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A method for generating pitch and rhythm for use in composition based on analytical techniques of Jonathan Bernard

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The Ohio State University, 1992
A METHOD FOR GENERATING PITCH AND RHYTHM
FOR USE IN COMPOSITION
BASED ON ANALYTICAL TECHNIQUES
OF JONATHAN BERNARD

DOCUMENT

Presented in Partial Fulfillment of the Requirements for
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By

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*****

The Ohio State University
1992

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INTRODUCTION

The art of composition has always been an art of expression, either of the individual, or of society by an individual. This expression has usually been within a single musical language during any one period. Composition in the twentieth-century, however, has entailed, more and more, a search for alternative languages; composers of western art music have been exploring new melodic, harmonic and rhythmic resources. Their search has taken them from the modal scales of the distant past to the musics of distant cultures. They have even looked outside the musical world for ways of producing new sounds and for inspiration on how to organize and structure those sounds. This has led to new musical forms and new techniques for relating the sounds within those forms. The means for unifying their compositions have varied from the micro-controlled structures of total serialism to the exact opposite of entirely intuited, free-composed pieces. However the means, from whatever influence (non-western, extra-musical, etc.), a single twentieth-century language has not shown itself to be the norm against which others are to be seen in relation, such as eighteenth- and nineteenth-century tonality was.

Because of the lack of a common language, theorists have regarded this growing body of extremely individualistic music with an awareness of
the problem of finding a way of explaining its structures. They are aware that new tools are needed to better understand it. The search for new methods of expression is often closely allied with that of the search for new methods of comprehending the usages to which those new methods of expression have been put. In some instances, a new technique of composition may inspire a new method of analysis. This is certainly the case with Schoenberg’s twelve-tone theories. In other cases, new methods of analysis have promoted new ways of approaching composition. Set theory may be a suitable example of this. The author has similarly found compositional inspiration in the work of a theorist: Jonathan Bernard. An examination of Bernard’s approach to the music of Edgard Varèse has provided the inspiration for the development of new techniques for generating pitch and rhythmic material for composition.

These techniques allow the composer to generate pitch and rhythmic material in a reasonable and demonstratable manner while, at the same time, they give the composer considerable latitude and choice as to exactly what pitches and rhythms are produced. Relationships can be established in the music that remain consistent with a composer’s stylistic biases and yet have some theoretical basis. The techniques have also led the author to the discovery of new sound combination that, while not entirely foreign to the author’s inner ear, may not have previously been his first choice. This has led to a richer, more diverse, harmonic and melodic language. The ease of pitch and rhythm generation has also allowed the author to focus on the construction of other musical element, such as articulation and dynamics.
CHAPTER I
The Constellation System of Jonathan Bernard

In *The Music of Edgard Varèse*¹, Jonathan Bernard uses a unique method of analysis whereby he segments Varèse's music into trichords and investigates relationships among the trichords. He focuses on trichords for reasons that will be explored later. Bernard is struck by the registrally spatial organization in Varèse's music. Thus, the principal criteria for segmentation are the spatial relationships among adjacent pitches of the trichords. Bernard’s spatial orientation and the emphasis on adjacencies requires that he consider pitch in register, without octave equivalence.² Pitch itself plays a secondary role in this spatial universe. The relative positioning and movement of pitches and collections of pitches within the framework of the musical space is more important than establishing of a hierarchy of pitches and collections around a central pitch or collection. A pitch or collection of


²In this study pitches will be represented using the ASA convention: a letter name represents the pitch-class and an integer locates the register of the pitch. For example, middle C is C⁴, and all pitches within a seventh above it are located within that same octave designation: Db⁴ to B⁴.
pitches may have different relationships attached to them depending upon the register and their relative position in the overall musical space.\textsuperscript{3}

To categorize and relate various trichords in the musical space, Bernard examines the intervals between registrally adjacent pitches of the trichords. These intervals are unordered. An unordered interval is represented by an integer surrounded by square brackets counting the number of half-steps the interval contains. For example, [3] represents the unordered interval of a minor third. Bernard's spatial emphasis denies interval inversion. When considering the intervallic space occupied by an interval, the size of the interval is critical, not the direction. As shown in example 1, [8] occupies twice as much musical space as [4], even though in this instance both dyads share the same pitch classes.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{ex1.png}
\caption{Example 1}
\end{figure}

