

Explorations of Just Intonation, Minimalism, and Spectralism in 20th Century Music

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Abstract

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This thesis consists of three analyses on works by twentieth century composers who explored the theoretical and practical applications of the harmonic series and just intonation. The first chapter provides a description of Harry Partch's theoretical work as outlined in his book *Genesis of A Music*, and investigates the application of his theory to a passage from his composition *Castor & Pollux* (1952). The second chapter demonstrates the influence of minimalist aesthetics in the works of James Tenney through a survey of his compositional output, and reveals how his spectral compositions arose out of minimalist models and concepts. The third chapter examines Gérard Grisey's early spectral work *Périodes* (1974) and his use of domain independence and process composition to explore the harmonic spectrum as a precompositional model.

TABLE OF CONTENTS

List of Figures.....	ii
I. Harry Partch: Theory and Practice in <i>Castor & Pollux</i> (1952).....	1
II. Minimalist Aesthetics in the Music of James Tenney.....	44
III. Domain Independence and Gradual Processes of Musical Tension and Release in Gérard Grisey's <i>Périodes</i> (1974).....	77
Sources Cited.....	123

LIST OF FIGURES

I. Harry Partch: Theory and Practice in *Castor & Pollux* (1952)

Figure	Page
1. Symmetry between 1/1 Otonality and 1/1 Utonality.	5
2. The dual Identity roles of a ratio in different Tonalities.	6
3. The 1- through 11-Identities of 1/1 O represented as a chord and as a scale. Ratios for each pitch are written below the staff, and cents deviation from 12-TET are written above the staff.	7
4. The twelve primary Tonalities of Partch's system, each made up of its respective 1-11 Identities.	7
5. The 43-tone scale, from Partch's <i>Genesis of a Music</i> , 134.	9
6. Kithara II notation, <i>Castor</i> mm. 1-2. This fragment indicates the second string of the orange hexad (hexad 12) should be plucked with the rod at the 15/8 marking along the soundboard. The second eighth note in parentheses is not rearticulated, but rather the rod is moved downward to the 1/1 position, creating a glissando.	11
7. Cloud-Chamber Bowls notation, from score instructions of <i>Delusion of the Fury</i> (1966).	13
8. Harmonic Canon II notation, <i>Castor</i> mm. 1-2. The bottom staff indicates the left hand should strum several strings in a single motion. Pitch material for each numbered string comes from the opening instructions of the piece, not shown here.	14
9. Bass Marimba notation, from <i>Genesis of a Music</i> , 275.	14
10. Diamond Marimba layout, from <i>Genesis of a Music</i> , 261. The yellow and blue numbers (in the left and right corners of each bar respectively), as well as the staff and ledger lines along the right side indicating the notation for each row, are my additions.	15
11. Diamond Marimba notation, <i>Castor</i> mm. 3-4. Following the diagram in Example 9, the first note of m. 3 is 4/3 in the fourth row from the bottom, marked with a yellow 1 (following the numbers on the left side of each bar). The second beat of m. 4 is a descending arpeggio 4/3 – 10/9 – 16/9, following the blue 5s down from the fourth row.	16
12. Formal analysis of <i>Castor</i> , mm. 1-24.	17
13. Low Bass Marimba pattern, <i>Castor</i> mm. 1-4.	18
14. Diamond Marimba, <i>Castor</i> mm. 1-2.	21
15. Diamond Marimba reduction, <i>Castor</i> mm. 1-8.	22

16. High Bass Marimba, <i>Castor</i> mm. 1-2.	23
17. Harmonic Canon II, <i>Castor</i> mm. 1-2.	24
18. Harmonic Canon II and high Bass Marimba reduction, <i>Castor</i> mm. 1-8.	25
19. Symmetry in the Kithara II horizontal intervallic relationships, <i>Castor</i> mm. 1-9.	28-29
20. Surrogate Kithara, <i>Castor</i> m. 2.	30
21. Cloud-Chamber Bowls, <i>Castor</i> mm. 1-2.	31
22. Voice leading map for the harmonic layer of <i>Castor</i> , mm. 1-8.	37
Appendix 1. Transcription of <i>Castor</i> mm. 1-8 in traditional staff notation.	40-43

II. Minimalist Aesthetics in the Music of James Tenney

Figure	Page
1. The first twenty-four partials of the A1 harmonic spectrum. The cents deviation from equal temperament is given below the partial number.	50
2. Formal structure of <i>Noise Study</i> (1961) depicting the changes in five parametric values over time. The vertical lines designate each section of the music (Tenney 1969).	53
3. Parametric mappings with the combination and alignment of the three tapes for <i>Noise Study</i> (1961). Dots along the plotted lines indicate the start of a new section. The three tapes align at the start of the fourth section (Tenney 1969).	54
4. <i>Swell Piece</i> (1967), <i>Swell Piece No. 2</i> (1971) and <i>Swell Piece No. 3</i> (1971) from James Tenney's <i>Postal Pieces</i> (1965-71).	56
5. <i>Having Never Written a Note for Percussion</i> (1971), from James Tenney's <i>Postal Pieces</i> (1965-71).	56
6. <i>For 12 Strings (Rising)</i> (Tenney 1971).	60
7. Computer model of <i>Spectral CANON for CONLON Nancarrow</i> (1974), James Tenney. The computer model is designed by Santana et al (2013).	62
8. <i>KOAN for Solo Violin</i> (1971), from James Tenney's <i>Postal Pieces</i> (1965-71).	65

9. Opening four measures to <i>KOAN for String Quartet</i> (1984), James Tenney.	67
10. Formal structure and pitch map for <i>KOAN for String Quartet</i> (1984), James Tenney.	68
11. Spectral organization of pitches in Tenney's <i>KOAN for String Quartet</i> (1984).	71
12. An example of a major triad formed by the intersection of independent processes in the second measure of this excerpt. From Tenney's <i>KOAN for String Quartet</i> (1984), mm. 191-193.	72
13. <i>In a large, open space</i> (1994), James Tenney.	74

III. Domain Independence and Gradual Processes of Musical Tension and Release in Gérard Grisey's *Périodes* (1974)

Figure	Page
1. Examples of non-traditional accidentals used in <i>Périodes</i> .	80
2. The first twenty-one harmonics of the E1 spectrum, as realized in the opening instructions of the score (Grisey 1974).	81
3. <i>Périodes</i> , formal outline for one full period. From introductory remarks to the score (Grisey 1974).	83
4. Formal structure for <i>Périodes</i> . Rehearsal numbers are in boxes.	83
5. The intervallic content of the harmonic spectrum is used to proportion the duration of each formal stage (Féron 2011).	83
6. Pitch material for each <i>Repose</i> stage and its relationship to the E1 spectrum. During R ₅ , the upper partials are found an octave higher than their initial formation in the spectrum.	86
7. R ₁ stage (Grisey 1974, 1).	87
8. R ₂ stage (Grisey 1974, 15).	89
9. Harmonic <i>subito f</i> interjections in the viola at the R ₃ stage (Grisey 1974, 28).	90
10. Dynamic pulses in the viola outlining the Fibonacci sequence at I ₁ .	95
11. Trombone gesture, based upon dynamic pulses heard in the viola during I ₁ (Grisey 1974, 7).	96
12. Harmonic aggregate beginning each group of dynamic pulses in the viola during I ₁ . Open noteheads are harmonic pitches of the E1 spectrum, and closed noteheads are pitches outside of this spectrum.	97
13. Introduction of glissandi in cello at I ₁ (Grisey 1974, 3).	98

14. Shortening of durations between successive repetitions of F#4 in the flute during I ₂ (Grisey 1974, 16).	99
15. Expansion of the grace note gesture in the flute and clarinet (Grisey 1974, 17).	100
16. An example of the <i>arco gettato</i> and <i>pizzicato</i> gestures in the cello during I ₂ (Grisey 1974, 18).	101
17. Long tones with <i>ff</i> interjections during I ₃ . Inharmonicity is introduced by the viola in the second measure of this passage with the pitch D [♯] 4 (Grisey 1974, 29).	102
18. Groupings of <i>ff</i> interjections during I ₃ . The shaded regions indicate the proportion of inharmonic pitches infiltrating the harmonic aggregate.	103
19. Arpeggio and tremolo gestures in the violin, viola and cello during I ₄ (Grisey 1974, 34).	105
20. Notations and durations of different fermatas above the repeated dyads of I ₄ . (Grisey 1974).	105
21. Comparison of the number of harmonic and inharmonic pitches during the I ₄ stage. The solid line indicates harmonic pitches, and the dotted line indicates inharmonic pitches.	108
22. First five cycles of G#3-F#4 glissandi during E ₁ . Circled numbers are added to the score to indicate cycles for each instrument (Grisey 1974, 11).	111
23. Transformation of glissandi into lines of discrete pitches in the bass during E ₁ (Grisey 1974, 12).	112
24. Order of pitches removed from G#3 – F#4 lines during E ₁ .	112
25. Alternations of double stops and harmonics in the strings during E ₂ (Grisey 1974, 19).	114
26. Independent processes in the string instruments during E ₂ .	116
27. Pitch reservoir reduction over time during the first section of E ₄ .	120
28. Voice leading in the last five gestures of E ₄ .	121

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Chapter I:

Harry Partch: Theory and Practice in *Castor & Pollux* (1952)

In the winter of 1974, *Perspectives of New Music* dedicated a page to the memory of Harry Partch in honor of his death earlier that year (Mandelbaum 1974). Alongside the praise and respect for Partch's work, the eulogy laments the neglect of his music by more traditional cultural and artistic circles within his lifetime. Despite this exclusion, there has been a resurgence of interest in his music and philosophy since his death. His writings still circulate in print, and performances of his works are given on both his original and replicated sets of instruments. Perhaps what resonates most with people is his attitude towards art: individualistic, anti-authoritarian, and bold. It is partly for these reasons that his legacy has found a place amongst curious musicians since his passing.

Partch's theoretical work has also been influential for a number of composers, ushering in a compositional technique known best as microtonality. While by no means the progenitor of these ideas outright, his demonstration of microtonal concepts serve for many as an introduction to the topic. His theoretical explanations for microtonality and subsequently his own compositions are found in his book *Genesis of a Music*, first published in 1949 (hereafter *Genesis*). The construction of Partch's scale has been scrutinized in some detail, and successive generations of microtonal composers cite his theoretical ideas as influential in their own approaches to choosing pitch material (Keisley et al. 1991, Gilmore 1995).

However, what remain less discussed are the details of how Partch put his theory into practice. How does Partch compose with his microtonal design, and do these approaches agree with his theoretical descriptions of tonality and resolution? There are several obstacles standing in the way of making sense of any of his pieces. His music can only be performed on his own invented instruments; only one full and one partial replica

of this collection have been constructed beyond his own set, and the space and upkeep for these instruments is costly. Furthermore, the scores for these instruments come to us as handwritten tablature, and the notation lacks any description of pitch. With the instructions included in *Genesis*, the translation of some of these scores becomes possible. However, others remain unintelligible without other sources such as information from other unrelated scores, word-of-mouth explanations, and first-hand access to the instruments themselves.

To provide an answer to these questions, Partch's 1952 piece *Castor & Pollux* will serve as an example of his compositional output, and we will explore his theories within the context of this piece. This work, a freestanding instrumental movement depicting the subtitled "Dance for the Twin Rhythms of Gemini," was at one time combined with two other pieces to form the set *Plectra and Percussion Dances* (1952). Partch later made minor revisions in 1968 to accommodate performance issues and instrument modifications. The following analysis will refer to this revised score.

Ratios, the 43-Note Scale, and Tonality

Partch uses ratios to represent pitches in place of letter names. The pitch G is defined as 1/1; a ratio in his music represents the frequency of pitch in relation to 1/1 (Partch 1974, 69). Each ratio is written between 1/1 and 2/1 and can represent the pitch at any octave. A useful way to conceptualize these ratios comes from the monochord. If a string (1/1) is divided into two equal parts, each division will sound an octave above the original length (2/1). Dividing the string into thirds gives a pitch an octave plus a fifth above the original length. The frequency of each pitch is inversely proportional to the length of the string. At one-third of the string length, the pitch is three times the

frequency of the undivided string (3/1). This ratio is divided in half to fit between 1/1 and 2/1:

$$3/1 \div 2 = 3/2,$$

and has a frequency one and one-half times that of 1/1, equivalent to the pitch D. Partch draws his initial pitch material from monochord divisions up to eleven equal parts. This scheme of division is sometimes referred to as a “limit”; the pitches that arise from dividing the string into eleven parts can be categorized as an 11-limit system of tuning.

Labeling pitches as ratios allows the intervallic distance between two notes to be measured fairly easily. To find the distance between two ratios, divide the higher pitch by the lower pitch. For example, the interval between 3/2 and 9/8 is¹:

$$3/2 \div 9/8 = 24/18 = 4/3.$$

The resulting ratio is representative of the frequency relationship between the two pitches 3/2 and 9/8. Similarly, to find a pitch some interval above another pitch, multiply the starting pitch by the interval in question. For example, to find the pitch that is 4/3 above 9/8:

$$9/8 \times 4/3 = 36/24 = 3/2.$$

Ratios with similar numerators or denominators can be combined to form a Tonality, a collection of pitches analogous to a key in common-practice music, although the treatment and function of Tonality in Partch’s terms are completely different. He identifies two types of Tonalities: Otonality and Utonality. An Otonality is based on the pitches of the overtone series. Successive harmonics of a given fundamental make up the pitch content of a given Otonality. Because the frequencies of these pitches are related to

¹ For the sake of clarity, any ratio explicitly written as an interval between two pitches will be *italicized*.

the fundamental by integer multiples, simultaneous pitches of the same Tonality can fuse together in sound (Partch 1974, 138-140).

Conversely, the basis for a Utonality comes from the spurious undertone series, which is essentially a mirror reflection of the overtone series about the fundamental (Figure 1). The undertone series has been widely discredited as a fabricated phenomenon that does not actually occur in nature (Ernst 2016). Despite this hiccup in Partch's theoretical research, undertones stand on equal footing with overtones in his musical design. The concept of Utonality must be interpreted as a viable part of Partch's compositional technique, regardless of its scientific authenticity².



Figure 1.
Symmetry between 1/1 Otonality and 1/1 Utonality.

A ratio expressed in an Otonality holds the Tonality in the denominator. 1/1 Otonality (1/1 O) is made up of ratios with denominators of 1 or some multiple of 2, such as 1/1, 3/2, 5/4, and 9/8. Each numerator refers to the Identity of that pitch in the

² Other composers have followed Partch's concept of Utonality, even though it is understood to not be an acoustical occurrence (Fonville 1991).

Tonality. 1/1 is the 1-Identity of 1/1 O, 3/2 is the 3-Identity, and so on (Figure 2a). The positioning of these two values in a Utonality is switched; the Tonality is found in the numerator, and the Identity in the denominator (Figure 2b). 1/1 remains the 1-Identity of 1/1 Utonality (1/1 U), but 4/3 becomes the 3-Identity, 8/5 is the 5-Identity, and so on.

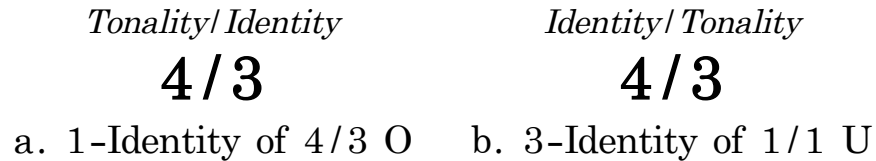


Figure 2.
The dual Identity roles of a ratio in different Tonalties.

Partch chooses the Identities 1, 3, 5, 7, 9, and 11 as the basis for his pitch material and subsequently his harmonic materials (Partch 1974, 160). These Identities can be ordered to build a chord in successive 3rds: 1-5-3-7-9-11. Since these pitches derive from the same fundamental 1-Identity, a six-note chord containing these pitches will exhibit sonic fusion and is treated as a form of consonance. These notes can also be ordered in a linear fashion for melodic or voice-leading purposes: the Identities 1-9-5-11-3-7 of 1/1 O are the just-intonation equivalents of the pitches G-A-B-C#-D-F (Figure 3).

Partch begins with the 1-11 Identities of 1/1 O [1/1, 3/2, 5/4, 7/4, 9/8, 11/8] and 1/1 U [1/1, 4/3, 8/5, 8/7, 16/9, 16/11]. These two pitch collections are symmetrical to one another about 1/1. For example, the 3-Identity of 1/1 O (3/2) is the interval 3/2 above 1/1, and the 3-Identity of 1/1 U (4/3) is the interval 3/2 below 1/1. Each of the pitches in this collection are then treated as its own O- or Utonality, and the 1-11 Identities of these Tonalties are identified (Figure 4). This procedure generates twenty-nine unique pitches,

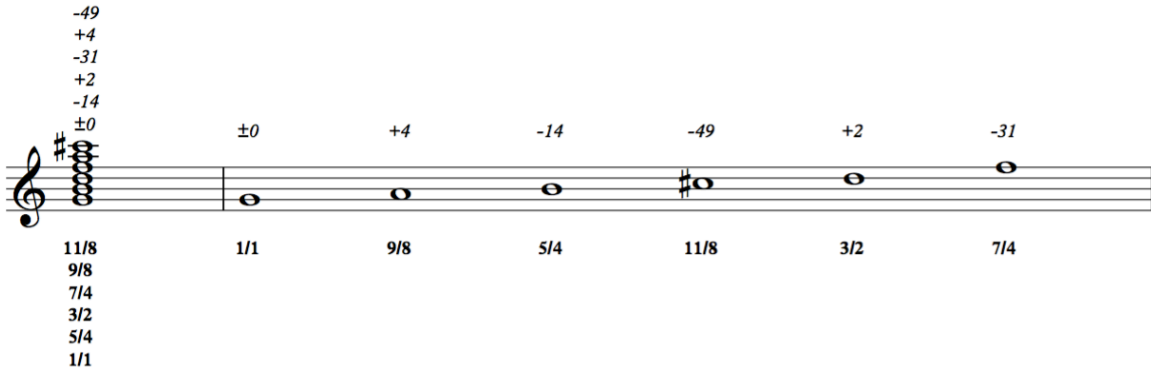


Figure 3.

The 1- through 11-Identities of 1/1 O represented as a chord and as a scale. Ratios for each pitch are written below the staff, and cents deviation from 12-TET are written above the staff.

combinations of which can be arranged to form Partch's twelve primary Tonalities. When these twenty-nine pitches are organized to form a scale, there are relatively large intervals between certain successive notes. The distance between 1/1 and 12/11 is roughly one and a half semitones, and the distances between 7/6 and 6/5, 9/7 and 4/3, and 4/3 and 11/8 are

Tonality:	1/1 O	4/3 O	8/5 O	8/7 O	16/9 O	16/11 O
1-Identity	1/1	4/3	8/5	8/7	16/9	16/11
3-	3/2	1/1	6/5	12/7	4/3	12/11
5-	5/4	5/3	1/1	10/7	10/9	20/11
7-	7/4	7/6	7/5	1/1	14/9	14/11
9-	9/8	3/2	9/5	9/7	1/1	18/11
11-	11/8	11/6	11/10	11/7	11/9	1/1

Tonality:	1/1 U	3/2 U	5/4 U	7/4 U	9/8 U	11/8 U
1-Identity	1/1	3/2	5/4	7/4	9/8	11/8
3-	4/3	1/1	5/3	7/6	3/2	11/6
5-	8/5	6/5	1/1	7/5	9/5	11/10
7-	8/7	12/7	10/7	1/1	9/7	11/7
9-	16/9	4/3	10/9	14/9	1/1	11/9
11-	16/11	12/11	20/11	14/11	18/11	1/1

Figure 4.

The twelve primary Tonalities of Partch's system, each made up of its respective 1-11 Identities.

roughly half a semitone each; the complements of these pitches below $2/1$ exhibit identical spacing imbalances. Two sets of seven pitches each are selected to shorten these gaps, again symmetrical to one another about $1/1$. These pitches are determined as the combination of two 11-limit intervals. For example, the pitch $33/32$, chosen as one of four pitches subdividing the interval between $1/1$ and $12/11$, can be reached by measuring the interval $11/8$ above $3/2$:

$$3/2 \times 11/8 = 33/16 = 33/32.$$

With the inclusion of these fourteen new pitches, sixteen secondary Tonalities are possible, albeit mostly in fragmented forms with some upper Identities not present.

This scale is now commonly referred to as Partch's 43-tone scale, although it is not a limitation of his musical materials (Figure 5). These 43 pitches serve as a basis for Partch's theoretical explanation and instrument construction, but his music makes use of pitches outside this collection. Several of his string instruments are not fixed in pitch, and each string can be tuned and divided to produce pitches not included in this scale. Sometimes these pitches will be written as new ratios, and others will be given the closest familiar ratio with a sharp or flat symbol.

A single pitch can exist in several different Tonalities, a phenomenon Partch refers to as "multiple senses" (Partch 1974, 163). For example, $1/1$ is found as some Identity in all twelve primary Tonalities, and both $3/2$ and $4/3$ are found in nine of the twenty-eight Tonalities. These allow for the possibility of motion from one Tonality to the next with common tones held between the two Tonalities. This concept of multiple senses can also lead to tonal ambiguity, a situation where two or more Tonalities are possible given the harmonic pitches.

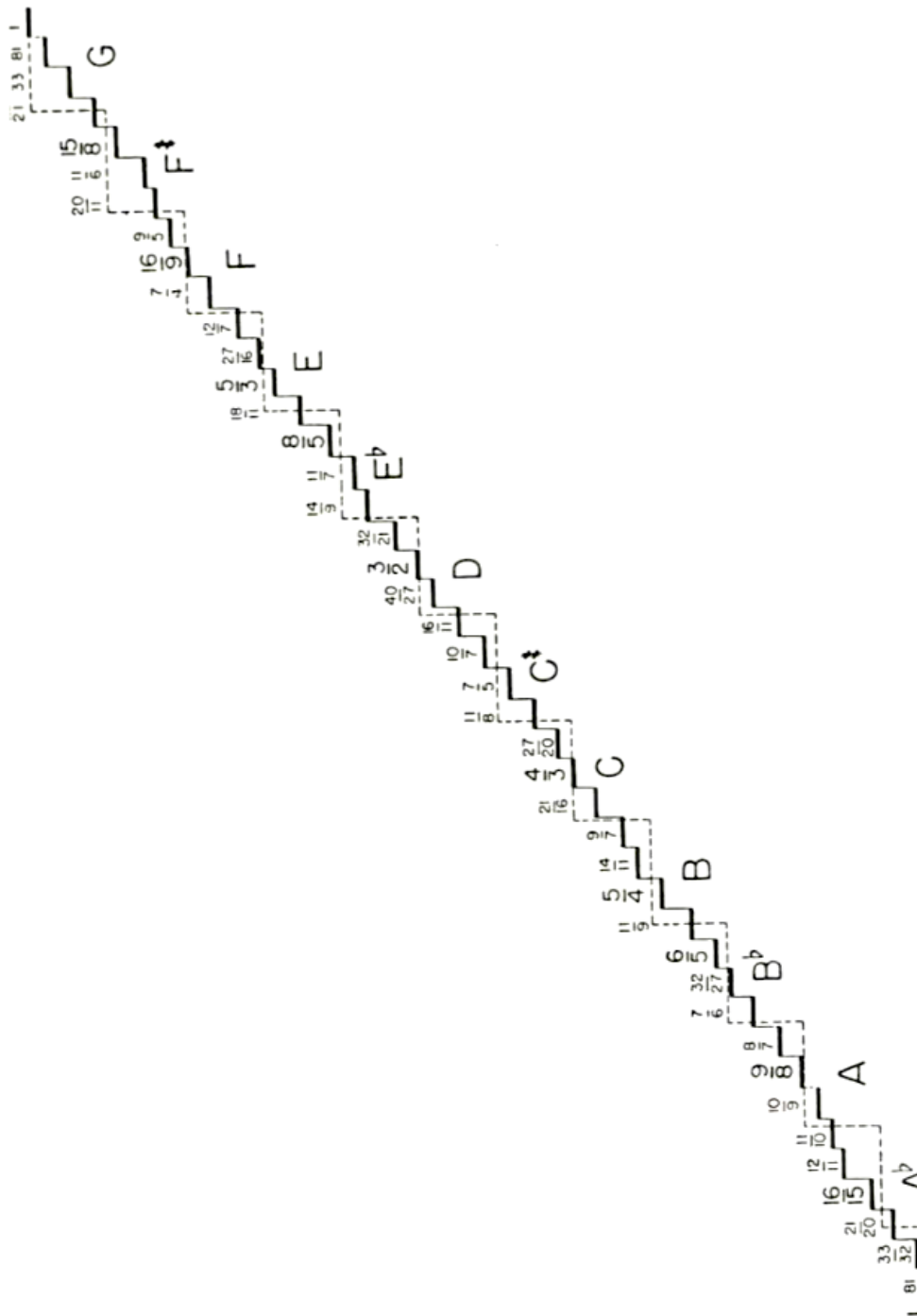


Figure 5.
The 43-tone scale (Partch 1974, 134).

