analyze noise used in this research revealed interesting truths and perplexing ironies present in the form of each work, the analysis was retrospective, and was effective in part because it comments on completed musical forms. While considering the creation of a new work informed by the findings of this research, it became necessary to confront the question of whether or not to use the noise analysis tool as a compositional aid during the compositional process, or to simply employ it as a descriptive tool after the fact. One argument against using it during the compositional process itself came from the fact clearly demonstrated throughout this paper, that the listener does not always perceive noisier sounds as noisy and harmonic sounds as consonant. Compositional decisions that are made based upon assumptions about what one may perceive from a sound's actual noise content (as analyzed by the tool) may yield unexpected and unfavorable results based upon the context of sounds and the listener's conditioning.

Where the tool may be more helpful compositionally is through informing a composer of some typical patterns and noise usage approaches as demonstrated in the previous analyses. This comparative study of the works analyzed demonstrated that
contrasting approaches to noise as it relates to form are possible and effective in contemporary composition. In the case of Urban Structure and Lontano, noise (often combined with harmonic dissonance in Lontano) was used to create tension, and common harmonic signifiers of repose from common practice were used to contrast with that noise at important formal junctures. However, in Chain 1 and Chreode (which happen to be the two more process-oriented works analyzed) the composers interpreted the function of noise differently, attaching less traditional meanings to noise based upon context. In the case of Chreode, noise was used somewhat incidentally as it related to timbre and while the presence of noise at different levels helped to shape the work and lead it to its final climax, its overall formal significance was limited. In the case of Chain 1, the traditional meaning of noise was inverted, and noise functioned effectively as a signifier of repose, a direct opposite approach to that found in Lontano.

In my new work, Divergence/Convergence, which like Urban Structure was written in the style of musique concrete, I avoided the use of the noise analysis tool during the compositional process for fear that the resulting work would become too programmatic, and that intuitive decisions that normally go into a composition would be limited. Instead, the subjectivity of perception was allowed full reign in the selection of sounds. Although I selected some sounds due to their perceived noisiness or lack thereof, I decided not to allow the tool itself to hamper the sound selection process.

Instead, I used some of the lessons I learned during the course of this research about the potential function of noise in relation to musical form to help shape the contour and progression of the work. Using a library of sampled sounds I collected around my home, I divided the sounds into categories, including hits and sustained
sounds, sounds with prominent pitched elements and those without. I decided to use these categories of contrast as driving formal ideas behind the work. Several methods were used to exploit the contrasts in the samples I was using. One was simple juxtaposition, where noisy sounds and pitched sounds were placed in close proximity, and the contrasting relationship between those sounds created a context for (and often progression of) ensuing events. For example, the opening section which runs until 00:43 is marked by a series of noisy hits that are followed by pitched decays, where the pitched elements were actually derived from the resonance of the hits themselves. The progression of four such hits moves towards those with more prominent pitch in the decay. This process creates a setting in which the juxtaposition of noise and harmonicity is a central compositional concept that leaves room for development throughout the section. In a sense, the opening section functions as a microcosm of the entire work, as this concept is exploited on varying scales throughout. For example, the next short section is derived almost entirely of the same pitched decay material with only one noisy attack in a formally insignificant position at 1:03. This creates a larger scale image of the hit to pitched contrast pattern, where the first 43 seconds are dominated by noisy hits and their decays, and the ensuing 29 seconds provide harmonically dominated contrast.

The rest of the work exploits the interplay of noise and harmonicity established in Section 1. The second section is short and while it relies primarily on noisiness as its defining feature, it treats noise in an opposite manner from the first 43 seconds of the work. Where the opening of this composition used punctuated hits as the primary source of noise with sustained sounds during the decays diffusing some of the noisy
tension, Section 2 is dominated by sustained noisy build-ups to hits which themselves contain some harmonic components. While the short and sustained foreground sounds' functions are thus reversed, the background formal effect of this section is akin to the first half of Section 1. Noise levels, as indicated by the analysis in Figure 6.1, are similar here as well, again showing a similar outcome through an opposite approach to the sampled sounds. And while noise is the dominant feature of the section, an ironic blending of cymbal-like noisy timbres, and pitched vertical structures alluding to the major chord create an integration of pitched and non-pitched elements. While retaining a primarily noisy affect for the section, this blending creates the possibility for more stark juxtapositions of noisy and harmonic sounds in subsequent sections of the work.

Figure 6.1. Noise Contour of *Divergence/Convergence*

Continuing to play off the concept of alternating noise and harmonicity, Section 3 begins at 1:56 with a melodic strand derived from extensive FFT processing. More developmental in nature than previous sections, this part of the work evolves more
slowly, focusing on melodic and harmonic features of the work. Although prominent reverberation providing rich and full timbres is present, noise levels begin relatively low and slowly climb as the timbres thicken and dynamic levels rise. Around 2:20, a new sustained harmonic sound is introduced, and severe time compression of that sound leads to a new melodic thread resembling a string ensemble at 2:53. Although noisiness builds intensity with thickening timbres up to a brief high point of about almost 0.88 around 3:12, the section remains well rounded and gives way to Section 4 around 3:36 with noise levels greatly decreased.