Bernard's trichordal collections are unordered as well. As stated above, Bernard segments Varèse's music into trichords of registrally adjacent pitches. He looks at the intervals between the adjacent pitches contained within the trichord. Bernard's trichordal groups are labelled with the smallest interval listed first. For Bernard's purposes the two intervals of a trichord must be different. A trichord such as [4][4] cannot exist as a trichord. It is considered, rather, to be a chain of [4]s, extending one

\textsuperscript{3}For a more detailed explanation of the non-constellational aspects of Bernard's theories see Bernard, pp. 43-72.
interval instead of representing two different intervals. Example 2 shows several different pitch collections, all of which represent trichord \([3][8]\).

Ex. 2

```
\begin{align*}
a. & \quad b. & \quad c. & \quad d. \\
   \begin{array}{c}
   \text{\includegraphics[width=\textwidth]{example2.png}} \\
   \end{array}
\end{align*}
```

Since it is the registral adjacencies that we are concerned with here, the horizontal sequential ordering of the pitches in a trichord does not matter. As a convenience, all examples of trichords in this study will be presented in ascending registral order, as in examples 2a and 2b.\footnote{Unless otherwise noted.}

Bernard uses a specific type of melodic inversion that he calls rotation to generate equivalent intervals from specific pitch dyads. The type of inversion used is not harmonic, where a pitch is shifted to a different octave resulting in a spatial change, for example, a major third becoming a minor sixth (see Ex. 1 above). Rather, the specific inversion that Bernard focuses on in this spatial environment is the melodic inversion where the direction of an interval changes, while the size of the interval remains constant. A rotation also signifies that one pitch is being rotated around another: one pitch acts as an axis of inversion. Bernard describes this operation analogously to the twelve-tone operation “...that produces the I-form of a twelve-note row from the P-form beginning on the same pitch.”\footnote{p. 49.} For example, a major third from G4 to B4 becomes a major third from G4 to
Eb4. (Ex. 3) Note that the ordering used in the example is only for the sake of clarity, to show the nature of the rotational operation. The total space remains the same, only the pitch content has changed.

Ex. 3

We can also represent [4] by the pitches G4 and D#4, labeling Eb4 with its enharmonic equivalent. Again, it is the intervallic space that matters, not the specific labelling of the pitches that define that space.

Bernard identifies certain trichords, called basic forms, to which he relates other trichords by way of the rotation techniques briefly outlined above. By rotating one member of a trichord around another, a new trichord can be produced. He groups trichords into constellations that consist of a basic form trichord and three rotationally related trichords. Bernard further clarifies his use of rotation on trichords by using the two terms unfolding and infolding. Unfolding is the technique of rotating the middle pitch of a trichord around an outer pitch.6 Infolding is rotating one of the outside pitches around the middle pitch. Thus for every trichord there will be two unfoldings and two infoldings. For example, take the trichord from example 2 ([3][8]) as our basic form, and let us represent it by the pitches F4, Ab4, and E5, the first example of trichord [3][8] in example 2. Rotating Ab4 around F4 generates D4. The resulting unfolding preserves the [3], now between D4 and F4, but results in [11] between F4 and Ab4.

---

6Middle and outer pitches refer, of course, to their registral position within the trichord.
and E5. (Ex. 4) Thus, we have derived the trichord [3][11] from the rotation of one pitch of [3][8].

Ex. 4

Unfolding #1

We can also rotate Ab₄ around E₅ in our example of the basic form trichord [3][8], a second unfolding, which results in the trichord [8][11]: Ab₄ has been unfolded around E₅ to result in C₆, leaving us with [8] between F₄ and E₅ and [11] between E₅ and C₆. (Ex. 5)

Ex. 5

Unfolding #2

The first infolding is produced by taking F₄ and rotating it around Ab₄, resulting in B₄. (Ex. 6) We then have the trichord [3][5] with an [3] between Ab₄ and B₄, and [5] between B₄ and E₅.