Each Identity has a relative strength of projecting or expressing the given Tonality. The closer the Identity is to 1, the stronger the projection will be. Conversely, the further the Identity is from 1, the less consonant it will be (Partch 1974, 151). The upper Identities 7, 9, and 11 provide a weaker definition of the Tonality than the 1, 3, and 5 Identities. When this hierarchy of Identities is combined with the concept of multiple senses, it allows us to determine the most likely Tonality that the pitch (or pitches) represents. For example, 9/8 is both the 9 Identity in 1/1 O and the 1 Identity in 9/8 U. From this pitch alone, the projection towards 9/8 U is greater than that towards 1/1 O. However, the Tonality will often be dependent on multiple pitches in the harmonic structure, and the combinations of these Identities within different Tonalitys can be weighed against one another to see which is strongest.

Instruments and Notation

The notation in Partch's scores is useful for performance, but is not necessarily descriptive of the actual sound. With few exceptions, pitch and contour are not visually represented, and only the rhythm resembles our familiar notation. To decipher these characteristics, the information in the score must be translated into Partch's language of ratios. Each instrument has its own system of notation, and therefore each will have a different translation process. *Castor & Pollux* (1952) employs six instruments, each of which is described in detail below.

The *Kithara II* (KII) is a plucked string instrument consisting of seventy-two strings, divided into twelve sets of six strings each. These sets, or hexads, are numbered 1 through 12 moving left to right on the instrument. Each hexad is tuned according to a

different primary Tonality. For example, the strings of hexad 1 are tuned to 8/7 O [8/7, 10/7, 12/7, 1/1, 9/7, 10/7] (Partch 1974, 229).

The two outermost hexads on either side (numbers 1, 2, 11, and 12) are marked both on the instrument and in the score by the colors green, red, violet, and orange respectively. Each hexad is equipped with a Pyrex rod that fits between the strings and the soundboard. This rod can slide up and down the length of the soundboard, changing the vibrating length of the string. These strings are tuned when the rod is at its topmost position, allowing the longest possible length of the strings. Each soundboard has a set of marked ratios indicating intervals above these pitches. The notation for Kithara II uses the spaces of the traditional staff, with the hexad number indicated below each note (Figure 6).

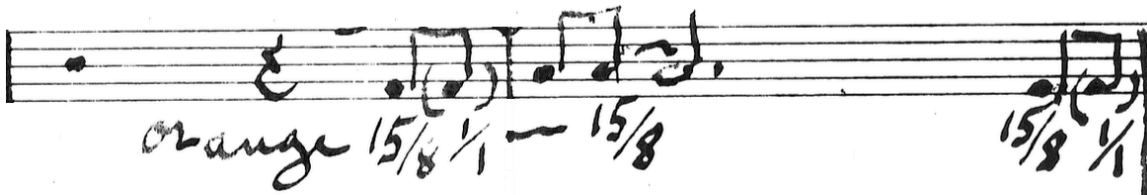


Figure 6.

Kithara II notation, *Castor* mm. 1-2. This fragment indicates the second string of the orange hexad (hexad 12) should be plucked with the rod at the 15/8 marking along the soundboard. The second eighth note in parentheses is not rearticulated, but rather the rod is moved downward to the 1/1 position, creating a glissando.

The pitch ratios in the score refer to the markings on the soundboard, and these markings measure the interval above the pitch of each string. To calculate the ratio of the sounding pitch P , the following formula will be helpful:

$$P(r, s, t) = r \times (s \div t),$$

where “r” is the marked ratio on the soundboard, “s” is the string’s tuning, and “t” is the Tonality of the given hexad. This process can be demonstrated using the opening measure of *Castor & Pollux* (see Figure 6). The second string of the orange hexad (i.e. hexad 12) is tuned to $3/2$ (s), the given tonality is $3/2$ Utonality (t), and the marked ratio is $15/8$ (r). Using our formula, we can calculate:

$$P(15/8, 3/2, 3/2) = 15/8 \times (3/2 \div 3/2) = 15/8$$

The solution $15/8$ is the interval above $1/1$. For ease of understanding, all ratios mentioned in this analysis will be converted to their sounding ratios within the context of Partch’s scale.

The *Surrogate Kithara* (SK)³ is another plucked string instrument consisting of sixteen strings, divided into two sets, or octads, of eight strings each. Each of these octads is also equipped with a sliding rod and ratio markings along the soundboard. The two octads are each marked with either the color green or orange, and the strings are tuned according to the tonalities associated with those colors on the Kithara II. Only one pitch, the highest string on the orange octad, is not found in the harmonic series of the $3/2$ Utonality. This pitch is included as a built-in dissonance, a quality inherent to the instrument and a clue to Partch’s treatment of Tonality and consonance. The same formula as above can be used to calculate the sounding pitches of this instrument. The notation is the same as the KII, with the additional two strings appearing in the spaces above the first two upper ledger lines.

The *Cloud-Chamber Bowls* are a percussion instrument made up of fourteen Pyrex carboys cut to various sizes to match different pitches in Partch’s scale. Each bowl

³ Construction of the Surrogate Kithara came about for *Castor & Pollux* specifically. Originally, both the Kithara II and Surrogate Kithara parts were written for one player on the KII, but the part proved too difficult for a single performer. The SK was built and the music was divided between the two instruments.

is represented on the staff by a space or line, beginning with the first ledger line below the staff (Figure 7). Each bowl can be struck on either the side or the top, notated as a circle or a square respectively. The sound produced by striking each bowl has a complex harmonic spectrum. Throughout Partch's life, bowls would break and he would change the configuration of the instrument, so the set of pitches varies between compositions. For this analysis of *Castor & Pollux*, the pitch information comes from the score to *Delusion of the Fury* (1966). The score for this piece contains an updated set of pitches for the *Bowls*, and is the closest chronological source preceding the 1968 revisions.

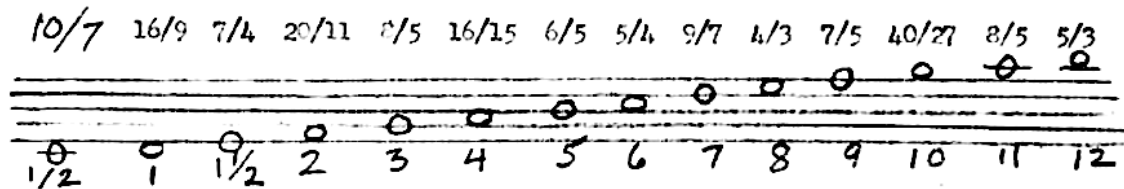


Figure 7.

Cloud-Chamber Bowls notation, from score instructions of *Delusion of the Fury* (1966).

The *Harmonic Canon II* (HCII) is another of the plucked string instruments consisting of forty-four strings set horizontally across a soundboard. Prior to a performance, the player is instructed to place wooden bridges of various sizes at specific points between the terminal ends of the strings. These bridges shorten the length of the string and provide two pitches, one on either side of the bridge. In *Castor & Pollux*, all forty-four strings are initially tuned to the same pitch before placing the bridges, although other string combinations are required for some of Partch's other compositions. The ratios are indicated on the opening page of the score, along with approximate measurements for bridge placement. The strings are numbered 1 through 44, and the score uses these numbers for notation as opposed to making use of the staff lines for a

method of organization (Figure 8). The music is written on two staves to indicate what notes are to be played by the performer's left and right hands.

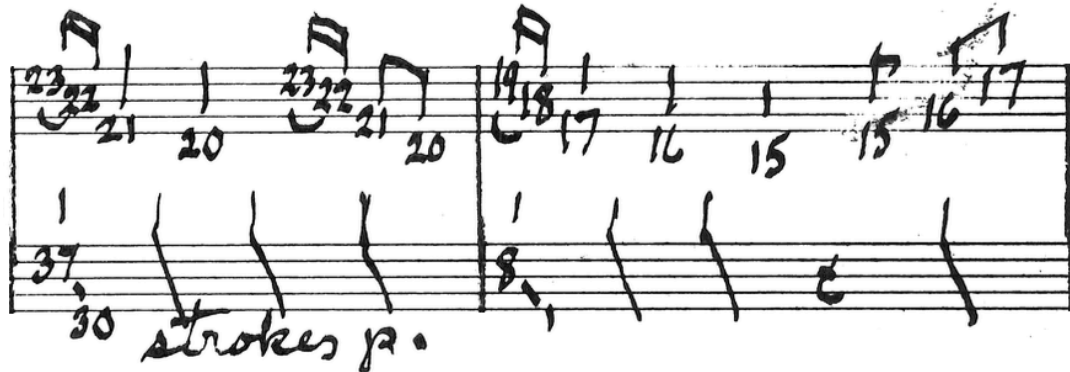


Figure 8.

Harmonic Canon II notation, *Castor* mm. 1-2. The bottom staff indicates the left hand should strum several strings in a single motion. Pitch material for each numbered string comes from the opening instructions of the piece, not shown here.

The *Bass Marimba* (BM) is a percussion instrument made up of eleven large bars of spruce atop a set of resonators. The bars are notated on the lines and spaces of the staff, and the ratio of each bar is easily found in *Genesis* (Figure 9). In *Castor & Pollux*, the Bass Marimba is separated into a high and low part, each played by a separate performer (HBM and LBM). These two players participate in separate duets or trios, and only perform together during the fourth repetition of each movement.

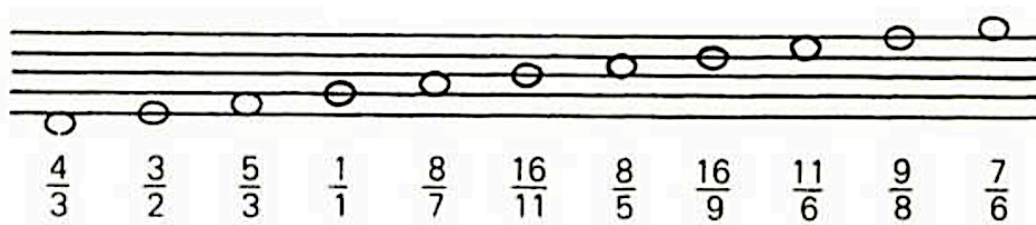


Figure 9.

Bass Marimba notation (Partch 1974, 275).

The *Diamond Marimba* (DM) is a percussion instrument made up of thirty-six wooden bars situated in the shape of a diamond. The bars are tuned to outline the first six identities of the primary tonalities ordered in ascending or descending thirds. Each bar is labeled with two different colored numbers, each referring to the Identity of that pitch in Otonality (blue) or Utonality (yellow) (Figure 10). In the score, each row of the instrument is represented by a line on the staff, with these rows extending three ledger lines above and below. The blue Otonality numbers are written below the noteheads, and the yellow Utonality numbers are above the noteheads (Figure 11).



Figure 11.

Diamond Marimba notation, *Castor* mm. 3-4. Following the diagram in Example 9, the first note of m. 3 is $4/3$ in the fourth row from the bottom, marked with a yellow 1 (following the numbers on the left side of each bar). The second beat of m. 4 is a descending arpeggio $4/3 - 10/9 - 16/9$, following the blue 5s down from the fourth row.

Harmonic Analysis of *Castor*

The formal structure of *Castor & Pollux* consists of two large sections each divided into four parts. The first three parts are a series of duos and one trio, while the fourth part is made up of these same three parts played simultaneously. *Castor*, the first section, begins with the trio, comprising the Kithara II, Surrogate Kithara, and Cloud-Chamber Bowls. The following duo is made up of the Harmonic Canon II and high Bass

Marimba, and the final duo features the Diamond Marimba and low Bass Marimba⁴.

While each duet and trio functions musically on its own, the combination of all seven members of the ensemble outlines a coherent organization.

The first half of *Castor* spans twenty-four measures and can be broken into three eight-bar periods. The meter alternates between 4/4 and 5/4 for this entire section. Some instruments repeat the same music in each period, such as the Kithara II and Bass Marimba, while others vary in successive repetitions. Figure 12 demonstrates the structure of these three periods and the repetition of musical material. The first period will be analyzed in some detail to determine the harmonic layer and Tonality of each measure. These eight measures are presented in staff notation with ratios and cents deviations labeled in Appendix 1.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
KII	a								a								a							
SK	a								a								a'							
Bowls	a		a		a		a		a		a		a		a		b							
HCII	a								b								a				b'			
HBM	a								a								a							
DM	a								b				a				a				b'			
LBM	a				a				a				a				a				a			

Figure 12.
Formal analysis of *Castor*, mm. 1-24.

With the exception of the Surrogate Kithara, each instrument has its own melodic line. Together, these lines form a dense contrapuntal texture held together by the emerging rhythmic patterns of the dance. Are these pitches organized in some way to outline a harmonic structure that suggests a specific Tonality? We can answer this

⁴ The instruments of the duos and trio are rearranged from this configuration in *Pollux*, although the KII and SK always appear together in the trio.

Given this information, $4/3$ O seems the likely candidate for the Tonality of this measure. However, other musical information can further guide this deciding process, and rhythm can play a role in determining the harmonic content. It seems most likely that $3/2$ and $1/1$ are a part of the Tonality because of their simultaneous appearance on the strong beats of the measure. Following this initial dyad, the pitches $5/3$ and $8/7$ appear sequentially and on the weaker second and fourth beats. $5/3$ and $8/7$ are $10/9$ and $8/7$ above $3/2$ and $1/1$ respectively, each interval roughly equivalent to two semitones away from a note of the previous dyad. These notes could be considered as non-harmonic pitches stepping away from and returning to the same harmonic pitches, equivalent to neighbor tones in common-practice music.

Another factor to consider is the vertical interval formed between the notes of each dyad. $3/2$ and $1/1$ form the strongly consonant interval $4/3$, while $5/3$ and $8/7$ create the dissonant interval $48/35$. This dissonance subsequently resolves back to the consonance from which it initially departed in the following beat. This alternation of “perfect” and “imperfect” intervals creates dissonance and resolution through the use of chromatic neighboring microtones.

The second and fourth measures of the LBM pattern have the same rhythm, the first three beats of which consist of a repeated note with a syncopated melodic line sounding above. The fourth beat is silent, and two simultaneous notes are struck on the fifth and final beat. In the second measure, $3/2$ repeats below a melodic line traveling $16/11 - 8/5 - 16/11 - 8/7$. This upper line gives the 5-, 7-, and 11-Identities of $1/1$ U, but none of these pitches shares any Tonality with $3/2$. On the fifth beat, $4/3$ and $5/3$ join together as the 1- and 5-Identities of either $4/3$ O or $5/3$ U, before rising to $3/2$ and $1/1$ in

the third measure. $4/3$ could be heard as the 3-Identity of $1/1$ U, but $5/3$ does not align with this Tonality.

From the LBM alone, there are several possible descriptions of Tonality for this measure. We could consider $3/2$ as a suspended harmonic pitch from the previous measure that resolves to $4/3$ in the fifth beat. By this logic, the first part of the measure outlines $1/1$ U, clouded by the suspended $3/2$ from the previous Tonality. The last beat of the measure has a shift in Tonality from $1/1$ U to $4/3$ O with the $4/3 - 5/3$ dyad. Another possibility is that the entire measure is in $4/3$ O, with the upper line creating dissonance and only resolving at the end of the bar. If this hypothesis were true, $3/2$ would belong to the Tonality while the upper line creates varying degrees of dissonance. This dissonance does not resolve until the upper line reaches $5/3$, forming the comparatively consonant interval $5/4$ with the $4/3$ below.

Other interpretations of this passage are conceivable. A likely alternative explanation considers the restrictions imposed by the instrument's construction. The composer is severely limited in his choices of pitch material, and he may be forced to pick a note that disagrees with the overall Tonality. Contour, instead of harmonic function, could be the determining factor for pitch choice. The LBM line has a musically satisfying contour that stands on its own when played in the duet section. When forced to make a choice between an effective contour and an expression of some Tonality, the composer must decide what best serves the music. In this instance, Partch chooses contour to create melodic lines with feelings of connectivity and provide a stable platform for the more agile instruments to perform above. As we approach the pitch

materials of the remaining ensemble, the BM may have less harmonic significance at certain points.

The Diamond Marimba is coupled with the LBM in *Castor*. This instrument has a larger number of available pitches than the LBM, but the layout and ranges of these pitches limit the options for stepwise melodic motion within the context of a specific Tonality. For these reasons, we can differentiate between harmonic and non-harmonic tones as we did with the LBM. The same basic rhythm makes up the first seven bars of this period. Four sixteenth notes lead into a descending arpeggiated triad, which is followed by three more eighth notes and a rest (Figure 14). The 5/4 bars each have an



Figure 14.
Diamond Marimba, *Castor* mm. 1-2.

additional three eighth notes after the rest. Each arpeggiated triad outlines three Identities of a Tonality. In measure 1, this triad is (in descending order) 1/1 – 5/3 – 10/7. These three pitches form the 5-, 3-, and 7-Identities of 5/4 U respectively, outlining the equivalent of a diminished triad. Most of the other pitches in this first measure belong to this triad, the only exceptions being 4/3, 14/9, and 12/7. These three non-harmonic tones are found neighboring to or passing between these triadic pitches throughout the melodic line. The final note in this measure is 12/7, a note not belonging to the Tonality expressed by the melodic line and the interval of 36/35 above the previous pitch of the Tonality, 5/3.

In the second measure, the arpeggiated triad contains the pitches $7/6 - 1/1 - 14/9$, outlining the 3-, 7-, and 9-Identities of $7/4$ U, equivalent to a major triad (although not the same major triad built on the 1-, 3-, and 5-Identities of some Otonality). The concluding note of the initial rhythmic pattern is $7/6$, a note belonging to this triad and Tonality. The note preceding this consonance is $6/5$, a note that does not belong to this Tonality. $6/5$ is the interval $36/35$ above $7/6$. The dissonance created at the end of the melodic line in measure 1 is resolved in the rhythmically equivalent spot in measure 2. What is more, the pitches $5/3 - 12/7$ in measure 1 are symmetrically related to $6/5 - 7/6$ in measure 2 about $1/1$. The last three pitches of measure 2 do not belong to $7/4$ U, but rather anticipate a return to the Tonality $5/4$ U in measure 3, which is a restatement of measure 1.

The arpeggiated triads can serve as the basis for the harmonic representation of the DM. Measures 1-7 all follow the same general pattern, but the eighth bar has consistent sixteenth notes that emphasizes two dyads of $1/1$ U. Figure 15 displays a pitch-class map of the voice leading from chord to chord. This voice leading does not function at the level of pitch itself because of the limitations of the instrument.

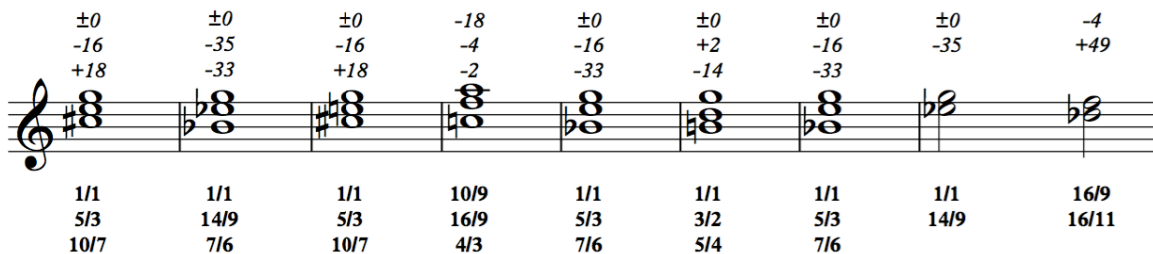


Figure 15.
Diamond Marimba reduction, *Castor* mm. 1-8.

How does each Tonality outlined by the DM correspond with the LBM? In measures 1 and 3, the LBM's pitches $1/1$ and $5/3$ match the $5/4$ U outlined by the DM.

This realization means the lowest pitch $3/2$ is not a part of the Tonality, but rather a neighboring tone to the $5/3$. In the second measure, none of the LBM pitches belongs to the $7/4$ U outlined by the DM. Only in the fifth beat of this measure do the LBM and DM align; both instruments play $5/3$ in anticipation of the forthcoming Tonality in measure 3. The LBM partly agrees with the $16/9$ O outlined by the DM in measure 4 with the pitches $4/3$ and $16/9$.

In measures 5 and 7, the LBM largely agrees with the $4/3$ O outlined by the DM. This time, the stepwise motion from $3/2$ to $5/3$ is between two harmonic tones, and only $8/7$ is a non-harmonic neighboring tone above $1/1$. In measure 6, only the repeated $3/2$ in the LBM aligns with the $1/1$ O triad in the DM. In this case, the LBM's $4/3$ is a lower neighboring non-harmonic note to $3/2$ that bridges measures 6 and 7. In measure 8, the LBM completely agrees with the DM, containing notes entirely made up of $1/1$ U. The pitches of the LBM are exclusively of $1/1$ U, with no non-harmonic tones present.

These explanations can help us understand the high Bass Marimba part as well. Again, melodic contour takes precedence over harmonic structure, and non-harmonic pitches are used to reach and connect harmonic pitches. In all but the last measure of each period, the HBM has an ascending or descending line of sixteenth notes followed by a repeated pitch in eighth notes (Figure 16). The repeated pitch is much more likely to be a



Figure 16.
High Bass Marimba, *Castor* mm. 1-2.

part of some harmonic structure, as opposed to the four notes preceding it. In the eighth measure, the HBM repeats the same descending four sixteenth notes three times, before repeating the lowest of these pitches on the fifth beat.

The Harmonic Canon II plays in duet with the HBM. The right hand is located on the upper staff and contains mostly melodic material, while the left hand strums chords on almost every beat (Figure 17). There are three different chords that rotate throughout

Figure 17.
Harmonic Canon II, *Castor* mm. 1-2.

this section, typically changing once per bar. Each chord is made up of two pitches repeated across seven or eight strings. All three chords are represented in the first four measures of this section: two 9/8s an octave apart, 1/1 and 7/6, and two 4/3s an octave apart. These chords undoubtedly contribute to the harmonic layer and provide a strong harmonic context for the counterpoint surrounding them. When combined with the harmonic pitch provided by the HBM, we can narrow down the number of possibilities for a Tonality in each bar (Figure 18).

The right hand of the HCII can confirm a Tonality for some of these measures. The melodic line occupies the pitch space between the two notes of the strummed chord.

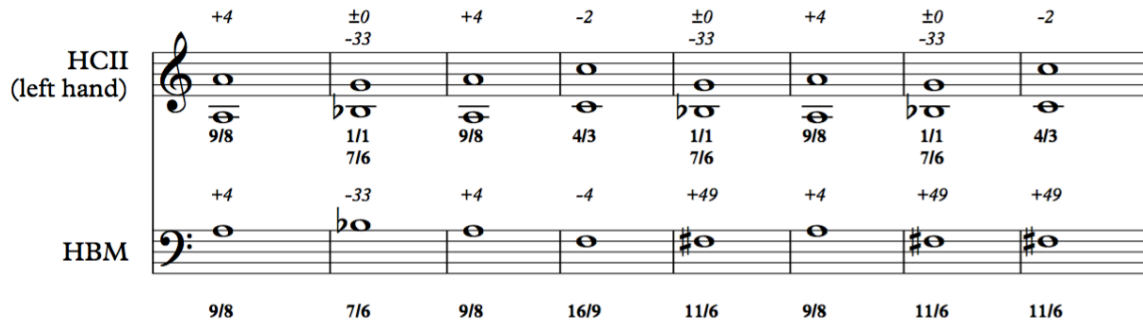


Figure 18.
Harmonic Canon II and high Bass Marimba reduction, *Castor* mm. 1-8.

The intervals formed between each note of the melody and the pitches of the harmonic layer form sequences of increasing and decreasing dissonance. In measure 1, the melodic line begins on 9/8 in unison with the strummed chord, but quickly descends through 11/6 to 16/9 and 8/5. The beginning unison is maximally consonant, but the other three notes form high-number intervallic ratios with 9/8 and are comparatively dissonant intervals (27/22, 81/64, and 45/32 respectively).

This first measure only emphasizes 9/8 as a harmonic pitch, but the remaining melodic material does not provide any clues to suggest a Tonality. In the second measure however, the melody travels to the harmonic pitches 7/5 and 7/4, aligning with 1/1 and 7/6 in the strummed chord and outlining the 1-7 Identities of 7/4 U. 7/5 and 7/4 form the intervals 6/5 and 3/2 above 7/6 respectively, consonant in comparison to the dissonant intervals 33/28 and 60/49 formed by the preceding two pitches in this measure. The arrival of the pitch 7/5 resolves the dissonances created by the harmonic discrepancies between melody and chord.

The third measure is a restatement of the first bar, once again resulting in an ambiguous Tonality. The fourth measure contains the harmonic pitches 4/3 and 16/9, suggesting either 1/1 U or 16/9 O. The melodic line reaches 16/9, 8/5, and 16/11, giving

the 9-, 5-, and 11-Identities of $1/1$ U. The other melodic pitches do not align with either of these possibilities for Tonality, leaving $1/1$ U the best candidate for this measure. Thinking back to the LBM/DM duet, we recall that the Tonality expressed in this measure was determined to be $16/9$ O for those two parts. We will address this discrepancy and others like it later on.