Section 4 once again turns the focus gradually from harmonic sounds to noisy ones, but the shift is subtle, indicated only by a change of timbre in the sustained bass sounds from 3:36 up to 3:47, where percussive sounds of very low noise level usher in the longest section of the work. This transitional period contains the lowest sustained noise levels in the work. As in the opening of Chreode, the results of noise analysis here contradicted the notion that percussive sounds must actually be noisy. Instead, this section grows slowly in noise and intensity, much like the section before, except that here it is percussive hits and not sustained sound providing the forward motion. By far the most complex section of the work, Section 4 develops intensity through increased layering and processing of the percussive sounds, while also layering in pitched elements reminiscent of the sustained sounds in Section 1b beginning at 4:19, and the more complex pitched sounds of Section 2 at 4:53. By 5:19, the section has a very high noise level, and almost a minute-and-a-half of processing on the percussive material of the section has run its course. While the original goal of processing this percussive material was to lead to a climax through reiterating and developing a repetitive theme
(as seen in *Chreode* and *Chain 1*), it became evident that the musical material around 5:19 could not adequately achieve this goal. This may be in part because the percussive material being used was primarily pitched, and it lacked the sufficient noisiness to propel the music—thematically based on stark juxtapositions of the harmonic and the noisy—to its breaking point.

Instead of changing course entirely, or even introducing a new section, new noisy material resembling static was introduced around 5:19 as a substitute for the previously heard percussive sounds. Initially introduced in a vacuum as pitched background noise is dying out, this material pushes the work to some of its highest noise levels (0.92 around 5:24). However, after the thick layering of the previous section, there is little energy in spite of the noisiness to lead to a climax. So a new layer of brittle harmonic sounds derived from a convolution of the percussive material from earlier in the section and noisy material similar to the static sounds introduced at 5:19 provides an intense shrill background as thickness and dynamic levels increase. Finally, around 5:34, a low pitched bass sound heard previously in the work begins providing more density and creating presence throughout most of the audible sound spectrum, up until the climactic hit at 5:51. Noise levels remain exceedingly high (averaging over 0.8) in this section, though they never to exceed the level of almost 0.94 found at 5:26 before the pitched bass sounds were added in.

Finally at 5:51, as the shrill, brittle sounds approach the threshold of pain, the music has run its course and the sound reserved for the climactic hit appears. While noisy in presentation, the decay of this hit actually falls quickly in noise level to about 0.65 at 6:22 when the pitched material of the coda (derived from reprocessed pitched
material found earlier in the work) takes over. From this point, the music decays to nothingness and disappears into silence. Noise levels stay relatively low, but ambient noise present in the samples does push it up slightly towards the end around 7:30.

The climax of this work provides an interesting case study in compositional process as it relates to noise. In a work that juxtaposes noise and harmonicity as its central developmental theme, it became obvious that neither the most noisy or harmonic sounds in this context had the ability to push the music to its point of highest intensity. While relatively homogenous focused and intense sounds were able to accomplish this in *Chreode* and *Chain 1*, for some reason it was necessary to layer three contrasting primary sounds of highly differing degrees of noise to create the needed intensity. While the resulting outcome of the layering (revealed by the noise chart) perhaps accomplished the goal of pushing to an exceptionally high level of noise before it dissolves with the decay of a noisy hit, the audible effect was actually of a very shrilly pitched climax dissolved by noise.

**Conclusion**

The process of composing a new work while focusing on the functional role of noise underscored how complex the interplay of physical sound characteristics, musical context, and listener perception actually can be. It also emphasized both the potential and the limitations of noise analysis principles as they relate to composition of new works. The knowledge of noise function added another dimension to consider during the compositional process, but it did not change fundamental compositional habits present in my previous works. Similar composer preferences to those displayed in *Urban Structure* regarding sound selection, processing, and arrangement can also be
observed in the new work, although noise function as defined in this paper was not intentionally considered during Urban Structure’s compositional process. Other factors that normally inform compositional decisions continued to be in play as well, including the influence of other works in the repertoire. This is particularly true in the case of how the climaxes of both Chreode and Chain 1 influenced the concept for the climax of this work. While the noise analysis of both works helped me as the composer understand the function of the climaxes better, ultimately the idea of creating a climax similar to that of Chreode—a climax that used a repeated thematic pattern at frantic speeds to provide enough impetus to lead to a noise crash at the most intense point—did not ultimately work in this context, and a different approach to supplement the sound was required.

The knowledge gained through this research allowed for a more analytical approach to composition, but it did not fundamentally change the way compositions are written. Conversely, in the area of analysis, this research demonstrated a new way to describe musical form through considering noise function, but these descriptions did as much to support conclusions drawn from other common forms of analysis than to contradict them. Although the analysis of noise content did reveal some surprises and new truths about the underlying structure of musical compositions, it did not fundamentally change the way that we understand the form of each work, but it did help cast each in a clearer light. Ultimately, it simply revealed another dimension of musical understanding, and while this is only a single dimension in a complicated web of timbres, linear and vertical sound structures, human perception, expectations, and conditioned listener biases, it provided a fascinating glimpse into the physical properties of sounds that may cause us to understand them as we do.
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