Ex. 6

Infolding #1

Ex. 7
Infolding #2

The two collections produced by the two infoldings — Ab4, B4, E5 and C4, F4, Ab4 — are not intervallically distinct, even though their pitch content is certainly distinct. Both Ab4, B4, E5 and C4, F4, Ab4 represent the same trichord: [3][5]. Since the two infoldings have produced the same trichord, we have derived from the four foldings only three new trichords — [3][11], [8][11], and [3][5] — from the original basic form — [3][8]. The final two possible rotational possibilities, that of rotating the two outer pitches around each other, also do not produce any additional distinct trichords. Bernard thus does not provide any folding term for these actions, however the term outfolding may be used as appropriate. Rotating F4 around E5 produces Eb6, and the trichord that the resultant pitches form — Ab4, E5, Eb6 ([8][11]) — is, again, a repeat of the second unfolding. (Ex. 8)

Ex. 8
Outfolding #1

The two collections produced by the two infoldings — Ab4, B4, E5 and C4, F4, Ab4 — are not intervallically distinct, even though their pitch content is certainly distinct. Both Ab4, B4, E5 and C4, F4, Ab4 represent the same trichord: [3][5]. Since the two infoldings have produced the same trichord, we have derived from the four foldings only three new trichords — [3][11], [8][11], and [3][5] — from the original basic form — [3][8]. The final two possible rotational possibilities, that of rotating the two outer pitches around each other, also do not produce any additional distinct trichords. Bernard thus does not provide any folding term for these actions, however the term outfolding may be used as appropriate. Rotating F4 around E5 produces Eb6, and the trichord that the resultant pitches form — Ab4, E5, Eb6 ([8][11]) — is, again, a repeat of the second unfolding. (Ex. 8)
E5 rotating around F4 results in another incarnation of [3][11] — F♯3,D4,F4. (Ex. 9)

Ex. 9

Outfolding #2

[3][8] [3][11]

Thus, only three, not six, new trichords can be derived from one basic trichordal form. These three trichords thus produced, are termed first-order derivatives. A basic form and its first-order derivatives are collectively called a constellation. (Ex. 10)

Ex. 10

Constellation

<table>
<thead>
<tr>
<th>[3][8]</th>
<th>[3][11]</th>
</tr>
</thead>
<tbody>
<tr>
<td>basic form</td>
<td>unfolding #1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>[8][11]</th>
<th>[3][5]</th>
</tr>
</thead>
<tbody>
<tr>
<td>unfolding #2</td>
<td>infolding</td>
</tr>
</tbody>
</table>

Bernard provides the following mathematical formulae of the folding operations to derive the first-order derivatives from a basic form.7 (Ex. 11) The formulae produce, however, the trichord forms themselves rather than pitch representations of trichords that resulted from the folding operations

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7Bernard, p. 75.
performed above. In the formulae, $X$ is the outer pitch of a trichord that forms the smaller interval with the middle pitch of the trichord. $Y$ is the middle pitch of the trichord, and $Z$ is the outer pitch that forms the larger interval with the middle pitch. $[XY]$ is the interval (i.e. number of half-steps) between pitch $X$ and pitch $Y$; $[YZ]$ is the interval between pitch $Y$ and pitch $Z$; and so forth.

Ex. 11

basic form: $[XY], [YZ]$ (where $[XY]$ is always $< [YZ]$)

unfolding #1: $[XY], [XZ]$ (where $[XY]$ is the interval between $X$ and $Y$ and $[XZ]$ is the interval between $X$ and $Z$)

unfolding #2: $[YZ], [XZ]$

infolding: $[[YZ]-[XY]], [XY]$ if $[[YZ]-[XY]] < [XY]$

or

$[XY], [[YZ]-[XY]]$ if $[[YZ]-[XY]] > [XY]$

The either/or of the infolding formula is necessary to result in a correctly ordered label (i.e. with the smallest interval first).

trichord [3][5] produced using the formulae to be labelled correctly according to Bernard's strictures. The mathematical formulae generate the same constellation as the rotations of pitches.

Constellations can then be additionally related to each other by what Bernard calls intersections and second-order derivatives. Intersection occurs where two different constellations share at least one first-order derivative. If we consider the two basic forms [3][8] and [5][8] and their constellations (see Ex. 12), we find that they both contain the trichord [3][5] as a first-order derivative.