In the second half of this first period, the harmonic implications become clearer. The harmonic layer of measures 5 and 7 give the three pitches $1/1$, $7/6$, and $11/6$, outlining the 3-, 7-, and 11-Identities of $4/3$ O. In both cases, the right hand strongly supports this Tonality. In measure 5, the melodic line is made up of $4/3$ (the 1-Identity of $4/3$ O), $1/1$, and $7/6$, as well as the non-harmonic pitch $21/20$. This latter pitch is a neighbor note to $1/1$, and never appears on a strong beat. In measure 7, the right hand strums the $4/3$ chord atop the $1/1$ and $7/6$ chord in the left hand.

Measure 6 has the same harmonic pitch $9/8$ found in measures 1 and 3, but the HCII's melodic line provides some pitch material that aligns with this note. The melodic pitches $15/8$ and $1/1$ combine with the harmonic pitch $9/8$ to outline the 15-, 1-, and 9-Identities of $1/1$ O. The 15-Identity is reached as an extension of the harmonic series beyond the eleventh partial and is a viable option for determining Tonality, albeit a comparatively weaker Identity than those based upon lower partials.

In the eighth measure, the HBM and HCII give the harmonic pitches $11/6$ and $4/3$ respectively. Together, these form the 1- and 11-Identities of $4/3$ O, the Tonality expressed in the previous measure. However, the melodic line of the HCII appears to center around $1/1$ U with the pitches $16/9$, $8/5$, and $16/11$. The $4/3$ chord also belongs to this Tonality, suggesting that the HBM is not expressing any harmonic pitches for this

measure. This harmonic discrepancy is again caused by the limitations of pitch material and construction of the instrument. When the duets and trio are combined, the LBM uses the bars directly adjacent to the HBM part. For the LBM player to play this part successfully, the HBM player is confined to the pitches above the note $16/9$, none of which align with $1/1$ U. Given these considerations, it seems most likely that the Tonality expressed by the HCII and HBM in the eighth measure is $1/1$ U.

It proves to be more difficult to determine a Tonality for each measure in the trio. The Kithara II has only a single melodic line, and the Cloud-Chamber Bowls repeat the same two-bar pattern throughout the entire first period. The Surrogate Kithara part, originally conceived for the KII, provides more definitive harmonic content. In three of the eight measures, the SK has a plucked note followed by a strummed chord. In each case, the chord clearly outlines a single Tonality. However, the KII and Bowls seldom outline any Tonality, and only on occasion does one align with the SK. Tonality remains ambiguous for the measures without SK chords when played separate from the remaining ensemble.

The KII consists of four two-bar phrases, each of which has some combination of ascending and descending dyads. The second note of each dyad is not plucked, but rather the rod is slid to this position after plucking the first note, creating a glissando. The first three of these phrases end on $3/2$, while the last phrase initially ascends to $3/2$ and eventually descends to $15/8$, ending an octave above the starting pitch of the first phrase.

Because of the large number of strings and application of the sliding rods, the possibilities of pitch choice for this instrument are potentially infinite. The instrument is

not limited to pitch choice because of its construction, as with the percussion instruments. Some pitches that arise in this section are ratios not found in Partch's scale, such as 15/14 or 9/5 \sharp ; the selection of these pitches makes it difficult to understand this part from the perspective of Tonality⁵.

What is the organizing principle for the KII's pitch material? Interestingly, the intervals between the notes of each dyad form a pattern of symmetry. In the first phrase, seen in measures 2-3, the notes of each dyad are each 16/15 apart from one another, equating to roughly a minor 2nd (Figure 19a). The four dyads making up the second

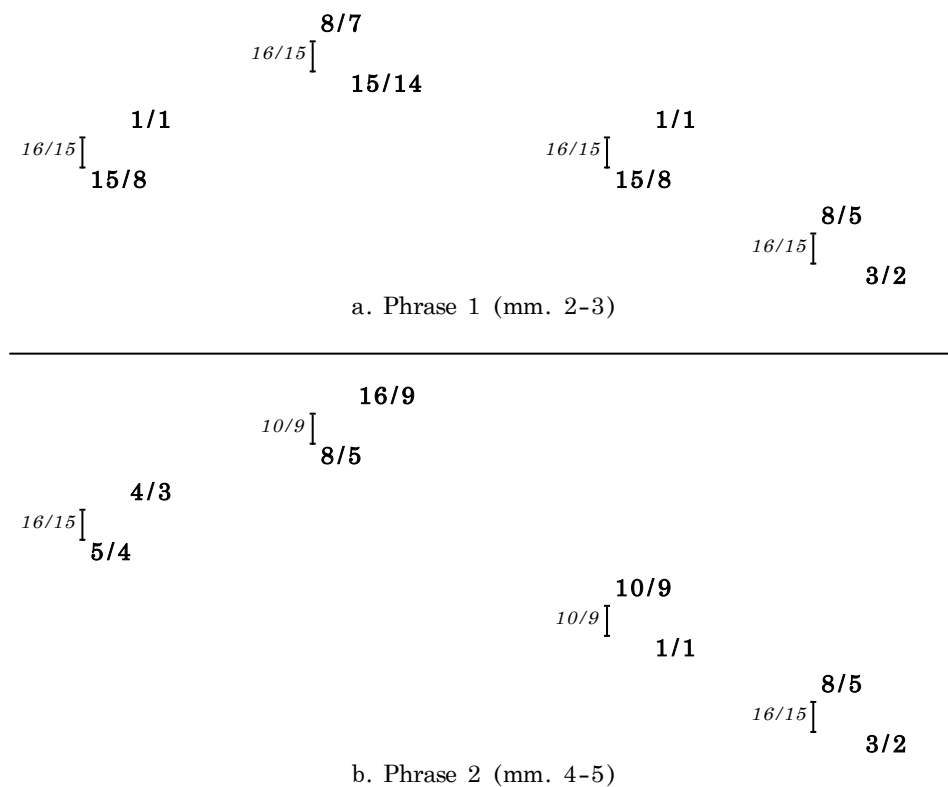


Figure 19.
Symmetry in the Kithara II horizontal intervallic relationships, *Castor* mm. 1-9.

⁵ Partch occasionally refers to ratios on the KII as \sharp or \flat of a marked ratio. Despite the notation, he may have a specific ratio in mind that is not marked on the soundboard. In this case however, the 9/8 \sharp on the downbeat of measure 9 is probably to create dissonance with the 9/8 chord played by the HCII in that measure.

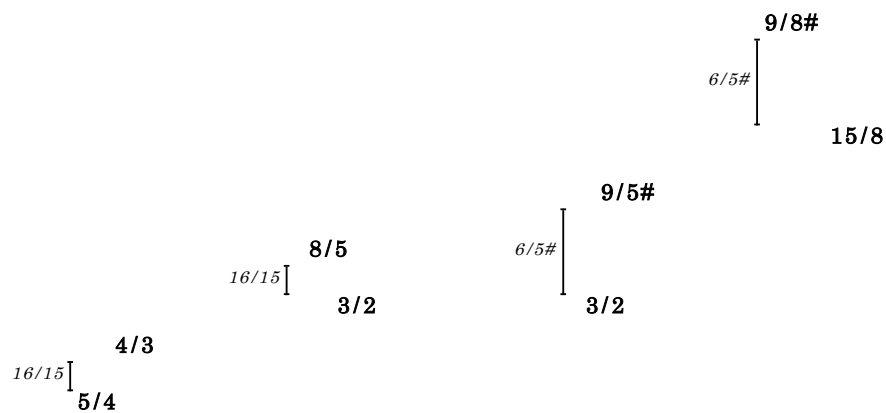
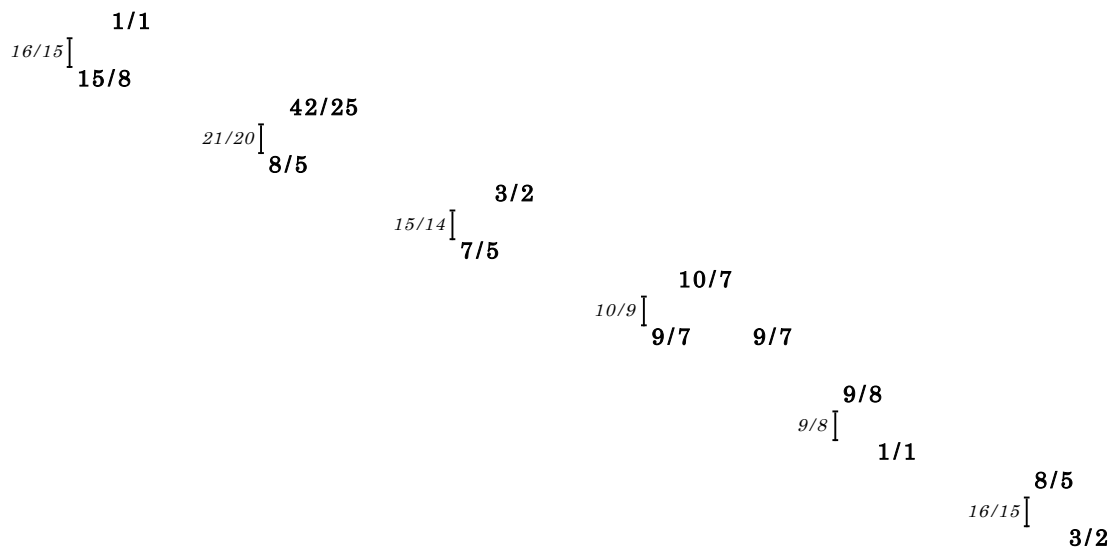


Figure 19 continued.

phrase begin and end with 16/15, but the inner two dyads each contain the interval 10/9 (Figure 19b). The third phrase is not entirely symmetrical, consisting of several differently sized seconds, but the first and last dyads are both separated by 16/15 (Figure 19c). In fact, these two dyads are the same as the first and last dyads of the first phrase, but the opening dyad is an octave higher in the third phrase. This third phrase is an

expansion of the first phrase, traveling down the octave to the now expected endpoint of $3/2$. The fourth and final phrase ascends to $3/2$ in the first half, with each of the two dyads traveling the interval of a $16/15$ (Figure 19d). The second half of the phrase breaks the pattern and travels $\sim 6/5$ for both dyads, roughly a minor third, ending on $15/8$ and aligned to begin the second period.

It is difficult to draw any harmonic conclusions from the KII melody itself, as no two dyads belong to the same Tonality. The SK chord enters in the middle of the first, second, and fourth KII phrases, and provides a harmonic context for the KII pitch material. This chord in measure 2 outlines $7/4$ U, sounding the 1- through 9-Identities [$7/4, 7/6, 7/5, 1/1, 14/9$] as well as the non-harmonic pitch $35/18$. (Figure 20). The pitches



Figure 20.
Surrogate Kithara, *Castor* m. 2.

$8/7$ and $15/14$ of the KII dyad preceding this chord are the 1- and 15-Identities of $8/7$ O. $7/4$ U and $8/7$ O are opposite Tonality, in that they are symmetrical to one another about $1/1$ ($7/4$ is the interval $8/7$ below $1/1$). $1/1$ is shared as the 7-Identity of both Tonality and acts as a pivot note between the two pitch collections. Therefore these opposing

Tonalities clash with one another and form maximal dissonance (e.g. the intervallic ratio between $8/7$ and $7/6$ is $49/48$).

The two subsequent chords outline Identities 1-9 of $16/9$ O [$16/9, 4/3, 10/9, 14/9, 1/1$] and $1/1$ U [$1/1, 4/3, 8/5, 8/7, 16/9$] in measures 4 and 8 respectively. The pitch material in the KII's melodic line largely agrees with the SK's $16/9$ O chord in measure 4. However, in measure 8 the KII does not match the $1/1$ U given by the SK chord. The melodic dyad preceding the chord contains $8/5$ and $3/2$, the 15- and 1-Identities of $3/2$ U respectively [$3/2, 1/1, 6/5, 12/7, 4/3, 12/11, 24/13, 8/5$]. The relationship between the Tonalities of the KII dyad and SK chord are not symmetrical as in measure 2. The distance between any given pitch of $3/2$ U is further than a single "step" away from $1/1$ U. There are also two shared pitches between the two Tonalities, $1/1$ and $4/3$. This combination of Tonalities creates dissonance in this measure, a dissonance comparably greater than that found in measure 4, but comparably less than that found in measure 2.

The Cloud-Chamber Bowls complete this first trio. Throughout the first period, the Bowls stubbornly repeat the same two-bar phrase. This phrase consists of two figures, each beginning with four sixteenth notes alternating $20/11$ and $16/9$. The first figure descends to $10/7$ and the second ascends to $16/15$, the latter of which is held into the $5/4$ bar (Figure 21). Of these four pitches, only $16/9$ and $16/15$ belong to the same Tonality

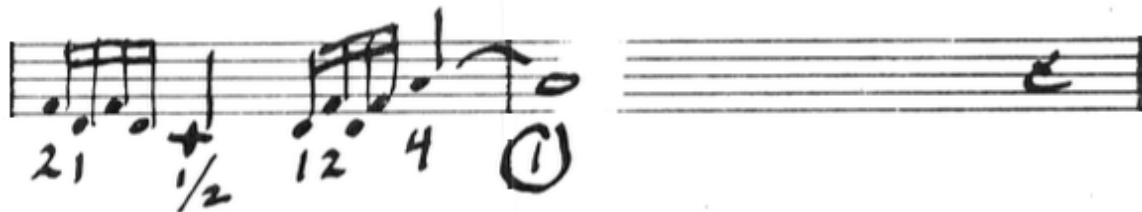


Figure 21.
Cloud-Chamber Bowls, *Castor* mm. 1-2.

(1/1 U). When this pitch material is compared with the accompanying KII and SK, the Bows only align with 1/1 U outlined by the SK chord in measure 8. This could be seen as an anticipation tone that lasts throughout the entire period, only finding resolution/consonance in the final measure of the period.

In the final part of *Castor*, the duos and trio combine to form a dense counterpoint. Despite this concentration of melodic lines, the emerging harmonic layer clearly outlines a Tonality in each measure. Not all instruments represent the harmonic layer equally, however. The primary harmonic information comes from the strummed chords in the SK and HCII, and the repeated notes of the HBM contribute to this harmonic structure. Because of its role as a bass instrument, the LBM should be considered as a part of this structure as well. However, sometimes the LBM will not align with the projected Tonality because of its pitch limitations, and must be taken on a case-by-case basis. The remaining instruments have a greater variety of pitch material. At times, these notes will help to illuminate and support the Tonality, while at other times create dissonance or even shades of bitonality.

In the first measure, the HCII and HBM provide constant repetitions of 9/8, serving as either the 1-Identity of 9/8 U [9/8, 3/2, 9/5, 9/7, 1/1, 18/11] or the 9-Identity of 1/1 O [1/1, 3/2, 5/4, 7/4, 9/8, 11/8]. Of these two possible Tonalitys, the LBM pitches 1/1 and 3/2 align as either the 9- and 3-Identities of 9/8 U or the 1- and 3-Identities of 1/1 O. When combined, these pitches form the 1-, 3-, and 9-Identities of both Tonalitys. Because 9/8 has a ubiquitous presence throughout the measure, it is tempting to label it as the 1-Identity and determine the Tonality to be 9/8 U. However, the KII provides a clue that tips the scales in favor of 1/1 O. The KII begins its melody with the pitch 15/8,

giving the 15-Identity of $1/1$ O. The KII also concludes its melody on $15/8$ in measure 9, the first measure of the second period with an identical harmonic layer to measure 1. This conclusion is clearly a moment of consonance and resolution that can only be understood in the context of $1/1$ O as the Tonality.

How do the remaining instruments fit in with this Tonality? The DM has only a single pitch in common with $1/1$ O, and this pitch happens to be $1/1$ itself. Since $1/1$ is present in all twelve primary Tonalitys and its presence in the DM part is only as a note in the arpeggiated triad, it is unlikely that this part is related to the harmonic layer. Instead, we can still consider the DM to outline the Tonality $5/4$ U as heard in the preceding duo. Interestingly, the Bowls give the pitch $10/7$ on the second beat of the measure, coinciding with the triad in the DM, the lowest note of which is also $10/7$. Although this instance is one of the only times the Bowls agree with another instrument, this alignment does not appear coincidental.

In contrast to the ambiguity of the first measure, the second measure clearly outlines $7/4$ U. The SK's strummed chord gives the 1- through 9-Identities of $7/4$ U, and the HCII and HBM provide further emphasis with the pitches $1/1$ and $7/6$. This time, the DM's arpeggiated triad also aligns with this Tonality, giving the pitches $7/6 - 1/1 - 14/9$, the 3-, 7-, and 9-Identities of $7/4$ U. However, none of the LBM pitches belong to this Tonality. This discrepancy cannot override the Tonality outlined by the rest of the harmonic layer, and the LBM part must be discounted for this measure. Similarly, the KII and Bowls do not belong to $7/4$ U either, but rather provide harmonic dissonance that will be resolved in later measures.

The third measure is nearly identical to the first, with only the KII and HCII providing any additional pitch content. The HCII still has $9/8$ chords in the left hand, but the melodic line travels through different pitches than in measure 1. The only harmonic pitch of this melody is $9/8$, while the other non-harmonic pitches center around this note. The KII reaches the pitch $3/2$ and aligns with the $1/1$ O expressed by the harmonic layer. The following pitch $5/4$ also belongs to $1/1$ O, but it is quickly left and approaches the non-harmonic pitch $4/3$ with a glissando.

In the fourth measure, the SK strums a chord outlining $16/9$ O [$16/9, 4/3, 10/9, 14/9, 1/1, 11/9$]. The HBM repeats the pitch $16/9$ throughout the bar, and the HCII strums $4/3$ chords. The LBM also emphasizes $4/3$ on the first three beats, and the apex of its syncopated upper line reaches to $16/9$ as well. The DM's arpeggiated triad gives the pitches $4/3 - 10/9 - 16/9$, all belonging to $16/9$ O. The KII also agrees with this Tonality, reaching a held $16/9$ just prior to the SK chord, and proceeding to $10/9$ and $1/1$ in the last beat of the measure. Similar to the third measure, the HCII melodic line contains only a single harmonic pitch $16/9$, while the rest of the line is made up of non-harmonic tones.

The fifth measure outlines the Tonality $4/3$ O [$4/3, 1/1, 5/3, 7/6, 3/2, 11/6$]. The HCII strums the pitches $1/1$ and $7/6$, and the HBM repeats $11/6$ throughout the measure. The LBM largely agrees with this Tonality, with only one non-harmonic pitch acting as a neighboring note to $1/1$. The DM also matches $4/3$ O, outlining the triad $7/6 - 1/1 - 5/3$ on the second beat (7, 3, 5). This triad is composed of the 7-, 3-, and 5-Identities respectively, equivalent to a diminished triad. These are the same three Identities outlining $5/4$ U in measures 1 and 3, but here they belong to the Tonality instead of

causing dissonance. The KII reaches the pitch $3/2$, giving the 9-Identity, but the Bows still do not align with $4/3$ O.

In the sixth measure, the HCII chords and HBM both give the pitch $9/8$ once more. This time, the DM helps to determine the Tonality expressed in this bar. The arpeggiated triad outlines $3/2 - 5/4 - 1/1$, the 3-, 5-, and 1-Identities of $1/1$ O. The $9/8$ making up the harmonic layer becomes the 9-Identity of this Tonality. The LBM repeats a low $3/2$ in the first three beats of this measure and aligns with $1/1$ O. This interpretation is in contrast to measure 2, where the LBM did not match the expressed Tonality $7/4$ U. In measure 6, the remaining pitches of the LBM still do not belong to $1/1$ O, but the presence of $3/2$ is enough to support this Tonality. The KII has a succession of dyads that only tangentially align with $1/1$ O, therefore providing dissonance through non-harmonic tones. The HCII melodic line reaches the pitches $15/8$ and $1/1$, the 15- and 1-Identities of $1/1$ O respectively, before departing to dissonant pitches once more. These notes act as passing tones that lead into the next measure.

The seventh measure is a repetition of the fifth measure. This time, only the HCII has any real differences. Instead of a melodic line, the right hand strums two $4/3$ chords on the first and last beats of the measure. The pitches of this chord help to emphasize the 1-Identity of $4/3$ O and add to the density of the harmonic layer. Again, the KII sounds $3/2$ throughout most of the measure, but the dyad that appears on the last beat is different than in measure 5. This dyad travels from $5/4$ to $4/3$, forming another consonance with the harmonic layer in the last beat of measure 7.

The eighth and final measure of the first period clearly outlines $1/1$ U [$1/1, 4/3, 8/5, 8/7, 16/9, 16/11$]. The SK chord provides the 1- through 9-Identities of this Tonality,

and the HCII chords and LBM give the pitch $4/3$ at three different octaves. The LBM's syncopated line and final dyad all belong to $1/1$ U as well. This agreement contrasts with the fourth measure of this period, where this same LBM pattern only partly aligned with the expressed $16/9$ O. After the first three notes of the HCII melodic line, the next several notes all belong to $1/1$ U, and the final three notes anticipate $1/1$ O in the next measure. The beginning and ending notes of the DM line agree with the Tonality, with the other notes acting as passing non-harmonic tones. Finally, the Bowls align with the Tonality, giving the pitch $16/15$ as the 15-Identity of $1/1$ U. The KII and HBM are the only two instruments that do not align with $1/1$ U. The HBM is limited in its pitch choice and is forced to provide dissonance. The KII reaches the apex of its fourth and final phrase of the period, which does not resolve until the first beat of the following measure. The held pitch $3/2$ given by the KII is therefore a dissonance in relation to the harmonic layer.

These shifting Tonalitys are summarized in Figure 22, accompanied by a voice-leading map of harmonic tones. These harmonic tones come primarily from the LBM and HCII, but other instruments contribute to this harmonic layer as well. As stated earlier, a Tonality in Partch's system could be treated analogously to a key. However, the outlined Tonalitys in this section of *Castor* do not represent specific key areas that are reached through modulation each measure. Rather, a more appropriate comparison of Partch's use of Tonality here is to harmonic function. The harmonic layer does not describe a single Tonality for large sections of the piece, but instead outlines a different Tonality with each successive harmony.

Despite this complex harmonic language, several techniques of tonal composition in a contrapuntal setting are still followed. The use of non-harmonic tones to embellish

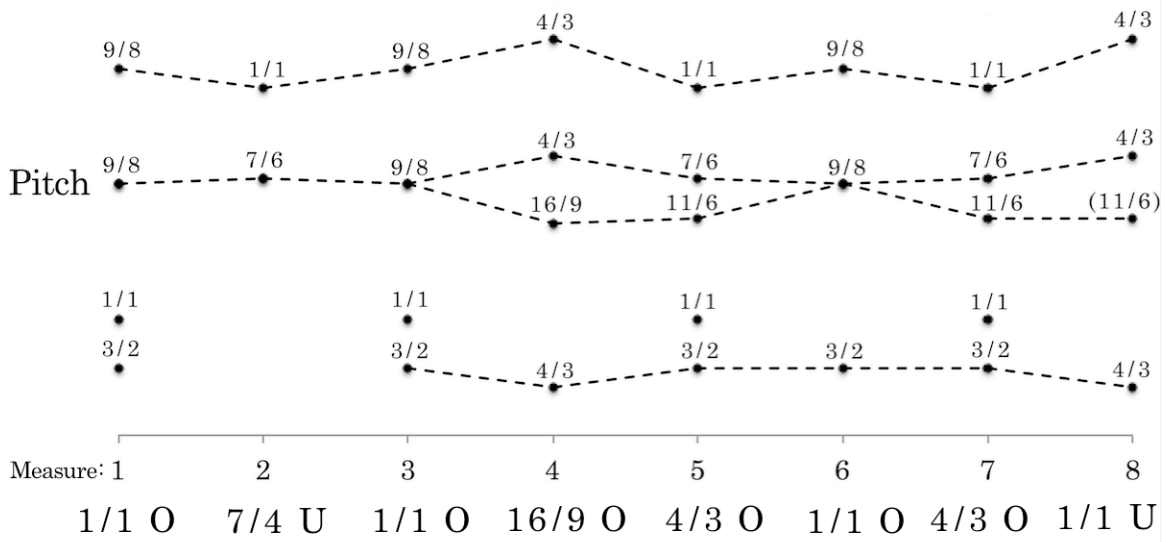


Figure 22.
Voice leading map for the harmonic layer of *Castor*, mm. 1-8.

the projected Tonality is a practice well known in traditional Western music. This approach could be applied to a further analysis of *Castor & Pollux* or other similar contrapuntal pieces. The expansion of pitch material generates a greater number of non-harmonic tones between each harmonic tone, allowing for a variety of dissonances and contrapuntal activity. The Tonalties change once per measure, outlining a harmonic rhythm that can be found in numerous examples of common-practice music. Given the large number of possibilities for modulation, the harmonic rhythm could potentially be increased without sacrificing harmonic variety. However, Partch chooses to maintain this pacing to ensure perceptibility and sonic fusion of harmonic tones.

The dissonances formed by the non-harmonic tones, whether they pass to some harmonic pitch or express some other Tonality outright, help to create harmonic and melodic interest. This interest lies in the combinations of pitches of different Tonalties, where notes do not wholly agree as a single unit, but rather pull the ear in several

directions at once to hear the overall sound. The musical sensation encountered by the listener is a confrontation of sounds that do not completely fuse into a single entity. This crudity is an inherent part of the music, organized around a consonant harmonic foundation.

Conclusion

Partch created this system of Tonality out of a dissatisfaction with the practices of traditional Western music. His division of the octave into nearly four times the number of pitches results in a greater variety of harmonic and melodic content. His use of just intonation allows consonance to expand beyond the triad and include previously non-harmonic tones. The Tonality made available by the 43-tone scale are more abundant than the traditional keys designated by conventional tonality. Similarly, the possibilities of tension have also been expanded to include varying degrees of dissonance.

To account for these modifications to tonality, new methods of composing must be formulated. Perfect consonances are not limited to major and minor triads, nor are these triads indicative of said consonance. There are several different chordal thirds and fifths to choose from, and combinations of these pitches do not necessarily need to belong to the same Tonality. These qualities can be extended to include the chordal seventh, ninth, and elevenths as described in Partch's system, resulting in a huge variety of consonance and dissonance treatment.

Obviously, the quality of a system such as this cannot be measured by its quantity of material. However, Partch's work serves as a demonstration of the untapped possibilities of pitch and tuning. His system was never meant to be copied, but rather to inform and inspire musicians to look beyond the confines of tradition. Successive

generations of composers interested in just intonation, alternative tuning, and microtonality look to Partch as a point of reference. It is my hope that this study and others that follow will help to illuminate this reference point further.

3

KII

SK

CCB

HCII

HBM

DM

LBM

403
119
109
116
106
169
403

(1615)

1007

Chapter II:

Minimalist Aesthetics in the Music of James Tenney

James Tenney, who has been called ‘America’s most famous unknown composer’, exerted a lasting influence not only in the artistic fields of music, painting, theatre, and film, but also in the scientific realms of psychology, electroacoustics, and computer technology. The fact that Tenney’s active presence can be charted across several areas of study reflects his own multifarious interests and provides an opportunity to examine how individuals in different disciplines reciprocally affected the composer. (Smigel and Krausas, 2007).

The diversity of music written by James Tenney (1934-2006) makes it difficult to distill a generalized compositional approach from his works. He is often viewed as a leading figure of North American spectralism, having written some of the earliest spectral music that would later pertain to the modern-day definition. However, he has historical and aesthetic ties to minimalism as well (Gilmore 2003, Wannamaker 2008). Tenney was a member of both Steve Reich’s (1967-70) and Philip Glass’s (1969-70) ensembles, and performed with Terry Riley on the first commercial recording of *In C* (1968). During this period he studied composition with John Cage (1961-69) and was involved with Fluxus and his own Tone Roads Chamber Ensemble (1963-70). This abundance of musical influences has shaped Tenney’s compositional language, giving him a distinct voice through a combination of techniques.

To understand Tenney’s relationship to minimalism, we will have to explore the connotations of this term. Minimalist music shares an affinity with the visual art forms of the same label in both philosophy and creative approach (Bernard 1993). The two arts involve the use of a severely limited variety of materials to explore inherent qualities of the materials themselves. The presentation of these materials is direct and upfront in such a way that their construction and arrangement is clearly perceptible. Instead of combining these materials to suggest or represent something outside the artwork, the audience is

given an opportunity to contemplate the materials as both individual units and a formal whole.

This aspect of minimalist music takes on the term “non-narrative,” described by Elaine Broad as a facet of the minimalist aesthetic⁶. Music suggesting a narrative expresses action or emotion, referring to a semantic approach that designates meaning to motives, gestures, and musical relationships. Tonality with its goal-oriented organization of pitch hierarchy is a useful vehicle for musical narrative, although it is not the only way to achieve this outcome. In contrast to the narrative approach, non-narrative music invites the listener to approach the sound as a phenomenon itself without any extramusical connotations, instead shifting the focus to the molecular changes of musical parameters. These two opposing qualities are ultimately subjective, and it is possible the listener could conceive of a narrative deriving from a phenomenological piece.

The intent and approach of the composer can demonstrate the absence of narrative. In regards to the notion of musical interpretation, Tenney recalls a statement from Cage

where he talks about his new way of working in which he’s not interested in emotion. But that doesn’t mean that people won’t feel emotion when they listen to the music. Then he goes into some analogies like, ‘Don’t people feel mirth when they see otters playing? Or awe when they see a thunderstorm?’ ...Music is an emotional experience but you’re not being made to feel a particular emotion by a manipulative compositional process (Dennehy 2008).

This comment suggests that music composed with the intent of evoking a specific emotional response guides the listener (or pushes, depending on the listener’s attitude) along a fixed path. The journey taken along this path constitutes the musical narrative,

⁶ The term “narrative” is used only within the confines of this definition of minimalist aesthetics, and does not refer to other approaches of narrative theory.

subject to the listener's interpretation but still directed by the composer. Cage sought to remove this directed emotional response through the use of chance methods by allowing some external force to determine the structure of his music. Composers of strict minimalist works approached a similar goal, but through very different means. By presenting a limited number of musical materials, the listener can focus on the details of the individual materials and their arrangement in time.

The minimalist aesthetic is strongly represented in Steve Reich's definition of process music, outlined in his seminal essay *Music as a Gradual Process* (1968). This text was written during the same period as when Tenney was playing in Reich's ensemble, and Tenney is quoted by Reich in his essay⁷. Reich describes the musical process as a device that determines the details of each note and a larger form at the same time. He gives the examples of "a round or [an] infinite canon" as structural models for these processes (Reich 1968). Perceptibility plays an important role in this definition of process music, which can be achieved by allowing the process to modify the music at a gradual rate. Also important in Reich's definition is his acceptance of all results of the musical process. To change the details of the music, the initial process must be modified in some fashion; the process itself is the piece.

As we will see, Reich's philosophy had a strong impact on Tenney, and this influence can be seen in the latter's work after their collaboration. A distinct change in compositional approach occurs in Tenney's works after his encounters with the New

⁷ In reference to the process becoming the sounding music, "James Tenney said in conversation, "then the composer isn't privy to anything". I don't know any secrets of structure you can't hear" (Reich 1968). Reich's inclusion of this comment suggests that Tenney was an active participant in the discussions of minimalist philosophy and thought during its development.

York minimalist scene⁸. His works written during and directly after this time exhibit these concise and perceptible qualities of process music, and these qualities continue to appear in his music throughout his career. Tenney recalls his interest in continuous processes as being directly influenced by Reich's early compositions, and many of his pieces are structured by processes that echo those described by Reich (Dennehy 2008). A self-described "phenomenologist," Tenney's works are designed so that the sound itself becomes the focus of attention (Kasemets et al. 1984). To guide this approach to listening, he employs a continuous formal structure to avoid surprise and unexpected changes (Belet 2008). In a 2006 interview, Tenney reflected on his musical philosophy and the influences of minimalism in his compositional process (Dennehy 2008). His thinking closely mirrors the description of minimalist aesthetics above:

I'm interested in a form that as soon as you've heard a couple minutes of it, you get a pretty good idea of what you're going to hear later. So you can sit back and relax and get inside the sound. [*Laughs.*]

This formal approach does not serve a narrative purpose, as by its very structure it is inherently predictable. Tenney's music has drawn comparisons to mathematical theorems, and Tenney admits that he strives for an elegance similar to that found in mathematics (Dennehy 2008). For this reason, he acknowledges his association as a "strict" minimalist, which is made distinct from other minimalist approaches such as those found in pulse-based music⁹. For Tenney, "it wasn't the stylistic aspects of the music, but the ideas of the people that influenced [him]" (Kasemets et al. 1984). Other definitions of minimalism as a style or technique rely on surface details, such as repeated rhythms and simple harmonies, to categorize minimalist works (Johnson 1994). While

⁸ Reich himself would diverge from this strict approach to process composition later in his career.

⁹ Pulse is not an inherent qualification for minimalism, and while Tenney employs this technique in some of his pieces, it is not a unifying factor (Bernard 2003).

these aspects are certainly present in some of Tenney's music, they are only the result of his attitude to the formal structure as a whole¹⁰. He describes this approach as working from "the top down...like sonic architecture," where the entire structure is conceived before the individual details are put in place (Dennehy 2008).

Also present in Broad's description of the minimalist aesthetic is the term "work-in-process" (Broad 1990). While this term makes a clear reference to Reich's definition of process music, the idea of a "work-in-process" can be achieved by incorporating improvisation as a characteristic of the piece; the composition is started by the composer, and completed by the performers¹¹. Improvisation can engage a number of different aspects of the music, and the amount of control a composer holds or relinquishes can have a significant effect on a piece's outcome. Performer choice plays a role in several of Tenney's works, which could arise from a desire to incorporate randomness into piece¹². This idea allows for the prospect of chance, but the musical possibilities are limited to produce an aural result within the confines of the compositional model. For example, the individual pitch choice or number of gestural repetitions are of less importance than the overall formal structure laid out by the composer. This approach invites a seemingly

¹⁰ Tenney's philosophy of music shows a strong influence of gestalt psychology, an approach to perception that looks at how the combination of parts make a whole. The details of his theories can be found in his book *META+HODOS: A Phenomenology of 20th-Century Musical Materials and an Approach to the Study of Form* (written 1961; published 1964).

¹¹ Some pieces in this category are still considered incomplete after a performance, such as La Monte Young's *The Well-Tuned Piano* (1964-). These pieces are continued or revisited in subsequent performances, but have yet to actually "finish".

¹² Tenney is known for the use of stochastic processes in his early compositions, especially in his electronic music (Dennehy 2008). Tenney describes his interpretation of stochasticity as the use of "constrained random process[es]," through which the composer provides a set of boundaries on certain musical parameters with the exact details determined by external forces (Smigel and Krausas 2007). In his electronic music, Tenney achieves stochasticity through the use of algorithmic processes, but in his instrumental works he achieves a similar result by giving musicians a selection of performance choices.

infinite number of possible performances made distinct by ensemble configuration and individual performer decision-making.

Finally, this analysis must also include a brief definition of spectralism. Shortly after leaving New York, Tenney began to explore the harmonic spectrum as a harmonic model and compositional tool. This approach would later be known by the name of spectralism, the techniques of which were explored concurrently in Europe and North America. Spectral music specifies just intonation and register of pitches corresponding to the harmonic series of a given fundamental (Figure 1). These pitches can be referred to as harmonics, partials, or overtones of a fundamental pitch. The application and organization of this structure is not dictated by the spectral technique, allowing for a number of varied uses of pitch, rhythm, dynamics, and tempo. Tenney is perhaps best known for his spectral music, dating back to as early as 1971 and encompassing over forty works. Robert Wannamaker emphasizes the influence of minimalism not only in

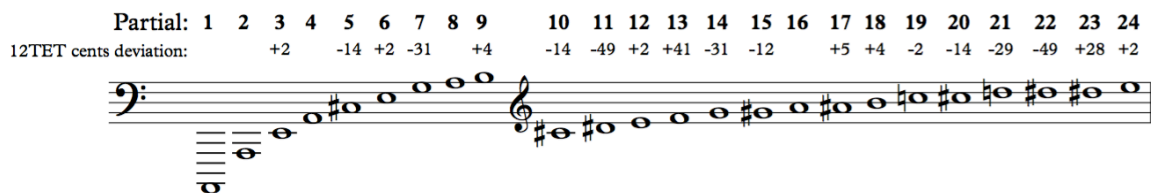


Figure 1.

The first twenty-four partials of the A1 harmonic spectrum. The cents deviation from equal temperament is given below the partial number.

Tenney’s pre-spectral works, but finds it is also recognizable in several of his spectral compositions (Wannamaker 2007). Wannamaker cites “late-1960s American process music” as a specific influence for Tenney’s compositional approach, but other aspects of minimalism beyond process can be found as well. The following analysis serves to

illustrate minimalist aesthetics in Tenney's spectral music. Tenney is able to realize and establish a spectral technique through the application of minimalist formal models, processes, and general aesthetics.

Early Process Music

Several of Tenney's early algorithmic pieces make use of processes to determine musical parameters. These pieces predate his interactions with Reich, Glass, and Riley; while Tenney's algorithmic processes do not bear a resemblance to the strictly minimalist works of these composers, they share a similarity in that the composer makes a decision that causes change to happen over time. Once that decision has been made, the outcome is not modified beyond the process. If the composer wishes to change the resulting music, he must modify either the process or the initial musical parameters from which the process begins.

Tenney's earlier use of algorithmic processes does not fit Reich's definition because the workings of the process are not directly perceivable. These processes suggest the influence of Cage, whose use of compositional processes Reich distinguishes as separate from his approach (Reich 1968). When Tenney encountered the music of the minimalists, perhaps he found that they had been thinking along similar lines to his compositional approaches earlier in the decade. However, there is a distinct change in his interpretation of the process in music from these early algorithmic works after he encountered minimalism.

Since most of these pieces are realized electronically, there is no conventional score to consult when analyzing the formal processes at work. However, Tenney has written about his time at Bell Laboratories and provided several outlines of his

compositional designs. In regards to his piece *Analog #1 (Noise Study)* (1961), the impetus for the composition came from sessions of active listening while driving between New York and New Jersey (Tenney 1969). The sounds of the surrounding traffic would change gradually, and it was these aural changes over time that Tenney chose to represent in his own compositional process.

For *Noise Study*, Tenney constructed five digital instruments to make sound, modifiable by a number of sonic parameters (Tenney 1969). A total of five parameters control the amplitude, bandwidth, and frequency for each instrument. These instruments were recorded onto a tape, and this tape was replicated two times to produce versions one-half and twice the speed of the original. These three tapes (1/2x, 1x, and 2x speeds) were then combined, creating a texture of fifteen simultaneous sounds at times. This speed modulation results in a distinct register for each tape, and each layer is distinguishable when all the layers sound together.

The piece is divided into five distinct sections (Figure 2). Each new section coincides with a change in process, modified by altering the rate of change of parametric values. The initial values for the second and third sections are equivalent to the final values of the previous sections. At the beginnings of the fourth and fifth sections, the parametric values leap to new initial values instead of continuing from the final values of the previous section. The three tapes are aligned so they all reach the fourth section at the same time (Figure 3). The resulting structure is an asymmetrical arch form, beginning and ending with music from the slowest tape.

The actual values for these parameters were determined randomly, but these random values are selected from a specific range of values; the ranges themselves are subjected to gradual changes. Looking at the parameters for pitch alone, the opening section has a

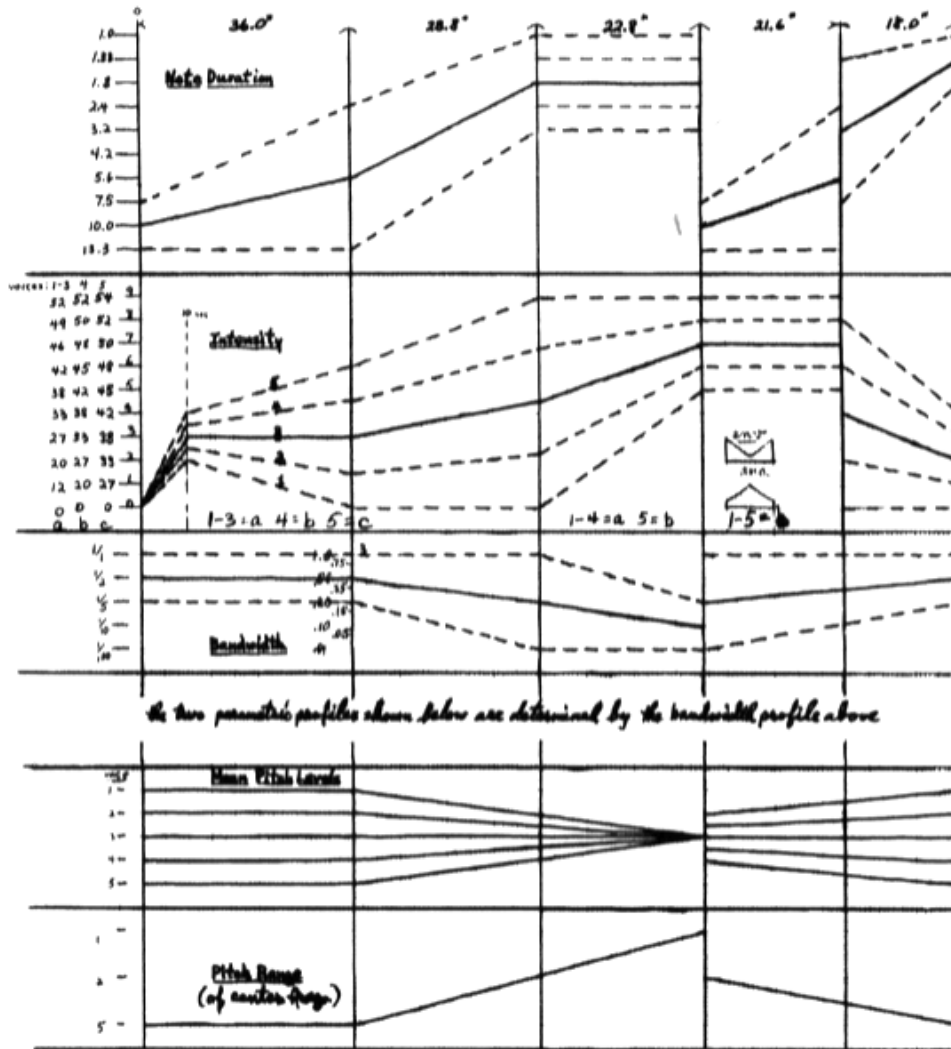


Figure 2.

Formal structure of *Noise Study* (1961) depicting the changes in five parametric values over time. The vertical lines designate each section of the music. From James Tenney's "Computer Music Experiences, 1961-1964" (1969).

wide range of pitch possibilities, resulting in a noise band with no distinct pitch. As the bandwidth parameter decreases over the second and third sections, these noise bands become ever narrower and eventually can be distinguished as individual pitches (Tenney

1969). For this reason, Tenney describes this piece and others as “statistical,” because the range of values is predictable or determined, but the individual values for parameters are determined by external forces – in this case, randomness.

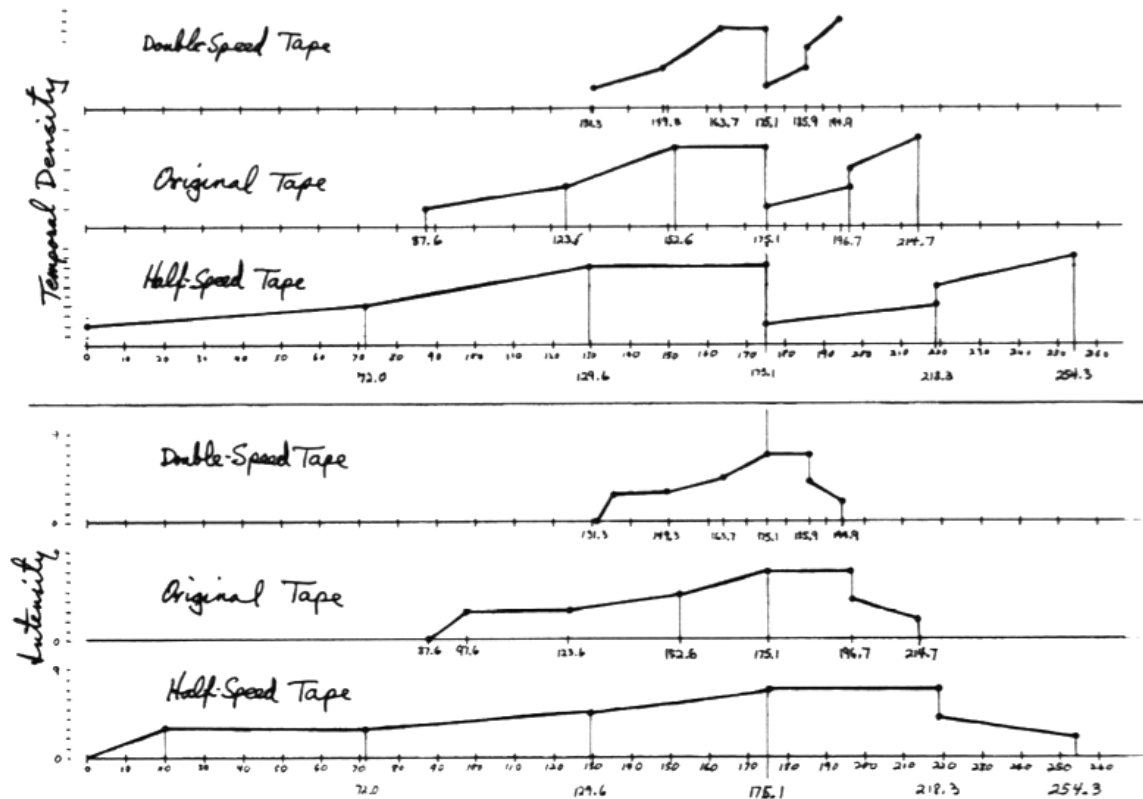


Figure 3.

Parametric mappings with the combination and alignment of the three tapes for *Noise Study* (1961). Dots along the plotted lines indicate the start of a new section. The three tapes align at the start of the fourth section. From James Tenney’s “Computer Music Experiences, 1961-1964” (1969).

Noise Study is not a minimalist piece; the rhythms, pitch material, and formal structure contribute to this classification, with an apparent influence of Cage’s aesthetic approaches. The processes themselves are not directly perceivable or unidirectional; between larger formal sections, the parametric values sometimes increase or decrease sharply, eliminating the continuity of the process. These sections are delineated by aurally distinct changes of process with regard to texture, timbre, and dynamics.

However, the use of compositional processes to create gradual changes over time exists in this work, and will continue to appear in other pieces throughout his life.

Postal Pieces

The first direct evidence of Tenney's intersection with minimalism can be found in his collection of *Postal Pieces* (1965-71). This set of ten short pieces, originally written on postcards and sent to friends, contains singular musical ideas centering on the concepts of intonation, swell, and meditative states (Polansky 1983). These compositions contain musical ideas already present in Tenney's other works of this time, but each idea is isolated and presented as an individual piece. Influences from Cage, Fluxus, and minimalism are abundant throughout these works; Tenney describes his attitude toward the *Postal Pieces* as evoking "sound for the sake of perceptual insight" (Polansky 1983). With these pieces he explores the methods of listening to sound in an artistic setting by avoiding musical drama.

Several of the *Postal Pieces* contain minimalist traits, and the *Swell Pieces* (1967-71) and *Having Never Written a Note for Percussion* (1971) will be useful as examples. The first *Swell Piece* (1967) designates instructions for a fixed dynamic shape, but all other musical aspects are left up to the performers, including pitch, duration, and timbral density. *Swell Piece No. 2* and *Swell Piece No. 3* (1971) follow the same dynamic shape but with specified pitches, either A4 or the dyad B3/F#4 respectively (Figure 4). As alluded to in the score, this latter piece is essentially La Monte Young's *Composition 1960, No. 7* with more specific directions for orchestration and dynamics. *Having Never Written a Note for Percussion*, the last piece of the set, presents this same dynamic swell isolated from the aspect of chance created by the ensemble in the *Swell Pieces* (Figure 5).

Swell Piece

for Alison Knowles

To be performed by any number of instruments beyond three, and lasting any length of time previously agreed upon.

Each performer plays one long tone after another (actual durations and pitches free and independent).

Each tone begins as softly as possible, builds up to maximum intensity, then fades away again into (individual) silence.

Within each tone, as little change of pitch or timbre as possible, in spite of the intensity changes.

James Tenney
12/67

SWELL PIECE NO. 2 (for any five or more different sustaining instruments):

for Pauline Oliveros

Each performer plays A-440, beginning as softly as possible, building up to maximum intensity, then fading away again into (individual) silence. This process is repeated by each performer in a way that is rhythmically independent of any other performer, until a previously agreed-upon length of time has elapsed. Within each tone, as little change of pitch or timbre as possible.

SWELL PIECE NO. 3 (for any eight or more different sustaining instruments):

with respect to LaMonte Young and his COMPOSITION 1960, No. 7

Divide the instruments into two approximately equal-numbered groups, primarily on the basis of a treble-bass distinction. The higher-pitched group plays the F-sharp a tritone above middle C, the lower-pitched group the B a fifth below. Play as in Swell Piece No. 2, but "for a long time".

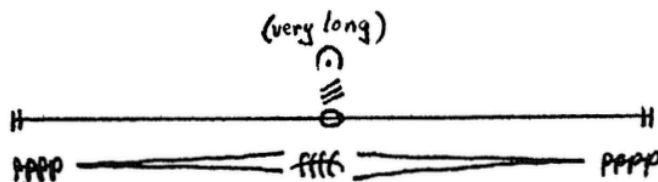
James Tenney
March, 1971

Figure 4.

Swell Piece (1967), *Swell Piece No. 2* (1971) and *Swell Piece No. 3* (1971) from James Tenney's *Postal Pieces* (1965-71).

HAVING NEVER WRITTEN A NOTE FOR PERCUSSION

for John Bergamo



James Tenney

8/6/71

Figure 5.

Having Never Written a Note for Percussion (1971), from James Tenney's *Postal Pieces* (1965-71).

These pieces are largely influenced by the practices of the Fluxus movement, especially those that are restricted to text instructions only. However, nearly all of Tenney's *Postal Pieces* deal directly with the experience of sound, and these pieces evoke an aesthetic similar to that found in minimalism. Tenney employs performer choice as an aspect of the *Swell Pieces* in regards to pitch material, instrumentation, and both local and global durations. The formal structure of each *Swell Piece* is open-ended and directionless, making it impossible to discern when the piece will end until it is over. Tenney regards the *Postal Pieces* as devoid of musical drama because the gesture or process making up each piece is predictable soon after it starts (Polansky 1983). Removal of dramatic anticipation allows the listeners to focus on the sound being created at each moment instead of shifting attention between contrasting sections.

The *Swell Pieces* qualify as process music, but these processes are not strictly regulated because of the improvisatory elements. The single-note gesture and dynamic envelope are predictable shortly after the piece has begun, but what remains unpredictable to the listener is the entrance and exit of each instrument. In contrast, *Having Never Written a Note for Percussion* turns this swell gesture into a single process delineating the entire continuous form of the piece. The only improvisatory aspect of this piece is the overall length, and performances vary greatly in their durations. Although the instrumentation is not specified, performances of this piece are typically on a tam-tam, and the resulting sound is a combination of resonance and noise beyond any simple harmony (Polansky 1983). It is possible that this piece could be performed with pitched percussion outlining a diatonic triad or seventh chord, or possibly even changing pitch

material throughout the piece. However, it is unknown whether any performer has attempted this approach, and it does not seem to be Tenney's intention for the piece.

For Ann (Rising)

In the midst of his collaboration with the New York minimalist scene and the creation of the *Postal Pieces*, Tenney produced the electronic piece *For Ann (Rising)* (1969), shortly after which he shifted his primary focus to writing instrumental music. This piece is well known in Tenney's oeuvre, and is perhaps one of the clearest illustrations of the minimalist influence. The twelve-minute piece consists of several rising tones layered upon one another to create a sound that appears to be constantly ascending. This illusion has since been designated with the label "Shepard tone," named after the cognitive scientist Roger Shepard, a colleague of Tenney's at Bell Labs (Shepard 1964, Polansky 1983).

Each glissando begins at a pitch below the threshold of hearing (20 Hz) and ascends over the course of thirty seconds above the upper boundary of hearing (20,000 Hz). The glissando fades in at the start of the gesture and fades out as it reaches its end, making it difficult to perceive its exact entrance and exit. The form of this piece is similar to that of a round, as the same gesture is repeated by several voices with staggered entrances. After a glissando has traveled about the distance of a minor sixth, another voice enters. At the densest moments of this piece, the texture consists of as many as fifteen glissandi sounding at once. As one voice fades out, another repetition of the gesture fades in. After several minutes the gesture ceases to repeat, and the remaining glissandi exit the texture one by one. The piece concludes with a single voice ascending to the end of its gesture, exposed for the first time for the listener to hear on its own.

This piece fits well into Reich's definition of process music. The structure of *For Ann (Rising)* is that of a round, with the repeated glissandi determining both the individual notes and the form itself. This layered structure is similar to the phased loops found in Reich's *Come Out* (1966). The process begins with a gradual accumulation of layers to reach a maximum saturation point, and after several repetitions concludes with a gradual shedding of those layers. At the apex of this accumulation, the process freezes for several minutes, resulting in a feeling of stasis created by perpetual activity. This arrested motion gives the impression of an object fixed in space with a constantly shifting and vibrating structure. The process ends when no more glissandi are produced, and the remaining lines complete their gestures. This process is represented visually in *For 12 Strings (Rising)*, an orchestration of this piece for acoustic instruments composed by Tenney in 1971 (Figure 6). Each instrument produces a glissando that is taken over by a higher instrument at the apex of the gesture. While this rendition cannot include pitches outside the range of hearing present in the electronic version, the form remains faithful to the original.

It could be considered that pitch is put through a process of its own, beginning at its lowest perceivable existence and gradually ascending to its highest point. The regular entrances of glissandi produces a slow, unbroken rhythm that continues throughout the entire piece. The overall texture is a result of the accumulation of these rhythmic patterns. Despite the thickness of texture and constantly changing pitch, the harmonic language of this piece is triadic. Because the entrances of each line are a minor sixth apart, the vertical alignment of pitches forms an augmented triad by the entrance of the third voice (beginning of the second measure in the score). These pitches will constantly be changing

M.
052
T44
F44

$\text{♩} = 60$

Violins I
Violins II
Violas
Cellos
Basses

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Nov. 16, 1971

Note: This middle section is to be repeated many times.

Figure 6.
For 12 Strings (Rising) (1971), James Tenney.

and are represented in several different registers, but any combination of glissandi will always form an augmented triad at any given moment.

This piece clearly falls within the scope of the minimalist aesthetic. There is no narrative quality to this piece, and the listener is invited to hear the sound created by these layers of glissandi. Through repetitions of this sound object, several opportunities are given to consider the different parts of what make up this sound. The illusory quality of this aural phenomenon suggests a contemplation of our perception of sound and invites the brain to contemplate a reason for the sound being heard. The instrumental version of this piece takes on the additional quality of a work-in-progress, as the middle section lasts for an unspecified number of repeats. This casual use of improvisation demonstrates a plasticity of this process and allows the performers to explore the piece for as long as desired.

Spectral CANON for CONLON Nancarrow

Another of these process pieces is Tenney's *Spectral CANON for CONLON Nancarrow* (1974) for player piano in just intonation (Figure 7). In addition to the use of a minimalist aesthetics, this piece makes use of techniques associated with spectralism. Tenney arranges the first twenty-four partials of the pitch A1 in a rhythmic canon to build a dense, polyrhythmic structure of resonant cacophony. As successive voices enter the canon, the compositional process becomes apparent and continues to be understood as the piece grows in complexity. The example presented here is a computer model realizing the score in a single page, providing a visual demonstration of the process as form (Santana et al 2013).

The unidirectional process of Tenney's *Spectral CANON for CONLON*

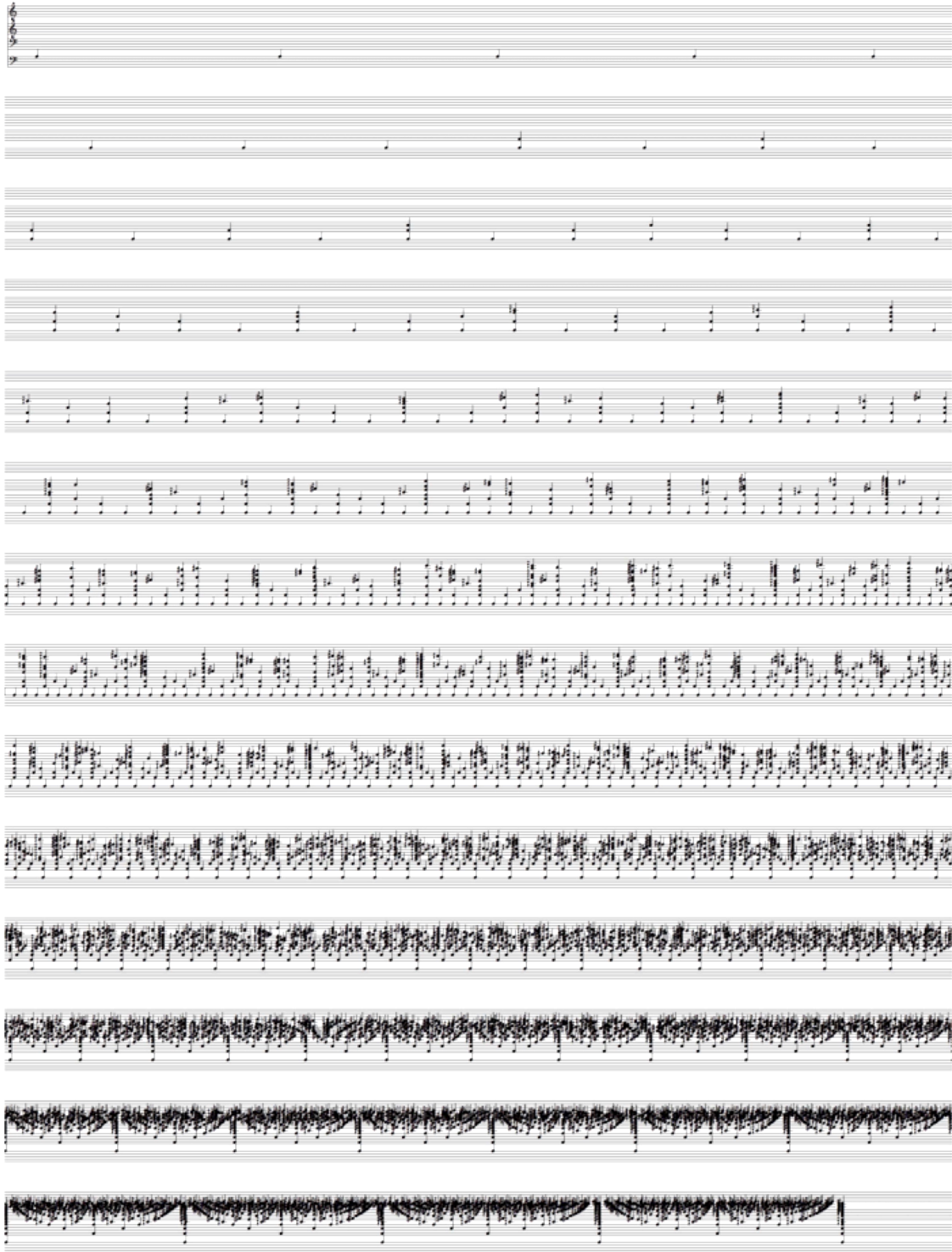


Figure 7.
Computer model of *Spectral CANON for CONLON Nancarrow* (1974), James Tenney.
The computer model is designed by Santana et al (2013).

Nancarrow has formal ties to Reich's early tape pieces. Both composers make use of a mechanical device to produce dense multi-layered textures that derive from a single musical idea. Tenney's composition is for player piano with specific pitches retuned to the harmonic spectrum of A1, and the damper pedal depressed for the entire piece. The canonical aspect is purely rhythmic; each of the twenty-four voices in the canon is assigned to a different pitch of the first twenty-four harmonics of the A1 harmonic series. In a single voice, the durations between attacks first become successively shorter, then this process is reversed and repeats the durational values in retrograde (Wannamaker 2012). Pitches enter the canon in order of increasing frequency; the piece begins with the first harmonic (A1), the next entrance is the second harmonic (A2), then the third (E3), and so forth. The piece ends when the first voice (A1) completes its retrograde, and all twenty-four pitches are attacked simultaneously for the first time.

The process in this piece is clear and can be heard throughout the performance, although individual details of the retrograding rhythm may not draw a listener's attention upon a first listening. The decreasing durations between newly introduced pitches give the feeling of an acceleration of tempo, and this phenomenon continues even as the earlier voices begin their retrograde. From start to finish, we are aware of an increasing density, and with it increasing polyrhythmic complexity. It is impossible to tell by duration alone when the rhythmic retrograde of the first voice is complete, because the length of time and number of repetitions of the whole rhythmic pattern are greater than the listener can perceive.

The intonation of the piano allows for simultaneous pitches to fuse together into a single sound (Wannamaker 2012). If these pitches were unmodified as in the normal

tempered tuning of a piano, fused simultaneities would occur only between pitches some number of octaves apart from one another. The use of just intonation and registral spacing for the pitch material according to the harmonic spectrum simplifies the relationship between pitches not related by octave. The final chord contains all twenty-four notes, and the listener is invited to hear this simultaneity as a single pitch A1 with the notes above sounding as overtones (Wannamaker 2012). This chord is not triadic by any means, but can be interpreted as a simple harmony with the preceding music consisting entirely of fragments of this chord.

Here we begin to see the use of minimalist aesthetics as a vehicle for spectral thought. Tenney is exploring fresh musical territory, and he uses process composition as a familiar model to center this exploration. While the chaotic texture makes it difficult to hear any kind of spectral organization until the final chord, later works by Tenney will continue to modify the minimalist aesthetic to present the harmonic spectrum in more recognizably perceptible ways.

KOAN

To backtrack briefly in Tenney's chronology, we turn to *KOAN for Solo Violin* (1971), a piece belonging to the collection of *Postal Pieces* (Figure 8). This work would eventually be expanded upon to create the piece *KOAN for String Quartet* (1984), which provides a harmonization for the solo violin part. The solo piece consists of a "fairly slow" tremolo between two strings, and is only minimally notated in a form of musical shorthand. Aside from the instruction to alternate between these strings eight to ten times per bow length, there is no indication of meter. This gesture begins on the G and D strings of the instrument; after one length of the bow, the violinist begins a "very slow"

KOAN for solo violin

for Malcolm Goldstein

(very slow glissando)

mp

(mp) \rightarrow pp

gradually move toward bridge, until nothing but noise is heard.

fairly slow tremolo

(3-10 note-pairs per bow)

James Tenney
8/16/71

Figure 8.

KOAN for Solo Violin (1971), from James Tenney's *Postal Pieces* (1965-71).

glissando on the G string, bringing the pitch gradually higher until the pitch of the two strings are in unison. This glissando on the G string continues upwards until reaching the pitch A4. The tremolo on these two pitches continues, but the violinist now switches to the open D and A strings. This same process repeats with a slow glissando on the D string up to E5, at which point the open A and E strings take over the tremolo. A third and final glissando ascends on the A string, this time traveling beyond the expected B5 and culminating on E6. When this rising pitch reaches B5, there is a decrescendo from *mp* to *pp* and an indication to move the bow toward the bridge of the violin, gradually replacing pitch with noise.

KOAN exhibits several of the characteristics of the minimalist aesthetic. The overall form is a closed structure dictated by the violin's construction and traditional tuning procedures. The process is strictly adhered to until the two highest strings are

reached, at which point the glissando extends beyond the expected stopping point. Melodic motion is completely absent, and the tremolo gesture consists of a single repeated rhythm that maintains a consistent tempo throughout the piece. This rhythm is the principal motion in this piece, as the gradual motion of changing pitch can provide a harmonic role, but does not have any melodic function. A bright tone may indeed be achieved by the violin if the performer chooses to play that way. The dynamic marking of *mp* may make this tone color difficult to maintain, and ultimately tone quality becomes a subjective part of this piece and is left up to the performer.

While not diatonic by any means, the organization of pitch material in the solo part results in a relatively simple harmonic language. The music travels through various degrees of dissonance to moments of highly consonant resolution. The slow speed of both the glissando and tremolo allow the gradual changes of pitch and interval to be easily heard and processed. Some of these arrivals of resolution may be subjective for the listener, but the clearest consonant intervals that appear are the perfect fifth and fourth, and the minor and major third¹³. Since the texture never thickens beyond two notes, the sounding pitches can only suggest a triadic harmony. While a majority of these intervals are dissonant, each moment of resolution will give two pitches of a diatonic triad.

This piece expands on the same basic concept of process found in *KOAN for Solo Violin*, and the first violin part is nearly identical with a few notable exceptions. The accompanying three instruments are subjected to similar processes of pitch modification, but with different rates and textures, resulting in a richer harmonic language than that found in the solo piece. The piece is divided into eight sections designated by letter

¹³ Although the octave is approached at end of the piece, this interval is reached only when the bow is nearly on top of the bridge. The resulting sound is noise, and does not have the same pure tone heard during the earlier moments of consonance.

names *A-G*, with each section corresponding to a single measure of *KOAN for Solo Violin*¹⁴. The first seven sections are forty-three measures in length, while the last section *G* is twelve measures long and serves as a coda. This expanded score has a more traditional appearance than that of the *Postal Pieces*, with tempo, time signatures, and measure lines to ensure the ensemble's alignment. The first measure is completely written out, indicating five alternations per bow and two bow lengths per measure (Figure 9). A majority of the following measures are still written in shorthand, but the two notes of the tremolo are given each bar.

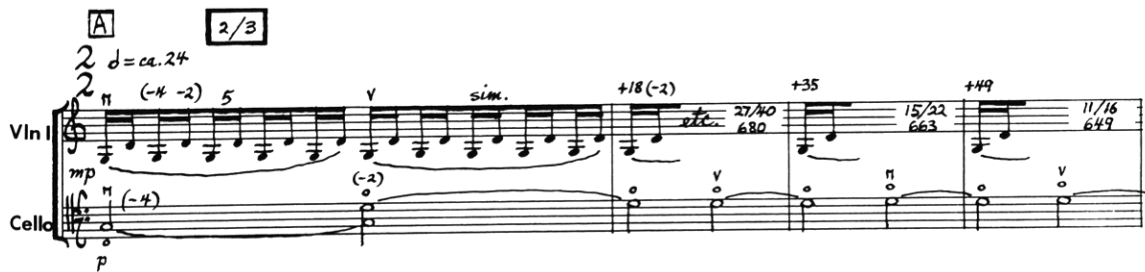


Figure 9.

Opening four measures to *KOAN for String Quartet* (1984), James Tenney.

In each measure, the first violin shifts one of its notes upwards by one-sixth of a semitone. The pitches on the staff are notated in 12-TET, but intonation of these pitches are indicated in the score by cents deviation from tempered tuning above the note, as well as both the frequency difference in cents and ratio to the fixed pitch for each measure¹⁵.

The remaining members of the ensemble serve to harmonize the pitch material in the first violin, with similar details regarding the intervallic relationship to the fixed pitch of each

¹⁴ Section labels in regards to *KOAN for String Quartet* will be italicized.

¹⁵ The notation of these ratios is a source of some confusion. For the first violin, the ratio describes the relationship of the first string to the second string; a ratio less than 1 refers to a pitch below the fixed pitch, and a ratio greater than 1 refers to a pitch above the fixed pitch. However, throughout the entire glissando on the D string, the ratios are reversed and gives the opposite relationship, measuring from the second string to the first.

section. Tenney suggests the use of electronic tuners to achieve accurate results. The first violin and cello begin the piece, and the viola and second violin enter at Sections *B* and *D* respectively (Figure 10). Each of the three accompanying instruments provides one additional note to the texture, creating a slow chord played in half notes to contrast and supplement the rhythmic motion of the first violin. Once a member of the ensemble enters the texture, it remains sounding for the rest of the piece.

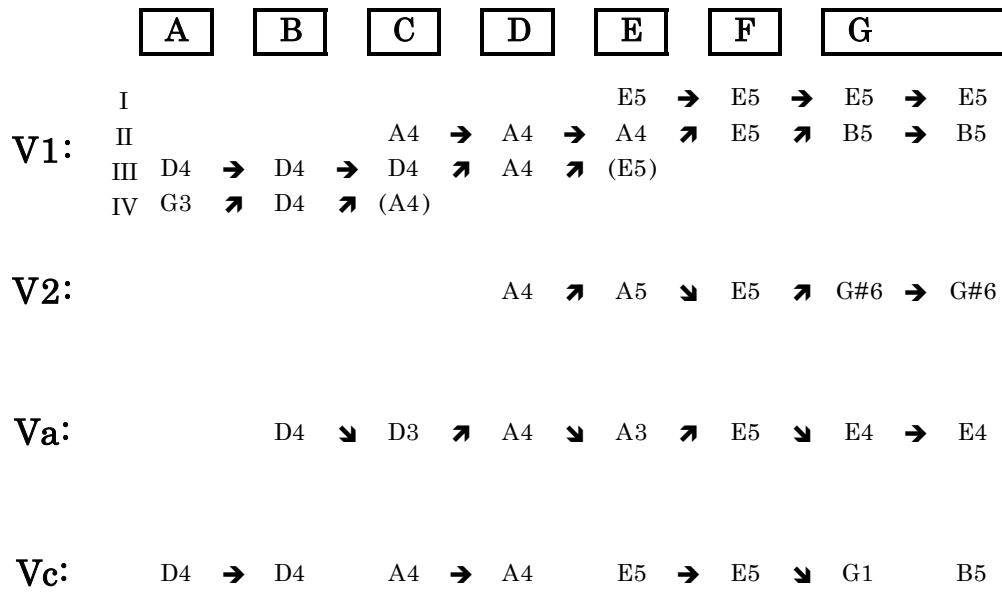


Figure 10.
Formal structure and pitch map for *KOAN for String Quartet* (1984), James Tenney.

The cello “doubles the fixed pitches” of the first violin for the first five sections *A-E* (Tenney 1986). The viola and second violin play held notes that gradually change in pitch each measure. These two parts also function as glissandi, but change pitch at different rates from both one another and the first violin. Section *B* coincides with the unison D4s on the G and D strings in the first violin. Here the viola enters on D4 in half

notes, matching the first violin and cello. From *B* to *C*, the first violin continues its glissando on the G string up to A4, while the viola has a downward glissando to D3. The cello and D string of the violin continue to give the pitch D4. When *C* is reached, the cello changes its pitch to match the A4 in the first violin, and this pitch becomes fixed for the next two sections.

From *C* to *D*, the first violin switches to the open D and A strings and glissandos from D4 up to A4. The viola also ascends to A4, but begins its glissando from D3 and must travel at a faster rate to catch up with the first violin. At *D*, the second violin enters and all four instruments play the pitch A4. From *D* to *E*, the viola repeats its same process from *B* and descends an octave to A3. The second violin has the opposite of this process and ascends an octave to A5. The first violin and cello continue their same patterns as before. When *E* is reached, the cello moves to E5 and the first violin switches to its open A and E strings. Throughout *E*, the three upper instruments glissando up or down to E5, and the ensemble reaches a unison on this pitch at *F*. During this section the viola repeats its process from *C* and ascends an octave plus a fifth. The second violin descends a fourth, traveling less distance than the viola overall but mirroring the contour of the motion.

From *F* to *G*, the first violin and viola continue the same processes, but the second violin and cello behave differently than before. The first violin rises to B5 on the A string, and the viola descends an octave to E4. The second violin ascends in contrary motion with the viola as before, but goes beyond the octave by a major third and reaches G#6. The cello descends for the first and only time in this piece down to G1, achievable by retuning the C string down by a fourth. The cello does not move by the same interval

each measure; its initial intervals are fractions of a semitone, but as the pitch becomes lower the intervals between each pitch become larger.

At *G*, the upper instruments maintain the pitches they have just reached and the cello changes pitch to a harmonic sounding at B5. There are no changes to pitch in this final section, differing from the solo version by eliminating the first violin's ascent to the octave E6. What follows in these last twelve measures is the timbral change seen in the solo piece; each performer moves his or her bow closer to the bridge, and the final two measures of the piece are played on the bridge itself. Dynamically, this ending diverges from the close of the solo version, as there is no decrescendo to close the piece. The piece ends at its most harmonically dissonant moment, created by the noise from the ensemble. The use of just intonation in *KOAN for String Quartet* is clear, but at first appearances does not seem to have a spectral component. However, there is a level of spectral organization in this piece that arises with the addition of the accompanying instruments. Several points of resolution and consonance outline some combination of the first five partials of the fixed pitch in the first violin. The pitches of these spectral outlines are in their proper registers according to the harmonic spectrum. The chord formed at *C* is the first instance of this harmonic structure with the pitches D3, D4, and A4 (Figure 11a). If D3 is considered the fundamental, D4 and A4 sound at the proper registers of the second and third harmonics respectively. Similarly, the chord at *E* is built of the first three harmonics of A3 (Figure 11b). At *G*, the fifth harmonic is reached by the second violin traveling to G#6, the major third found two octaves above the lowest pitch E4. The pitches E4, E5, B5, and G#6 form a major triad and form a spectral structure representing the first, second, third, and fifth harmonics respectively (Figure 11c).

a) The first three harmonics of D3 at the beginning of C, m. 87.

b) The first three harmonics of A3 at the beginning of E, m. 173.

c) The first, second, third, and fifth harmonics of E4 at the beginning of G, m.259.

Figure 11.

Spectral organization of pitches in Tenney's *KOAN for String Quartet* (1984).

In other instances of this piece, these processes of changing pitch align to form other diatonic harmonies, such as a major triad or dominant seventh chord (Figure 12). However, the notes of these chords fall within the space of an octave, and are not representative of the harmonic spectrum. To consider these notes as a part of some spectral organization would require the fundamental to be two octaves below the given root of the chord. Only at the moments outlined above in Figure 11 does the ensemble align in any spectral formation.



Figure 12.

An example of a major triad formed by the intersection of independent processes in the second measure of this excerpt. From Tenney's *KOAN for String Quartet* (1984), mm. 191-193.

In a large, open space

The final work to be explored in this essay is *In a large, open space* (1994), a later piece in Tenney's oeuvre (Figure 13). The length of the piece and instrumentation is open-ended, and performers are instructed to select a pitch from the first thirty-two partials of the F1 fundamental to be held for thirty to sixty seconds at a constant *pianissimo*. After the performer completes his note, another pitch is chosen and the

gesture is repeated, preferably on a pitch not currently sounding by another member of the ensemble. This composition is very similar to the *Swell Pieces*, but the characteristic dynamic shape is no longer present. There is no process to be discerned while listening to the piece, but the unfinished aspects of both pitch choice and improvised local and global durations create a work-in-progress quality. Despite the absence of a strict formal process, repetitions of the same musical gesture become predictable and allow the listener to experience the sound through a phenomenological perspective.

This construction of this piece falls within the boundaries of the spectral technique, as Tenney specifies the pitch material to derive from the harmonic series. The aspect of pitch is once again improvisatory as in the first *Swell Piece*, but is constrained by the limited choices from this collection. Further limitations are caused by the range of the instrument and the plasticity of intonation, as instruments with fixed pitch cannot stray outside of the harmonic spectrum. For example, a pitched percussion instrument would only be able to play the pitch F at some octave, since only that pitch is unaltered from its tempered tuning in the F1 harmonic spectrum.

As in Tenney's *Swell Piece No. 2*, a close scrutiny of tuning fluctuations is also explored throughout *In a large, open space*. In this latter work, all pitches are tuned according to just intonation, minimizing the beating heard between any notes. If a performer were to play out of tune, these beats would instantly become recognizable. These players must concentrate to maintain the intonation of each pitch for its full duration, and any disagreements in tuning would be difficult to reconcile without fixed pitch instruments or digital tuners. Even if all the pitches are in tune with one another, the

In a large, open space, within which the audience is able to move freely, for any 12 or more sustaining instruments.

James Tenney, Berlin, 1994

The musicians should be distributed in the space as widely and evenly as possible, with instruments of lower tessitura located more centrally, higher ones more peripherally. Each player plays one after another of the "available pitches" within the range of his/her instrument (see the notation below), very quietly (*pp*), with a soft attack, for some 30 to 60 seconds. After a breath or short pause, another pitch is chosen (generally trying to avoid duplicating a pitch already sounding on another instrument), and the same process is repeated, again and again, for the duration of the performance or installation.



Available pitches for *In a large, open space*. The numbers above each notated pitch indicate deviations from the tempered pitch in cents (hundredths of a tempered semitone). In order to achieve the required accuracy of intonation, players of instruments with variable intonation should be equipped with an electronic tuning device. Instruments of fixed pitch (e.g. accordion, vibraphone (arco), etc.) may play only pitches which differ by no more than 5 cents from the tempered pitch.

Figure 13.
In a large, open space (1994), James Tenney.

overtones formed by the various instruments in the ensemble may not all belong to the F1 harmonic spectrum, and beating will emerge in these moments.

The use of the spectral technique in Tenney's *In a large, open space* places musical attention precisely on the sound itself. The texture is made up of a synthesis of individual timbres that fuse together into a single harmonic sound, made possible by a complete lack of rhythmic motion. This sound becomes the focus of the music as it morphs and vibrates over time. The listener is "invited to hear tiny fluctuations in tuning," made all the more apparent in the context of just intonation (Johnson 1994). Nearly thirty years after his exposure to minimalism, Tenney still makes use of minimalist aesthetics to explore the boundaries of spectral music. While *In a large, open space* diverges from some of his more process-oriented music found directly following this encounter, the conceptual aspects of minimalism play crucial roles in the realization of this piece.

Conclusion

An exploration of these works of James Tenney demonstrates the influence of minimalism throughout his compositional career. The minimalist aesthetic provides Tenney with a conceptual approach around which to structure his musical ideas. This relationship to minimalism is not necessarily found in the surface level characteristics that make up the minimalist style or technique. Because these details are not always present, the influence of minimalist aesthetics will sometimes be found in the background or throughout the formal structure as a whole. Benjamin Belet describes Tenney's music as having "explored and then surpassed the various '-isms' of the day" (Belet 2008). The last three pieces explored here are not minimalist pieces with spectral tendencies, nor are

they spectral pieces with minimalist tendencies. Rather, they represent an equal combination of minimalist and spectral techniques, two unrelated approaches to composition that Tenney would synthesize into his art.

These works also demonstrate an innocence through their casual and playful qualities. This innocence invites the listener to understand not only the process (if one is present), but other aspects explored in the piece as well. Since the adoption of the harmonic spectrum as an organizational tool was largely uncharted territory at this time, the application of minimalist aesthetics helped both composer and audience understand some of the possibilities and inherent qualities of spectral composition. Minimalism provides a frame in which to view ideas of spectral thought in their first emergence.

Wannamaker writes of Tenney in reference to his influence as a spectralist: “certain artists bequeath to future generations...new aesthetics that enlarge our conception of the art form itself” (Wannamaker 2008). Given the timeline of Tenney’s musical history, it appears that he absorbed aspects of the minimalist aesthetic from his interactions with Riley, Reich, and Glass prior to the development of the minimalist style. These aesthetic traits continued to have a place in Tenney’s music despite its nuances that separate it from this style. As Reich writes about process music, there are “enough mysteries to satisfy all” (1968). These mysteries are abundant in the works of James Tenney, and they will continue to intrigue musicians through recordings and performances of his music.

Chapter III:

Domain Independence and Gradual Processes of Musical Tension and Release in Gérard Grisey's *Périodes* (1974)

Like many musical labels, the term “spectral” has developed a definition somewhat distant from its original meaning. The harmonic spectrum has been recorded as a theoretical basis for music in ancient Greek philosophy, and several 20th-century composers and theorists have cited this phenomenon to defend their claims of music deriving from natural laws (Creese 2010, Anderson 2000). In the early 1970s, composers began to use the structure of the harmonic spectrum itself as a resource for organizational materials. This music, which would eventually become categorized as spectralism, has been viewed as a reaction to integral serialism, the predominant compositional method at the time (Anderson 2000). The use of natural sound phenomena as the organizational basis for composition is in direct contrast to the arbitrary ordering dictated by the serial aesthetic.

Integral serialism separates different musical aspects (i.e. pitch, rhythm, dynamics) into distinct domains that are organized and modified independently of one another¹⁶ (Grisey and Fineberg 2000). The elements of each domain are ordered according to a single series, and the music is the resulting synthesis of these elements. If the serial method is strictly followed, this music can be modified only by a reordering of the domain elements. The determination of individual parts results in the piece as a whole, and the piece can be seen as an outcome of the ordering decisions made by the composer.

In contrast to the serial approach, spectral composition creates musical structures using the harmonic spectrum as a model, a preexisting structure with its own organization of elements. There is no fixed order of these spectral elements, allowing for a greater

¹⁶ The term “domain” comes from Hasty 1981.

compositional flexibility than permitted by serialism. Spectral music begins with a whole, the harmonic spectrum, and individual parts are derived from that whole. Gérard Grisey (1946-1998) explored the use of the harmonic spectrum as a structural model in several of his works, composing some of the earliest spectral pieces to come out of Europe. His piece *Périodes* (1974), which would later become the second movement of his large-scale *Les espaces acoustiques* (1974-1985), exemplifies this emergence of spectral thought. While the methods of organization in this piece differ from those of serialism, Grisey still borrows from serial thought by exploiting the idea of domain independence. These individual domains are modified over time through the use of compositional processes (Grisey and Fineberg 2000).

The harmonic spectrum is made up of a series of notes (partials), the vibrations of which are related to the lowest note of the series (the fundamental) by whole-number multiples of the vibratory frequency of the fundamental¹⁷. The second partial has a frequency equal to twice that of the fundamental, the third has a frequency three times the fundamental, and so on. The notes of this series are specific in their register and pitch value, and the intonations of these partials are different from the traditional Western tempered tuning. When discussing pitch material in spectral music it is necessary to include the particular octave of each pitch, as well as deviation from tempered tuning. In *Périodes*, these deviations are indicated by accidentals raising or lowering the tempered pitch by a $\frac{1}{4}$ or $\frac{1}{6}$ tone. The $\frac{1}{4}$ and $\frac{3}{4}$ sharp symbols are used throughout the piece, and an arrow symbol indicates a $\frac{1}{6}$ tone higher or lower than the tempered pitch as written (Figure 1).

¹⁷ The harmonic spectrum is an acoustical phenomenon, but is not something heard in its entirety from a given sound. In any sounding pitch, certain harmonics sound louder than others. This combination of harmonics and their respective amplitudes creates the timbre of the sound.

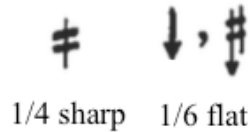


Figure 1.
Examples of non-traditional accidentals used in *Périodes*.

The pitch material of *Périodes* is derived from the harmonic spectrum of the fundamental E1 (41.2 Hz) (Figure 2)¹⁸. The first twenty-one partials of this spectrum are selected as the pitch reservoir for this piece, which yields eleven distinct pitches at specific registers. Grisey indicates these pitches in the opening instructions, and includes the second harmonic E2 as a part of this series, totaling twelve pitches: {E1, E2, B2, G#3, D#4, F#4, A#4, C#5, D#5, F5, G5, A#5}. In this diagram, Grisey provides two series of numbers: the number of quarter steps between consecutive partials {22, 14, 18, 12, 8, 7, 6, 5, 4, 4, 4}, and the corresponding partial numbers for each pitch {1, 2, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21}¹⁹. As will be shown below, the intervallic and vibratory relationships between these pitches provide the basis for the durational values of the overall form, as well as for more localized applications of duration and rhythm (Féron 2011).

The E1 spectrum is also used to define harmonic function in this piece, involving the concepts of harmonicity and inharmonicity. These ideas refer to the pitch organization of the harmonic spectrum. When partials of the same fundamental sound together, the notes fuse together into a single sounding aggregate, achieving harmonicity.

¹⁸ As François-Xavier Féron has pointed out, Grisey incorrectly notates the number of quarter steps between an octave as 22, when there are actually 24 quarter tones spanning an octave (Féron 2011). Despite this mistake, it appears that Grisey ignored this value when determining the formal structure of the piece.

¹⁹ Grisey's use of these accidentals is not entirely consistent. The opening instructions state that the tunings of these notes should be augmented to reflect the "acoustic reality" of the harmonic spectrum, referring to these deviations from tempered pitch (Grisey 1974). There are sections of *Périodes* where these deviations are implied, and performers should alter the written tempered pitch according to its position in the E1 spectrum, despite the absence of the necessary accidentals.

Simultaneously sounding notes that are not related by a similar fundamental will not create a fused sound, but instead result in rhythmic beating²⁰. A single inharmonic pitch disrupts the fused object achieved by perfect harmonicity, and inharmonicity is caused by the juxtaposition of pitches that are not related by the same fundamental pitch. Removal of E1 partials and the addition of further non-spectrum pitches result in a gradual increase of inharmonicity.

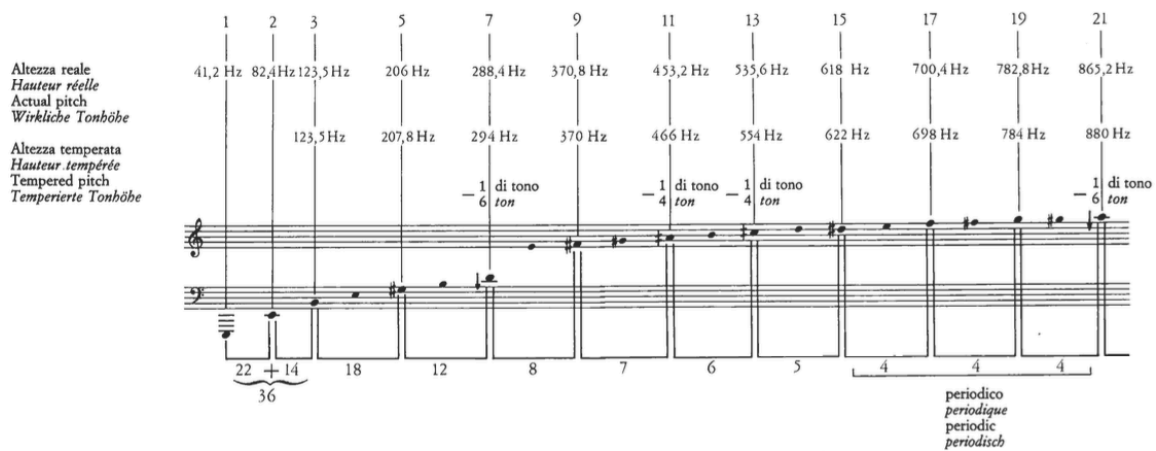


Figure 2.
The first twenty-one harmonics of the E1 spectrum, as realized in the opening instructions of the score (Grisey 1974).

The three stages of our breath cycle are the basis of the musical form of *Périodes*:
 Repose, Inhalation, and Exhalation (Figure 3). These stages analogize the flexing and relaxing of muscles in the body through the build and release of musical tension. Each stage is sequentially represented as a section of music and delineated by cue numbers and

²⁰ Harmonicity and inharmonicity can best be understood by example. Given the harmonic spectrum of E1, we find the note B2 to be an overtone of that spectrum. Once an overtone is reached, that note will theoretically be found in the spectrum at each consecutive octave above (i.e. B3, B4, etc.). However, that note will not be found at any octave below its initial appearance (i.e. B1). Therefore, if a note sounds at some octave lower than its placement in the harmonic spectrum of a given fundamental, that pitch will cause inharmonicity.

fermatas. Although there is no explicit label or division between Inhalation and Exhalation in the score, the stages are made distinct by a shift of musical material and process. The complete form contains four full repetitions of the breath cycle (or period) with an additional *Repose* as coda to frame the overall piece (Figure 4).

In François-Xavier Féron's analysis of *Périodes*, his study of Grisey's manuscripts reveals how the formal structure of this piece derives from the harmonic series (Féron 2011). Grisey measures the number of half steps between each new pitch of the harmonic series, and uses these proportions to determine the duration of each Inhalation and Exhalation stage. From this series of intervals, he excludes the initial octave between the first and second harmonic, and combines the last three intervals into a single group. The initial number of half steps is multiplied by eight, and this value becomes the number of seconds for a given section of music (Figure 5). The order in which these proportions appear in the harmonic series do not correspond to the order of durations for these sections, but are organized freely to incorporate the musical material of each stage.

The *Repose* stage can be heard as a static landscape built from repetitions of musical ideas. Here, the musical domains do not change, and the musical material is limited to rather simple organizations of pitch and rhythm. The pitch material of each *Repose* belongs to the E1 spectrum. From *Repose* follows the Inhalation stage; this transition is set in motion by effecting some change in the preceding *Repose* material, usually by adding some new feature to the existing sound. Musical tension is created through the modifications of harmonicity, rhythm, duration, and dynamic levels. This

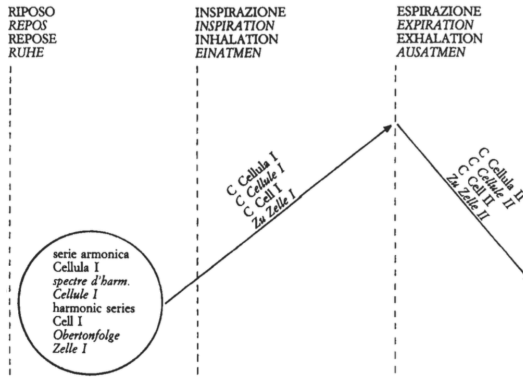


Figure 3.

Périodes, formal outline for one full period. From introductory remarks to the score (Grisey 1974).

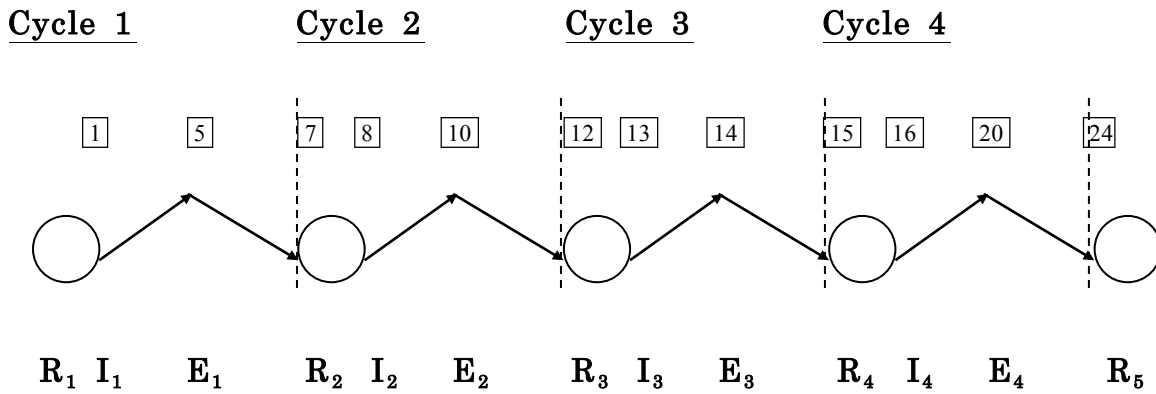


Figure 4.

Formal structure for *Périodes*. Rehearsal numbers are in boxes.

	E2	B2	G#3	D#4	F#4	A#4	C#5	D#5	F5	G5	A:5
# quarter tones:	14	18	12	8	7	6	5	4	4	4	4
Duration (s):	112	144	96	64	56	48	40	32	32	32	
Formal stage:	E ₂	I ₁	E ₃	E ₁	I ₄	I ₂	I ₃	E ₁			

Figure 5.

The intervallic content of the harmonic spectrum is used to proportion the duration of each formal stage (Féron 2011).

tension is released in the following Exhalation stage and returns to stasis, beginning the next period. While this overall periodic structure does not have any narrative function, the compositional processes involved in creating and lessening tension provide the music with a directionality and motion. In the Repose stages where these processes are not present, this motion is halted until the next process begins.

The compositional methods by which Grisey achieves either stasis or a change in musical tension are comparable in that they modify musical domains in similar ways. Formal organization is used as a framework to organize the applications of compositional techniques. These methods are arranged to create and release musical tension in accordance with the respiratory analogy of the piece. The techniques applied to each of the three stages of the periodic form are the same within all four periods.

An important facet of *Périodes* is its perceptibility. The phenomena of tension and release are perceivable throughout the progression of each stage, but they are also present within each individual gesture. Stockhausen posits that a listener will process differences in duration according to proportion instead of a strictly measured length of time (Stockhausen 1959). For example, the differences between nine and ten seconds versus one and two seconds both equal one second, but the proportional differences are ten and fifty percent respectively. The listener perceives the latter case as a larger, more noticeable difference than the former, despite the identical linear differences in time.

Proportional durations play an important role in *Périodes* to build and release musical tension. Durations in the Inhalation sections typically become shorter over time, resulting in a more perceivable difference as the music progresses. The aural impression is that of an accelerating tempo, despite the tempo remaining constant, as the musical

gestures appear closer to one another in time. In contrast, the durations of musical gestures become successively longer throughout the Exhalation sections. These gestures are not organized as a series of phrases, but rather as one long process lasting the entirety of the section. This “stretching out” of duration throughout the Exhalation leads into each following Repose stage, characterized by long tones or patterns held under fermatas that exist with unchanging durational values, made periodic by the use of repeat signs.

Repose Stages

To understand these static and gradual processes, the details of each stage can be analyzed to observe how musical domains change over time. Each Repose stage is characterized by cohesion and stasis. Cohesion is achieved through the shared musical domains between the ensemble members during each stage. These domains include aspects of pitch material, rhythm (or lack thereof), and dynamic levels. Not all of these domains will be common to the sounding instruments in a given Repose section, but those that are shared override any characteristics that separate individual instruments, resulting in an overall sense of cohesion.

Stasis is achieved through the unchanging relationships between these domains for the duration of each section. One domain is pitch, and the combination of these in vertical sonorities. The pitch material of each Repose contains only partials of the E1 spectrum. In the first four Repose stages, all twelve of these pitches are present in different combinations and densities (Figure 6). The fifth and final Repose (R₅) employs all twelve of these pitches at octaves higher than their initial register in accordance with the E1 spectrum. These twelve pitches cannot sound simultaneously due to the size of the ensemble, but rather are heard through successive gestural repetitions.

Partial	R ₁	R ₂	R ₃	R ₄	R ₅
22					A#5
21	A5			A5	(A6)
20					
19				G5	(G6)
18					F#5
17				F5	(F6)
16					
15				D#5	(D#6)
14					D5
13				C#5	(C#6)
12					
11			A#4		
10					G#4
9		F#4	F#4		
8					
7	D4	D4	D4		
6					B3
5		G#3	G#3		
4					
3			B2		E3
2	E2		E2		E2
1			E1		E1

Figure 6.

Pitch material for each Repose stage and its relationship to the E1 spectrum. During R₅, the upper partials are found an octave higher than their initial formation in the spectrum.

In each Repose stage, the given pitches should be played with deviations from tempered pitch appropriate to their positions in the E1 spectrum, despite the lack of accidentals indicating these deviations in several of these sections. The only exception to this instruction is found in the initial R₁ stage, where the violin and viola highlight the differences between tempered and just intoned pitch (Figure 7). Three pitches of the E1 spectrum (E2, D4, A5) are held as long notes by the bass, viola, and violin respectively. D4 and A5 are played on double stops by the latter two instruments. There is no traditionally notated rhythm and the durations of these notes are unmeasured. The only motion arises from slow glissandi on one of the two double-stopped notes. At the apex of

this gesture, the tempered pitch sounds simultaneously with its flattened equivalent in the E1 spectrum. These contrasting frequencies produce rhythmic beating, the velocity of which decreases with each successive gesture through indications of the number of beats per second.

The image shows a musical score for three instruments: Violino (Vno), Viola (Vla), and Contrabasso (Cb). The Vno part has a melodic line with a 30-degree mistuning indicated by a curved arrow. The Vla part includes dynamics like 'ord. P' and 'ord. f', and a 'Sofa' marking. The Cb part shows 'ord. P' and 'AST' markings. A large bracket at the top spans the duration of the gestures.

Figure 7.
R₁ stage (Grisey 1974, 1).

Underneath these motions, the bass does not alter the tuning of its pitch E₂, since its tempered tuning is equal to its frequency in the E₁ spectrum. The timbre of the pitch shifts by gradual changes in bow position between its normal usage (ORD) and *alto sul tasto*²¹ (AST), each shift aligning in time with the above gesture. This modification of

²¹ Playing with the bow very high on the fingerboard (Grisey 1974).

timbre results in different combinations of E2 harmonics, shifting between a comparatively thinner and fuller sound.

The material for subsequent *Repose* stages arrives from the ends of the preceding *Exhalation* stage. The second *Repose* (R_2 , cue 7) achieves stasis through the use of long tones and a periodic rhythmic gesture. The pitch material for this stage comes from the preceding *Exhalation*; as inharmonic pitches are removed during the release of tension, the last remaining three become the basis for R_2 . The pitches $G\#3$, $D4$ and $F\#4$ are alternated in held tones between the violin, viola and cello, consisting of three repeated vertical sonorities of the same pitch material with the pitches shifting between instruments at each repetition²² (Figure 8). The rhythmic gesture employed here uses these same three pitches in a descending line presented in hocket between the flute and bass. The whole gesture is a quarter note in length and repeats regularly, giving the impression of a ticking clock or heartbeat. The two instruments create this gesture using hocket; the flute plays $F\#4$ as a grace note to the bass's $D4$, which is followed with $G\#3$ from the flute once more.

Deviations from tempered tuning allow these pitches to have a greater function during this moment of stasis. The treatment of the diminished interval between $G\#3$ and $D4$ creates no tension. This is achieved by the contrast of the tension reached and eventually released in the *Exhalation* stage. Furthermore, when these pitches are modified to fit into the E1 spectrum, much of the dissonance (ie. beating) that occurs between these pitches in tempered tuning is removed. This “retuning” allows these intervallic relationships to have an opposite function of its more traditional usage. The periodicity of

²² Although $D4$ is notated as a tempered pitch without an accidental, Grisey's instructions at the beginning of the score indicate that pitches belonging to the E1 spectrum should be adjusted to match the intonation of the E1 partials. In this case, $D4$ should be played about a sixth-tone lower than the tempered pitch.

Figure 8.
R₂ stage (Grisey 1974, 15).

the gesture also allows the ear to become acquainted with this interval, and through repetition achieves a feeling of stability.

The third Repose (R₃, cue 12) contains a seven note chord, with each instrument giving one pitch of the aggregate. These pitches are held long tones that result from the decelerating rhythms of the preceding music. This aggregate is the densest of the Repose sections thus far, and consists of the fundamental E1 and its harmonics E2, B2, G#3, D4, F#4 and A#4. These notes are the first seven pitches of Grisey's harmonic pitch reservoir. A large part of this aggregate is formed by the partial combinations of pitch material in R₁ (G#3, D4, F#4) and R₂ (E2, D4, A5).

Above this chord, the strings interject with harmonics played *subito f* (Figure 9). These harmonics are the same pitches as the static chord heard at some octave higher. There are some improvisatory elements to this section. The conductor indicates whether the gesture will have one, two, or three attacks and determines its placement in time. The total number of interjections is left up to the conductor as well. Performers choose pitch material from a reservoir of three harmonic pitches and determine the order of these pitches in each gesture. These interruptions of the higher register sound like bursts of energy emanating from the static humming of the chord, and provide the only sense of motion for this stage. This dynamic contrast continues into the following Inhalation and becomes a vehicle for increasing inharmonicity.

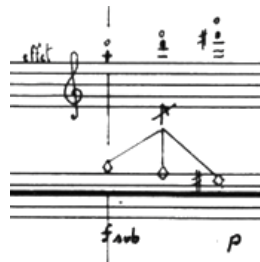


Figure 9.
Harmonic *subito f* interjections in the viola during R₃ (Grisey 1974, 28).

In the fourth Repose (R₄, cue 15) the piccolo, viola, and bass play a series of repeated patterns of varying durations of notes, overlapping with one another in time. The viola begins this section alone; the bass and piccolo individually enter at the beginning and end of the viola's first statement respectively. The durations of these pitches are purposely imprecise, indicated in the score as "around one second". The varying durations result in a shifting sense of pulse and rotating simultaneities. As I₄ begins, these

instruments fade out in the order that they entered R₄; the viola exits first, then the bass, and finally the piccolo.

Despite this lack of rhythmic unity, stasis is achieved through the repeated pitch material. The sounding pitches at R₄ are the upper five harmonics of Grisey's pitch reservoir (C#₅, D#₅, F₅, G₅, A₅). The repeated patterns in the viola and piccolo contain four of these five notes, while the bass pattern contains all five. These patterns produce wavelike contours of different shapes and direction. Aside from the aperiodic durations, each gesture is also set apart from the others in its pitch material and order. The contour of the viola pattern moves opposite to the piccolo, while the bass moves in a similar shape to the viola. These gestures neither begin together nor move at consistent speeds, so these relationships are not made apparent as each instrument enters. These wavelike contours are the basis of the gestures that make up the upcoming Inhalation stage, of which the tempo marking is described as "very flexible, like waves" (Grisey 1974).

The fifth Repose (R₅, cue 24) marks the end of *Périodes*. This last stage may also begin the following movement *Partiels*, and, if the two movements are played together, functions as a transition between the two movements. R₅ is broken into two sections. In the first section, the bass and trombone play the harmonics E₁ and E₂ respectively. The bass is directed to play E₁ very high on the bridge, so that the pitch will sound "nearly an octave higher" (Grisey 1974). The trombone plays a continuous note at a decrescendo, while the bass repeats its single-note gesture either three or four times. This single-note gesture harkens back to the repeated pulse of the trombone during I₁, and reemerges during the end of the preceding E₄ stage.

In the second section, the trombone E2 continues while the other six instruments individually enter in order from lowest to highest pitch. Each pitch enters one octave above its first emergence in the E1 spectrum; for example, the sounding pitch B3 is an octave above the initial B2. The violin has a choice of three different dyads, playing two of a possible five different pitches, these pitches matching the five highest odd numbered partials 13-21. These octave-raised harmonics are all performed with a single dynamic swell, each beginning *ppp* and fading out to *niente*. The apices of these crescendos all align in time, but the maximum dynamic level is different for each instrument. These dynamic levels are an indication of organization in *Partiels* (1975), where the dynamic markings of the harmonics match the relative strengths of the formants of the E1 spectrum of a trombone²³. Each of the upper three strings play with a mute, perhaps to provide a thinner sound with fewer harmonics than would be produced by the natural timbre of the unmuted instrument.

A common factor between these five stages of *Repose* is the cohesion between instruments. Each stage shares some domain (or domains) that connects the sounding parts together as a whole. As shown earlier, the pitches in each *Repose* relate to one another by a common fundamental, creating harmonicity and sonic fusion (see Figure 6). However, rhythm also plays an important role in achieving this cohesion. Long tones are prevalent in stages R₁ and R₃, and the lack of any traditional rhythm unifies these notes as

²³ Acoustic sounds are made up of several different simultaneous frequencies. The frequencies that make up a given sound are referred to as formants. Each formant has its own amplitude and dynamic envelope. When we perceive a sound as having a distinct pitch, that pitch corresponds with the predominant frequency of the sound. The combination of sounding frequencies and their dynamic envelopes create the timbre of the sound. This phenomenon is what the listener hears to differentiate between instruments playing the same pitch. In *Partiels* (1975), Grisey organizes pitch, duration, and dynamic values to model the formant structure of a trombone playing the pitch E1, the first example of instrumental synthesis in his work. The final aggregate of *Périodes* imitates this formant organization, but is not based off of a true formant analysis. Rather, it is possible he was aware of the idea and chose to emulate a possible structure with this final *Repose* stage, which served as the impetus for the following movement (Féron 2011).

a single object. Any rhythmic motion that does occur in these sections appears simultaneously in multiple instruments. During R₁, the violin and viola gradually shift toward their respective just intoned pitches at the same time; the remaining overall sound is a single aggregate held as long tones. At R₃, the *f* interjections are played at the same time by all members of the group.

These simultaneous rhythms do not occur to the same degree in the other three Repose stages, but each contains rhythmic gestures that contribute to the cohesiveness of the music. At R₂, the instruments are separated into two groups, but the instruments within each group are related to one another as either a chord of rotating held tones or a periodic rhythmic figure. The relationship between these two gestures is made stronger by the identical pitch material for each group, the trichord G#3, D4, F#4. The three instruments at R₄ each share gestures similar to the rotating held tones at R₂, but are purposely disjunct from one another in time. However, they achieve a cohesive relationship through similar durational values and overlapping pitch material.

Dynamics are also used to achieve this cohesion. At R₂, the instruments in each group share the same dynamic markings: the rotating chord is played *pppp* and the periodic gesture is played *mf*. The entire ensemble has identical dynamics at R₃ for both the *p* long tones and *f* interjections. During the second half of R₅, each instrument enters the sounding aggregate individually at *ppp* (with the exception of the trombone). The ensemble crescendos together and reaches its maximum dynamic at the same time, then decrescendos to *niente*. These maximum dynamic levels are not the same for each instrument, but they all align together in time.

The total duration of each *Repose* is flexible, but must last a minimum of thirty seconds; this length of time is either dictated by the conductor or predetermined before the piece begins. This feature is indicated in the score with large fermatas above the staff. With the exception of R_1 , these stages are freely repeated until cued to continue. This feature helps to maintain the underlying stasis of each of these sections; any one of these stages can repeat and continue without causing an increase of tension. This aspect is in direct contrast to the *Inhalation* and *Exhalation* stages, which contain no directly repeated sections of music and are marked by constant change.

Inhalation Stages

Each *Inhalation* stage is characterized by an overall increase of musical tension. This tension is created through a shift towards inharmonicity, increased rhythmic density/independence, a shortening of durational values, and increased dynamic levels. Some of these domains change gradually over the course of a given section, while others may be more sudden. Both approaches serve to create tension, as the sudden changes occur unpredictably and create tension through surprise.

The beginning of the first *Inhalation* (I_1) is marked by the viola, rearticulating $D\downarrow 4$ at *forte* with *molto vibrato*. This dynamic expression and wavering of pitch is in stark contrast to the steady tones heard just before. This rearticulation triggers the entrance of a new pitch $F\sharp 4$ in the clarinet, and as the viola gradually reduces its vibrato to a flat tone, an aggregate similar to that at R_1 is heard with this additional pitch and timbre. As the *Inhalation* stage progresses, changes to several musical domains cause a growing sensation of tension. These modifications still maintain the same basic gestures and ideas introduced in the preceding *Repose* stage.

The viola presents a series of dynamic changes, beginning with a strong attack and gradually decreasing in volume until the next attack. These pulses follow a durational pattern laid out according to a decreasing segment of the Fibonacci sequence (Figure 10). These durational values derive from the partial numbers of the harmonic spectrum, although only the numbers corresponding to the Fibonacci sequence are selected. Only the duration of eight seconds does not come from the series provided by Grisey (see Figure 2), but the eighth partial is still represented in the spectrum as the pitch three octaves above the fundamental. Each consecutive gesture has a shorter duration than the last, resulting in a perceived increase of tempo as pulses appear closer together in time. Upon reaching the end of the sequence the final pulse is repeated three times. This decreasing pattern follows the same trend as the series of quarter steps between successive partials. The final three one-second durations are modeled after the last three intervals of Grisey’s pitch reservoir, which he notes as having a periodic relationship.

Time Markers (")	3	10	2	6	2	3	3	2	3
Fibonacci Pulses	13		8		5		3	2	1 (x3)

Figure 10.
Dynamic pulses in the viola outlining the Fibonacci sequence during I₁.

The start of the second cycle corresponds with a louder dynamic in the viola than those heard immediately preceding it. This second cycle is shorter than the first, leaving off the initial thirteen-second pulse. A third and final cycle returns to the original duration of the first cycle, the end of which signals the entrance of the trombone. With this malleable musical pattern, Grisey is able attain the “soft periodicity” or “pseudo-periodicity,” which more accurately represents the flux of natural rhythms (Grisey 1974;

Féron 2011). At cue 3, the three one-second pulses in the viola are followed by two more pulses in the trombone on the same pitch D \downarrow 4. The trombone now becomes the primary sound around which the ensemble is organized, and presents five varying cycles based upon the ending and starting material of the viola's cycles: a series of one-second pulses followed by a long tone decreasing in volume (Figure 11). These cycles vary in the number of one-second pulses (5-3-5-3-11) and overall duration (9, 7, 8, 9, 11, 13). Again, the number of pulses and durations of each cycle come from the set of partial numbers provided in the piece's opening instructions.



Figure 11.

Trombone gesture, based upon dynamic pulses in the viola during I₁ (Grisey 1974, 7).

Rhythmic tension is found in the accompanying members of the ensemble. As the viola reaches a new pulse, the other instruments will often change pitches. These changes do not occur at the same moment, but rather are staggered to produce a gradual shift of color as new pitches are introduced or rearticulated by each successively entering instrument. Towards the end of each cycle, the accompanying instruments play each pitch with a shorter duration, and the rhythmic differences between the parts are more discernible. Within the final pulses of the third cycle, the accompanying members of the ensemble have dynamic swells rhythmically offset from one another to blur the pulse from the viola, producing tension and uncertainty.

Harmonicity moves towards inharmonicity over the duration of each Inhalation stage. The fluctuating pitch material in the first section of I₁ follows this trend. As each group of pulses proceeds, inharmonic pitches are introduced one by one. By comparing the sounding aggregate at the start of each group, we can see an increase in the number and proportion of inharmonic to harmonic pitches (Figure 12).



Figure 12.

Harmonic aggregate beginning each group of dynamic pulses in the viola during I₁. Open noteheads are harmonic pitches of the E1 spectrum, and closed noteheads are pitches outside of this spectrum.

Inharmonicity is also caused by the use of glissandi. This gesture results in a constant fluctuation of pitch, with the frequency of the sound continuously rising or falling. Theoretically, a glissando contains every possible pitch between the terminal points of the gesture²⁴. While certain specific frequencies will correspond with the harmonic spectrum, the sound produced is largely made up of frequencies not found in the harmonic spectrum at the sounding octave. An example of these glissandi occurs in the cello just before Cue 1 (Figure 13). These initial gestures travel a short pitch interval

²⁴ Actually, we do not perceive every frequency that occurs in a glissando. Studies have determined the just noticeable difference (JND) between two consecutive frequencies to be ~3Hz (for frequencies below 1000Hz) (Benesty et al. 2008). Given that there are 1400 perceptible steps in human hearing range and 120 notes in the equal-tempered scale, the human ear can perceive roughly twelve frequencies in the space between two semitones (Olson 1967). This measure of our perceptibility may be further obscured by the duration of the glissando, as these discrete frequencies may be perceived as occurring simultaneously.

between two terminal notes and coincide with the pulses produced in the viola. travels one semitone from A5 to B \flat 5 over the course of about four and a half seconds. only travel one or two semitones, the pitches A5 and B \flat 5, D \flat 6 and C6, and E \flat 5 and F5. Although each note is written as a tempered pitch, all six of these can be found in the E1 spectrum. Inharmonicity is introduced here by the frequencies that occur between the terminal pitches of each glissando. As I₁ proceeds, the ranges of successive glissandi gradually increase, resulting in a greater degree of inharmonicity.



Figure 13.
Introduction of glissandi in cello during I₁ (Grisey 1974, 3).

Inharmonicity is also achieved through more immediately perceptible methods. Extended bow techniques, mutes, and breath are implemented to produce noise. To define a sound as a pitch, it must exhibit a distinct frequency with greater amplitude than its complementary formants. Noise exhibits an aperiodic frequency that does not appear as a perceivable pitch, and no distinct frequency emerges from the sound (Berg and Stork 1982). The introduction of these noise techniques results in an increase of inharmonicity.

The second Inhalation stage (I₂) builds tension in two distinct sections, separated by rehearsal numbers. The first of these sections uses duration as a device to build tension, while the second moves towards inharmonicity in pitch and an intensification of rhythmic density. I₂ begins with the material from R₂: the pitches G \sharp 3, D \downarrow 4 and F \sharp 4 are held as long tones in the upper strings, and these same pitches are played as a single

rhythmic gesture between the flute, clarinet and bass. This gesture is the length of a quarter note, and repeats once per beat in a 2/4 meter.

A single bar of 3/8 shifts the position of the rhythmic gesture within the bar, placing G#3 on the downbeat and F#4/D#4 on the offbeat. Across successive repetitions of the gesture, the length of time between given elements of the object is shortened or lengthened (Figure 14). This modification happens gradually, and creates the effect of one of the pitches changing its temporal location within the gesture. In the score, these pitches appear to “walk” towards the barline throughout this process. Each repetition divides the pulse into different tuplets with divisions ranging from 3 to 8. These tuplets are organized so that each successive duration between repetitions is slightly shorter or longer than the one previous.



Figure 14.

Shortening of durations between successive repetitions of F#4 in the flute during I₂ (Grisey 1974, 16).

What was earlier a static object is now being modified by a change in position of one of the three elements that make up the gesture. These modifications cause a shift from periodicity to aperiodicity. Once F#4 reaches the downbeat, G#3 now becomes the grace note preceding it, effectively switching the positions of these two notes in the original gesture. Next, D#4 “walks” to the barline in the other direction, this time by

occurring slightly later than each preceding repetition. The order of pitches in the gesture has changed from F#4-D#4-G#3 to D#4-G#3-F#4, rotating the original pattern.

From this point forward, the grace note gesture is expanded into new pitch material shared by the flute and clarinet. The grace notes continue their upward leaps and steadily rise in register and volume (Figure 15). One, two, or three pitches now make up the grace note figure itself, and the final pitch of the gesture is held as a long tone until that instrument's next gesture. The gesture alternates between the flute and clarinet, and only occasionally are there two successive statements by the same instrument. These pitches all belong to the E1 spectrum and do not cause inharmonicity themselves. The growing tension is caused instead by the aperiodic statements of the gesture and the strident timbres of the high registers and volume. These rising pitches evoke an image of the excitation of electrons jumping to outer orbitals with the increase of energy. This energy is released as light and heat when the electron moves back down to its stable position.

The image shows a musical score for two staves, flute and clarinet. A box with the number '9' is in the top left. The flute staff (top) has a long note starting in the fourth measure, marked 'mf' and 'senza vibr. e senza dim.', with a 'non dim.' instruction above it. The clarinet staff (bottom) has a similar long note starting in the first measure, also marked 'mf' and 'senza vibr. e senza dim.', with a 'dim.' instruction above it. The score includes various musical notations such as accents, slurs, and dynamic markings like 'mf' and 'f'.

Figure 15.

Expansion of the grace note gesture in the flute and clarinet (Grisey 1974, 17).

Underneath this dialogue, the strings engage in their own pattern. Long tones are a predominant feature of this process, separated by percussive interjections. These interjections come in the form of three different gestures: pizzicato followed by a long tone, pizzicato alone, and *arco gettato*²⁵ followed by a long tone (Figure 16). These gestures are heard three times in this section. In the first two of these instances the gestures begin together, but the third is missing the solo pizzicato. Shortly after this third interjection, the solo pizzicato appears four times staggered amongst the string instruments, each plucking an inharmonic G4. In each of the string instruments, this G4 is approached by step, whether within the same octave or at an octave displacement.

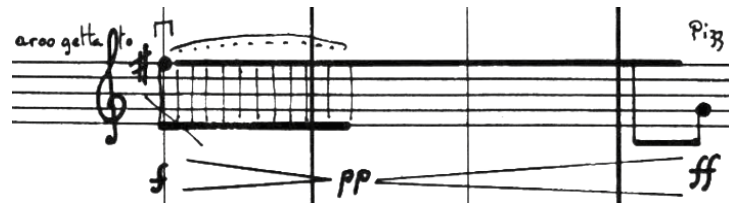


Figure 16.

The *arco gettato* and pizzicato gestures in the cello during I₂ (Grisey 1974, 18).

The third Inhalation (I₃) builds tension through the alternation of two states: the seven-note harmonic aggregate of the preceding Repose and its interruption by brief *ff* interjections (Figure 17). As I₃ progresses, the pitch material of these interjections becomes inharmonic and eventually is replaced with noise. The texture of these interjections generally becomes denser as they become more inharmonic. The durations of these interjections also increase over time.

²⁵ Throwing the bow on the string and letting it bounce.

The image shows a musical score for four instruments: Viola (Vla), Violoncello (Vc), Contrebasse (Cb), and Trombone (Trbn). The score is divided into four measures. The Viola part has a dynamic marking of *ff* in the second measure, with a note marked 'II II sola'. A box contains the following text: 'NOTA: 1° Pour les f, ne pas réattaquer. cordes d'archet à la corde. Pos. ordinaire vent: Sur le souffle. Respirer ad lib. sauf avant les f'. The Trombone part has dynamic markings of *ff* in the first, second, and third measures, and *ff* and *p* in the fourth measure. The bottom of the score has dynamic markings: 'Tous *ff* *p* <*ff* *ff* *ff* <*ff* *p*'. The Trombone part also has '2° pos' and '2° pos' markings in the fourth measure.

Figure 17.

Long tones with *ff* interjections during I₃. Inharmonicity is introduced by the viola in the second measure of this passage with the pitch D[♯]4 (Grisey 1974, 29).

These interjections are organized in time to be perceived in groups of two or three units. To describe the basic shape of these groups, the durations of the interjections can be thought of as *short-long* or *short-short-long* (Figure 18). These measurements are proportional to the units that make up the group; as the overall durations of these interjections increase, a *short* interjection may last for more time than a *long* interjection heard in an earlier group. These groups are separated from one another by durations of the underlying aggregate longer than those found within each group.

For example, the first group of interjections is made up of two units, *short* and *long*. The *short* interjection lasts for one sixteenth, followed by seven sixteenths of the harmonic aggregate. The *long* interjection lasts for two sixteenths, followed by ten sixteenths of the harmonic aggregate, at which point the second group of interjections

begins. This second group contains three units, perceived as *short-short-long*. The two *short* interjections are both one sixteenth in duration, and the *long* interjection lasts for four sixteenths.

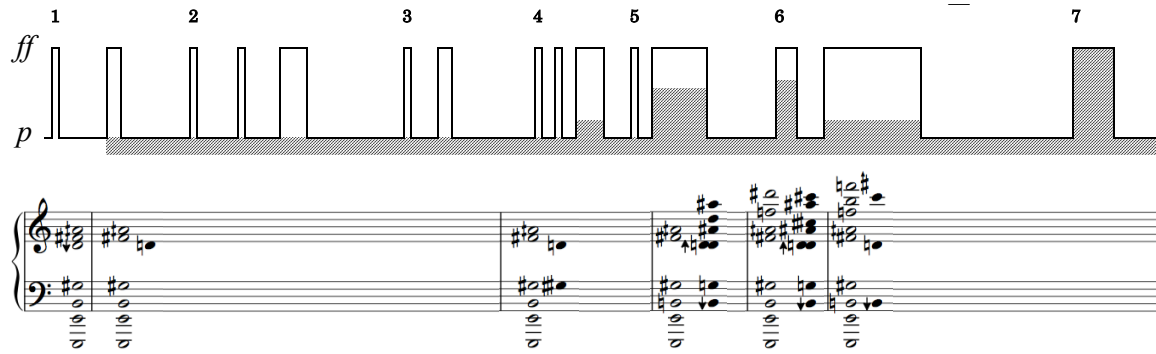


Figure 18.

Groupings of *ff* interjections during I_3 . The shaded regions indicate the proportion of inharmonic pitches infiltrating the harmonic aggregate.

The third and fourth groups maintain these same durational lengths for the interjections, but the durations between units in the same group are shorter. Again, this shortening of durations between louder dynamics (as in I_1) can be perceived as an increase in tempo, even as the conducted pulse remains the same. The fifth, sixth, and seventh groups conclude the I_3 stage and are all *short-long*, with the second unit of the last group beginning the following Exhalation stage (E_3). The durations for these final interjections are greater in length than those in the earlier groups, but the relative proportions of the units within each group are present.

The pitch material for these interjections generally moves towards greater inharmonicity throughout this section. The first group of interjections is on the same pitches as the aggregate itself, and does not create inharmonicity in itself. The first movement away from harmonicity actually occurs just after this first group of

interjections when the viola's D \downarrow 4 is raised to D \sharp 4 (see Figure 17). The viola continues on this pitch for the remaining statements of the harmonic aggregate. While this alteration may be interpreted as an approximation of harmonicity, the viola's shift away from the rest of the ensemble's harmonicity becomes an element in the release of tension for the following Exhalation.

Inharmonic pitches are introduced in the next six groups of *ff* interjections during the *long* units of each group. With the exception of the last two groups, the *short* interjections are still played on the same harmonic aggregate with the modified D \sharp 4. In addition to new pitch material, the overall texture of these interjections increases in density as notes are doubled or tripled across the entire ensemble. These doublings occur exclusively on pitches that are a part of the underlying *p* aggregate.

The fourth Inhalation stage (I₄) is a series of two-part gestures made up of accelerating arpeggios leading into two note tremolos (Figure 19). Tension is built through the gradual accumulation of inharmonic pitches, a decrease in gestural durations, and an overall aperiodicity between the individual instruments present throughout the entire section. The arpeggiating gesture derives from the disjunct chord found in the preceding R₄ stage, with these additional domain changes marking the start of a new section. This gesture will also be used in other movements of *Les espaces acoustiques*, and makes up a majority of *Prologue* (1976), the movement preceding *Périodes*.

The repeated dyads at the end of each gesture are held for a varying amount of time, indicated by one of four different fermata types. The relative lengths of these fermatas are dictated in the opening instructions of the piece, ranging from *short* to *very*



Figure 19.

Arpeggio and tremolo gestures in the violin, viola and cello during I₄ (Grisey 1974, 34).

long (Figure 20). The swell dynamic shape is also used for this stage; the instruments crescendo during each arpeggio and decrescendo during the tremolos. The instruments play their arpeggios within the same space of time, but do not align at any moment until the repeated dyads are reached. Each instrument begins its arpeggio independently, plays a different number of pitches, and accelerates at its own rate. This aperiodicity between instruments is a feature taken from the preceding R₄ stage, but has been expanded to create tension through accelerations of tempo.

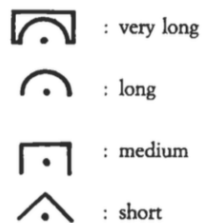


Figure 20.

Notations and durations of different fermatas above the repeated dyads of I₄. (Grisey 1974).

During each gesture, the instruments playing draw from the same pitch reservoir. Some instruments do not play all available pitches, while others play all and repeat some notes. These pitch reservoirs are altered at distinct moments of the gestures. When a tremolo is reached, one or two pitches are removed from the reservoir. The arpeggio following that tremolo adds one new pitch to the reservoir of available notes. By the end of the I₄ stage, none of the original pitches of the first gesture remain. Pitch-classes that were removed reappear at lower octaves, thereby causing inharmonicity. In the final gesture, five out of eight pitches in the pitch reservoir cause inharmonicity.

There are eleven gestures in total throughout the I₄ stage. The first gesture begins with the violin, viola, and cello, and is the only one of this section that does not end with a tremolo. There are an initial six pitches that make up the pitch reservoir (C#5, D#5, F5, G5, A↓5, C6); the violin makes use of all six of these pitches, while the viola and cello each play five of the six available. Across the entire arpeggiating gesture, the three string instruments play eleven, nine, and eight notes respectively. These pitches all achieve harmonicity with the E1 spectrum. The highest pitch (C6) is not included in Grisey's pitch reservoir described in the opening instructions (see Figure 2), but it is the twenty-fifth harmonic of E1 and does not cause inharmonicity.

The second gesture maintains the same instrumentation and pitch reservoir, with the cello and violin playing an additional one and two notes respectively. This second arpeggio does lead to simultaneous tremolos and trills amongst the three string instruments, and upon reaching this point F5 is removed from the pitch reservoir. When the third gesture begins, the flute joins the three string instruments and two new pitches are now added to the reservoir: E5 and A#4. These two new pitches are still a part of the

E1 spectrum and achieve harmonic, but the addition of a fourth instrument creates a greater aperiodicity and a growing sense of tension. The fourth gesture sees the addition of one new pitch, B5, and its concluding tremolo excludes the pitch G5 from the reservoir of available notes. The sixth gesture sees the inclusion of the clarinet as the fifth instrument engaging in these gestures.

It is not until this sixth gesture that we see any inharmonicity introduced by way of pitch material. The harmonic pitches C#5 and C6 no longer sound after the arpeggios of the fifth gesture. In the following gesture the newly introduced pitch is the inharmonic pitch C4. It is the same pitch-class as the pitch removed in the previous gesture, reappearing two octaves below and causing inharmonicity. C4 persists in the pitch reservoir for the remainder of the I₄ section, and other inharmonic pitches are introduced in a similar manner. The end of the seventh gesture sees the removal of pitches A↓5 and B5, and the following gesture introduces A3 as a new pitch. Again, A3 is two octaves below the removed A5 and now causes inharmonicity. Five of the eight pitches making up the final eleventh pitch reservoir cause inharmonicity, and four of these five inharmonic pitches are lower octaves of the pitches making up the opening gesture of this section (Figure 21).

Throughout each Inhalation stage, duration is used as a device to build tension. The durations of gestures and phrases are lengthened or shortened throughout each Inhalation stage. These modified durational values, when heard in succession, create unpredictability in regards to the placement in time and length of each gesture. At I₁, the amount of time between the dynamic pulses of the viola become progressively shorter. The “walking” motion of the flute and bass at I₂ shortens the distance from the clarinet’s

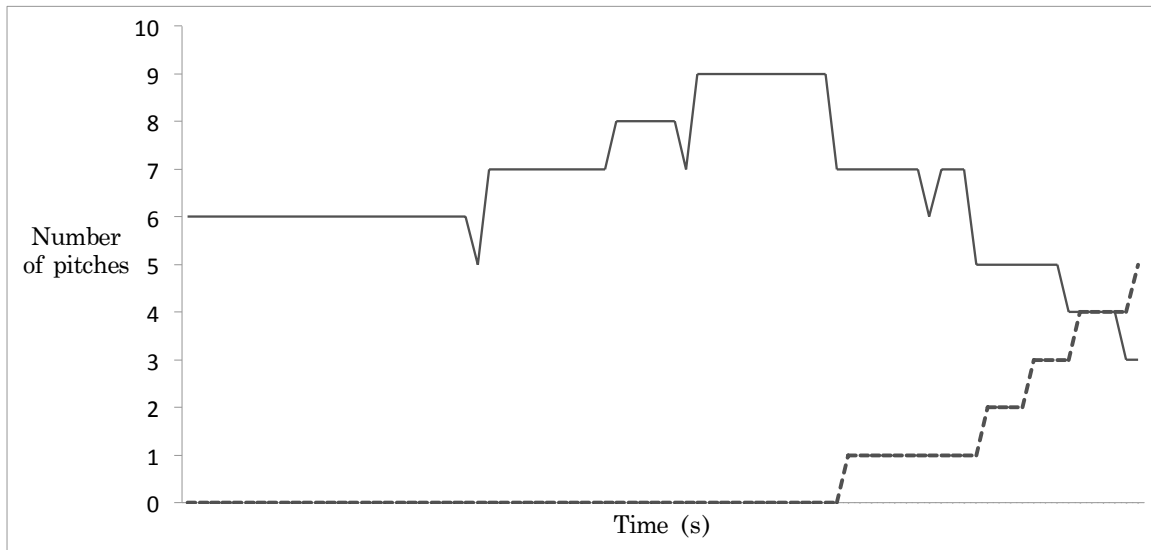


Figure 21.

Comparison of the number of harmonic and inharmonic pitches during the I_4 stage. The solid line indicates harmonic pitches, and the dotted line indicates inharmonic pitches.

periodic note, resulting in the rotated trichord. This tension is temporarily relieved when the flute reaches the clarinet, but tension is built once more with the bass following in a similar fashion.

Throughout I_3 , the durations between the *short* and *long* interjections become successively shorter in successive groups. The *long* units become progressively longer, further contrasting the shorter distances between the *short* and *long* units. The durations between these groups increase as well. Since the *long* units are increasing, the length of time between groups must increase to make those groups distinct from one another. By constantly changing the durations of these four different segments of the music, successive interjections become unpredictable, and tension is achieved through the creation of surprise and anticipation.

The durations of each gesture at I_4 are condensed over time. Similar to the organization of phrases in I_1 , durations become progressively shorter until reaching a maximum brevity, at which point a new phrase begins with a longer durational value.

This start of each new phrase coincides with the entrance of a new instrument. Each individual gestural duration is also affected by a slight improvisatory element. The fermatas that appear above the tremolos are of varying lengths, but their durations are only in proportion to one another. There is no exact measure of time for these fermatas, so the length of time between gestures may differ from one performance to another.

An increase in dynamics also serves to build musical tension. These dynamic intensifications can take the form of crescendos as in I₂ and I₄, or can occur suddenly with *subito f* indications as in I₁ and I₃. At the start of I₁, the viola has long tones with relatively strong dynamic markings (*mf, f, ff*) that are followed with a decrescendo. The trombone takes up this dynamic pattern in the second half of the I₁ stage, while the rest of the ensemble imitates this pattern at lower dynamic levels (*mf* or *pp*). These sudden shifts of dynamic levels, combined with the unpredictability and flux of durational values, create musical tension throughout this section. As the music continues, the listener anticipates another strong dynamic to arrive suddenly, but cannot easily predict when that moment will be. These sudden dynamic contrasts are also heard during the I₃ stage. The *ff* interjections that characterize this section of music are introduced with little to no gradual increase in dynamic level, before returning back to *p* with the same immediacy as it had left.

During the I₂ and I₄ sections, the crescendo is the predominant dynamic effect. In the second half of I₂, the flute and clarinet have a constant crescendo during their upward leaps leading from *mf* to *ffff* when the next E₂ stage is reached. The long tones in the strings also follow this dynamic shape, beginning *pp* and culminating in plucked notes at *ff*. The flute and clarinet grow more or less at the same rate throughout this section, but

the gestures of the strings and trombone are separated from one another in time. The dynamic shape at I₄ resembles the swell gesture, beginning at *p* and growing to *f*, then returning with a decrescendo during the tremolo. Only one gesture does not maintain this exact shape, but begins *mf* and quiets to *p* before growing to *f*. Although pitch, contour, and rhythm are not aligned between members of the ensemble during this stage, the instruments do exhibit the same dynamic shape at the same time. This dynamic unity is consistent throughout the entire section. Dynamic unity is also consistent in I₃, and present in I₁ and I₂ but less frequently.

Exhalation Stages

Each Exhalation stage is constructed using a common compositional technique: a single process applied to several instruments, but each functioning within its own durational framework. This process is made up of several repeated cycles of the same musical gesture, but the musical domains of each successive cycle are modified in some fashion.

At the start of the first Exhalation (E₁), maximal tension is expressed through cycles of glissandi in five of the instruments and the noise created by the fluttertongue of the trombone. Each glissando encompasses all frequencies between G[#]₃ and F[#]₄, but each instrument is separated rhythmically from the rest of the ensemble. These rhythmic separations are achieved through staggered entrances and slight differences in duration (Figure 22). Each repetition of the G[#]₃ – F[#]₄ cycle increases in duration, and is sometimes separated from its previous cycle by a rest. Through the rhythmic organization of these gestures there will be no sounding unisons between any members of the

Figure 22.

First five cycles of G#3-F#4 glissandi during E₁. Circled numbers are added to the score to indicate cycles for each instrument (Grisey 1974, 11).

ensemble, except when a pitch within a glissando temporarily aligns with that of the trombone.

At Rehearsal 6, the G#3 – F#4 glissandi transform into lines of eleven discrete pitches, keeping the same direction and terminal pitches of the previous gesture (Figure 23). The first instance of each line is presented in a fragmented form. Each fragment is preceded by rest, and begins from some point in the middle of the chromatic line. As each line enters in succession, another note is added to the start of the fragment. By the entrance of the final line transformation, the fragment has expanded into the entire line. After each instrument's initial fragment, the following cycle contains the eleven chromatic pitches from G#3 to F#4.

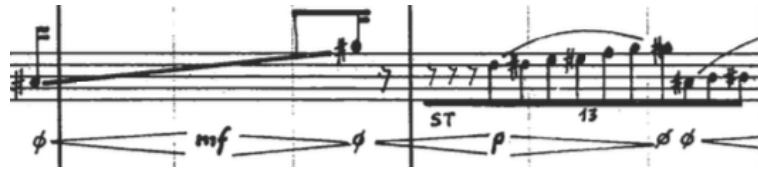


Figure 23.

Transformation of glissandi into lines of discrete pitches in the bass during E₁ (Grisey 1974, 12).

As the cycles progress, notes are removed individually from within the lines, eventually transforming lines into arpeggios. The first six notes to be removed in this manner are those that do not correspond to the E₁ fundamental (Figure 24). The remaining five pitches, however, belong to the E₁ spectrum and achieve harmonicity. Grisey accomplishes this gradual change from inharmonicity to harmonicity by the transformations of glissandi into chromatic lines and arpeggios. This process is further made gradual by the rhythmic offset of cycles, so that each instrument steps towards harmonicity at its own pace. By the end of this process, only three pitches remain: G#₃, D₄, and F#₄.

n	Pitch content (G# ₃ -F# ₄)											Next removed pitch	Partial of E ₁ spectrum
11	G#	A	A#	B	C	C#	D	D#	E	F	F#	A#	-
10	G#	A		B	C	C#	D	D#	E	F	F#	D#	-
9	G#	A		B	C	C#	D		E	F	F#	C	-
8	G#	A		B		C#	D		E	F	F#	F	-
7	G#	A		B		C#	D		E		F#	A	-
6	G#			B		C#	D		E		F#	C#	-
5	G#			B			D		E		F#	E	1
4	G#			B			D				F#	B	3
3	G#						D				F#	F#	9
2	G#						D					G#	5
1							D						7

Figure 24.

Order of pitches removed from G#₃ – F#₄ lines during E₁.

The duration of individual G#3 – F#4 cycles varies with each repetition. There is an increase of duration during the cycles of glissandi from five to thirteen sixteenth-notes. Despite the minimal deviations of duration between instruments, this similarity is obscured by the staggered entrances of each cycle. These cycles are further separated by rests and durational deviations, so that the transformations from glissandi into lines are staggered by a full measure of 3/4.

When the glissandi are transformed into lines, each instrument begins its own durational process independent of the others. The initial rhythmic values of the notes of each line vary between instruments, getting shorter with each successive entrance. The flute is the first to enter with discrete pitches, with rhythmic values equal to 11-tuplets. The next entrance in the bass enters with 13-tuplets, then 15, and so on until the violin enters with 21-tuplets. The increasing number of tuplets describes a division of the measure, corresponding with a faster rhythm and shorter duration. The overall increase of duration of these cycles creates the feeling of a continuous decrease in tempo.

The second Exhalation (E₂) continues the division of the ensemble into two groups from the preceding I₂ stage, with the bass joining the other strings and the trombone combining with the woodwinds. The strings sound continuously through this section, while the woodwinds/brass group enters and exits the musical texture periodically throughout the section. Each string instrument is subjected to the same process, but each process operates independently from the others. These four instruments are set apart from one another in their rhythmic and pitch domains, as well as in durational differences of each cycle.

Each string instrument alternates between two pairs of notes: a double-stop and their artificial harmonics (Figure 25). The speeds of these alternations are constantly changing through successive accelerations and retardations, but these changes occur in each part independently. These changes of speed are linked to the dynamic shape of these gestures. The common gestural feature of this section is the dynamic swell. The string instruments play without rest during this section, with crescendos and decrescendos between *p* and *mf* dynamic markings. The rhythmic speed of their attacks is linked to the dynamic shape; the quietest part of the swell is played at a slow rhythm that accelerates simultaneously with the crescendo. The maximum rhythmic speed is reached at the height of the dynamic swell, and slows back down to its original speed during the decrescendo to *p*.

The image shows a musical score for a string quartet, consisting of four staves: Violin (Vno), Viola (Vla), Violoncello (Vc), and Contrabasso (Cb.). Each staff contains musical notation for double stops and artificial harmonics. The score includes dynamic markings such as *mf*, *p*, and *acc.* (accelerando), and performance instructions like *rit.* (ritardando) and *poco acc.* (poco accelerando). The notation is complex, with many notes and stems, and includes fingering numbers (e.g., 1, 2, 3, 4, 5) and bowing directions. The overall structure is a continuous, flowing piece of music.

Figure 25.

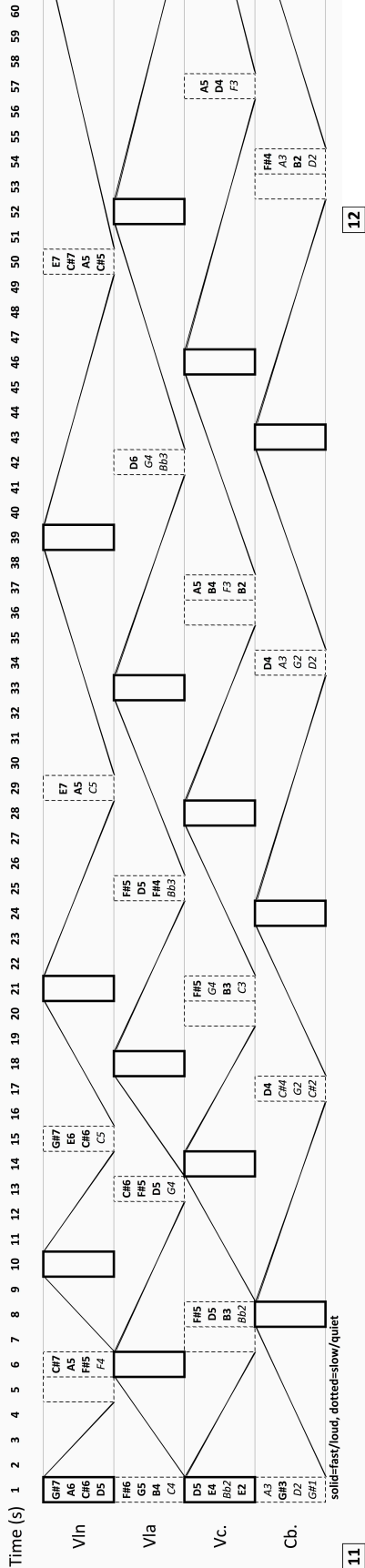
Alternations of double stops and harmonics in the strings during E_2 (Grisey 1974, 19).

Figure 26 diagrams this process over the course of the entire section. The domains for pitch, rhythmic density, and dynamics are illustrated for each instrument over time. Pitches are written at their first occurrences along the time axis, and those pitches continue to be played until a new set of pitches is introduced. Pitches belonging to the E1 spectrum are in bold, while inharmonic pitches are italicized. The boxes surrounding these pitches represent both the rhythmic density and dynamic level. A box with a solid line is the peak of the dynamic swell, corresponding with the maximum rhythmic speed and *mf* dynamic level. In contrast, a box with a dotted line marks the beginning or end of the dynamic swell, corresponding with the slowest rhythmic speed for each instrument and *p* dynamic level. The slanted lines connecting these boxes indicate a change of speed; lines with a positive slope show acceleration of the alternating dyads, and lines with a negative slope show retardation.

The maximum points of these swells are organized so that no two align at the same point in time. At the start of E₂, the violin and cello begin in the middle of their swell gestures, playing their fastest rhythms at *mf* while the viola and bass begin their swells from *p*. The resulting sound of this section is a succession of pulses that emerge from the thick yet subdued musical texture. The entrances of these pulses do not seem to form any strict pattern, but rather appear at unpredictable moments. Again, we have another example of Grisey's soft periodicity, seen earlier in I₁. The pattern is periodic because the pulses consistently return in each instrument, but the entrances do not follow any strict relationship in time to one another.

The brass and woodwinds also have dynamic swells, but with a number of differences from the string instruments. The three instruments play together as a single

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11

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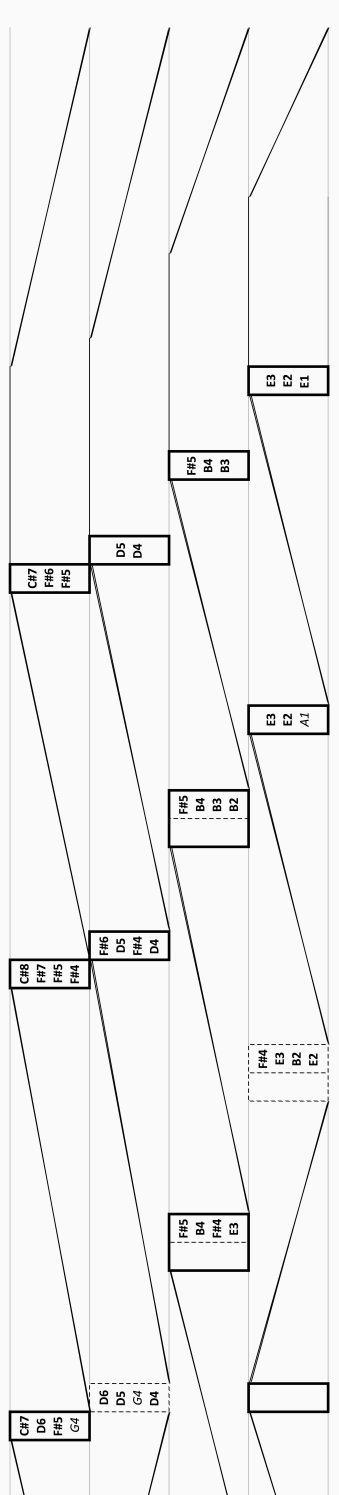


Figure 26. Independent processes in the string instruments during E₂.

unit instead of independently from one another. Furthermore, they do not play rhythmically, but instead play a single long tone that makes up the swell. Each of these three instruments has a different maximum dynamic marking (*mf/mp/ppp*), but these markings are consistent throughout the section.

The pitch material for this section moves towards harmonicity in the strings, but the brass and woodwinds are consistently inharmonic until their final gesture. Whenever a swell gesture is completed in the strings, the pitch material of that instrument changes. The opening sixteen pitches that sound in the strings' opening gesture contain five inharmonic pitches. Harmonicity is not directly approached from this point, but actually becomes more inharmonic at first. As the gestures are successively completed and the overall pitch material shifts, more inharmonic pitches are initially introduced, but these are gradually removed over the duration of this section. By the end of E₂, no inharmonic pitches remain and both the strings and the woodwind/brass groups achieve perfect harmonicity.

The third Exhalation section (E₃) at cue 14 begins out of the previous Inhalation stage, where the music has been alternating between the two states of harmonicity and growing inharmonicity. At the start of E₃, the inharmonic state has won out, and noise dominates the soundscape. This noise continues for a total of forty-six seconds, longer than any length of noise heard in the previous stage. The instruments play at a consistent *fff*, but exit the texture one by one, each with a short decrescendo to *pp* before stopping its sound. The texture becomes gradually thinner as the woodwinds and brass exit, followed shortly by the three lower strings until all that remains is the violin. The noise from the violin thins out and is reduced to a single pitch, C#5 played at a *p* dynamic.

During this section of noise, the clarinet and strings engage in their own independent cyclical processes. These processes employ changing timbres of each instrument; precise pitch is absent from the music at this point, and rhythm cannot be considered since the instruments continue to play long tones. The clarinet moves between *région grave* and *région medium* while the strings shift bow positions between *sul ponticello* and *alto sul tasto*. A cycle here refers to a single gradual shift from one timbral position to another. Similar to the previous E₂ stage, the violin and cello begin in the middle of one of these cycles, beginning this stage at standard bow position and moving towards *sul ponticello*. The viola and bass begin at the start of the cycle at *sul ponticello* and move towards *alto sul tasto*. These two groups also alternate the initial directions of bow movements for their first cycles; the viola and bass move from bridge to fingerboard, while the violin and cello move towards the bridge.

These timbral shifts each take place over different amounts of time. With the exception of the clarinet, the durations for these shifts get progressively longer with each cycle. These additive modifications are in keeping with the exhalation idea, a gradual lengthening of durational values and an assurance that no two cycles would align in time. Each instrument also has a different number of cycles, dictating when the instrument exits from the noise texture. The clarinet has only two motions, moving from *région grave* to *région medium* and back to *région grave* before exiting the sound. The strings exit in order of low to high register, beginning with the bass after three cycles, and finishing with the violin after six cycles. After the violin returns to a precise pitch, it stops playing and a fermata is reached.

What follows next is a sort of “disagreement” between the violin and viola about the intonation of the pitch C#5. The viola plays a tempered C#5, while the violin plays the harmonic pitch C#5. When these two pitches are played simultaneously, an audible beating emerges from the dyad. These notes are separated by rests with fermatas, and the score indicates a short theatrical interplay between the two instrumentalists, dictating their confusion as to the correct pitch through wordless motions and facial expressions. Eventually, the viola matches the C#5 of the violin, and the following period (R₄) is reached.

The fourth Exhalation stage (E₄) is also broken into two sections. The first of these sections continues with the arpeggiated gestures of the previous Inhalation played with several immediate differences to produce noise and inharmonic formants. Instead of being slurred together into a distinct group, pitches are now played *marcato* at a constant *fff*. Each instrument undergoes its own pattern of tempo changes through independent series of accelerations and retardations, creating a sense of randomness and frenetic energy. As the music progresses, the flute drops out and the space between arpeggiated notes becomes gradually longer in duration. The *marcato* notes transform into gradually longer tones, and shed the accent marking for a dynamic shape of a *sfffz* followed by a decrescendo. The strings begin each note with a down bow atop the bridge, and follow with a quick shift of the bow back to the ordinary position.

The pitch reservoir contains seventeen pitches at the start of this first section, only three of which belong to the E1 spectrum. As the music progresses, pitches are gradually removed from this reservoir until only five inharmonic pitches remain: F1, F#2, C3, G3, and D#4 (Figure 27). The three harmonic pitches B3, G#4 and E5 are removed within the

first six measures of this section. In this case, harmonicicity is not approached gradually, but rather moves towards a lesser stage of inharmonicity. This movement is achieved by the thinning out of the overall pitch reservoir, as well as the elimination of the juxtaposition between harmonic and inharmonic pitches.

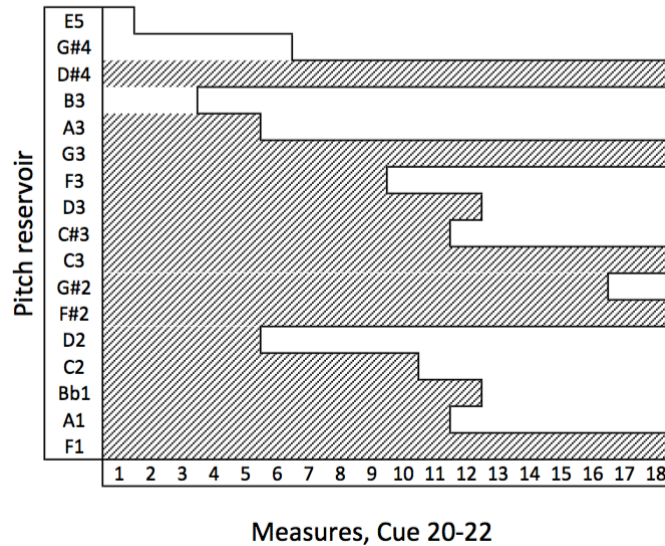


Figure 27.
Pitch reservoir reduction over time during the first section of E₄.

The second section of E₄ finds the harmonic pitch E₂ played by the trombone as a long tone with fluttertongue, accompanied by the accumulation of several inharmonic tones in the lower strings. The trombone repeats this gesture three times, its starting dynamic level decreasing from *fff* to *f* with each successive gesture. At the end of the second and third gesture, a plunger mute is used to create quasi-periodic pulses, similar to the pulses at I₁ (see Cue 3). At Cue 23, two more repetitions of the trombone gesture occur before reaching R₅. These final gestures are articulated with no fluttertongue this time, but instead a gradually closing plunger in time with the decrescendo. The quasi-

periodic pulses are now picked up by the bass, plucking a low E1. The bass and cello now have a reverse swell dynamic, growing in volume to the attack of the next trombone note. Bow shifts and additional pressure create a changing timbral shape that aligns in time with the dynamic envelope.

The number of inharmonic pitches is gradually reduced during this section. The aggregates constructed during each trombone gesture shed the highest and lowest pitches of each previous chord, while the inner pitches move by step (Figure 28). The final aggregate is the symmetrical trichord D2, E2, and F#2, with E1 quietly plucked in the background. The pitch reservoir decreases in range throughout the entire E₄ stage, and the final carriers of inharmonicity sit on either side of the second harmonic. At R₅ the inharmonic pitches disappear and total harmonicity is achieved once more.



Figure 28.
Voice leading in the last five gestures of E₄.

Conclusion

Grisey applies the idea of domain independence to his compositional approach to *Périodes*. However, the organization of these domains bears no resemblance to that of serialism, and instead more organic processes are used to compose the details of the music. The aural result is a cohesive sound that gradually changes over time. The same basic shape is chosen for each formal stage, and each domain follows the same general trend to increase or decrease tension. Different combinations of basic gestural shapes and

domain modifications are affected by some process of change, resulting in aurally different results for each section. No two similar *Reposes* sound alike, and the decrease of tension in the *Exhalation* does not resemble the increase of tension in the preceding *Inhalation*. Through the adjustments of these individual domains, Grisey creates a living sculpture of sound deriving from the E1 harmonic spectrum.

Périodes marks one of the earliest instances of the application of structural aspects of the harmonic spectrum to the formal structure of a musical composition. While the harmonic spectrum has been explored by other composers in works prior to *Périodes*, the spectrum was used primarily to determine pitch material and intonation requirements. Grisey would continue to use the harmonic spectrum as a structural model throughout the remaining movements of *Les espaces acoustiques* and other compositions. Through studying the beginnings of spectral composition in *Périodes*, it is my hope that these analytical approaches can be used to explore other works of Grisey.

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