Ex. 12

<table>
<thead>
<tr>
<th>Basic form:</th>
<th>[3][8]</th>
<th>[5][8]</th>
<th>[3][5]</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-order</td>
<td>[3][5]</td>
<td>[3][5]</td>
<td>[3][8]</td>
</tr>
<tr>
<td>derivatives:</td>
<td>[3][11]</td>
<td>[5][13]</td>
<td>[5][8]</td>
</tr>
<tr>
<td></td>
<td>[8][11]</td>
<td>[8][13]</td>
<td>[2][3]</td>
</tr>
</tbody>
</table>

Thus, there is an intersection between the constellation of trichords [3][8] and [5][8]. If a first-order derivative belongs to a constellation whose basic form is a first-order derivative of another trichord, then it is a second-order derivative of the basic form of the second trichord. Thus, in the three constellations in Ex. 12, [2][3] is a second-order derivatives of both [3][8] and [5][8] since it is a first-order derivative of [3][5] and [3][5] is a first-order derivative of [3][8] and [5][8].

In his analyses, Bernard restricts most of his segmentations to trichords. Dyads, although useful for examining Varèse's spatial environment, are so all-inclusive that to utilize them to delineate the internal structure would result in "...a tangle of 'relationships' verging upon

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8See Bernard, pp. 97-98.
incoherence." So, there would be so many relationships and contexts that it is unlikely that any single dyad (or even a small, manageable group of dyads) would emerge as being of prime importance. The use of trichords, however, permits the definition of spatial configurations — arrangements of intervals in the musical space — as well as demonstrating relationships with only the few relatively simple operations as described above. Bernard mentions the possibility of using larger collections than trichords, but their use would geometrically increase the number of connections between sets to a point where the complexities of such a system would far outweigh the possible benefits. Indeed, with a collection of pitches as small as a tetrachord, the number of first-order derivatives increases from a trichordal constellation of three plus the basic form, to a tetrachordal constellation of twelve distinct tetrachordal forms plus the basic form. The situation would only grow even more unusable with even larger collections, since with each additional pitch in the collection there would be even more possibilities for unfolding and infolding. There does not seem to be any further benefit for the purposes of analysis to exploring this vein of larger and larger collections. Thus, a trichordal division is, for Bernard’s purpose of analysis, the only practicable one, and comes from "...the unique characteristics of groups of three in a spatial context, not upon any empirically observed preference on Varèse’s part for sound masses, or even subdivisions of masses, made up of three notes." 

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9p. 73
10pp. 77-8.
11p. 77.
Bernard’s analytic techniques provide insight into how Varèse’s music evolves, how Varèse expands and contracts chords and moves pitch events — chords or merely individual notes — within the musical space. His chief concern is with the movements of these events rather than with the specific pitches that make up the sonorities he uses or any pitch hierarchy that could provide harmonic form and structure. Composers who are interested in this type of spatial interactions can avail themselves of the relationships that Bernard’s techniques create directly, without any modification of his methods. By shifting the focus away from spatial movements to pitch movements, however, pitches, pitch-classes, and interval-classes can be generated after some modification to these techniques. The above techniques and their application to pitch-class collections open up new avenues to the composer.

Bernard’s constellation is only a starting point for the composer who is interested in generating pitches rather than intervals by rotation. Shifting attention away from the intervals of a trichord to the pitches of a trichord allows a freer interpretation of Bernard’s methods, but it also complicates matters some. Since it is now important what the pitches of a trichord are,
his labelling convention whereby the smallest interval was listed first becomes less useful. There is now a difference between the four trichords that Bernard labels [3] [8] in example 2. One contains the pitches F4, Ab4, and E5, while the other contains the pitches F4, C#4, and E5. They are not the same collection of pitches even though they are the same collection of intervals in his spatial view. Because the same rotational technique is used in the generation of pitches, the denial of pitch-class and interval-class equivalence is followed in the operation, but only as far as the folding itself. Once pitches have been generated by rotation, the composer will, naturally, move them to whatever octave is most musically suitable. Pitch- and interval-class equivalence becomes practical in the compositional process. Since intervals are still important for the folding techniques that are used, the convention of identifying pitch collection forms by their interval content will still be used. The intervals, however, will now be registrally ordered, labelling the lowest interval first. To distinguish between the two labelling systems, curly brackets will be used for registrally ordered intervals. Thus example 3 would now contain the trichords {3} [8] and [8] {3}.

Concern with the registral ordering of pitch now allows the techniques that were not used to construct Bernard’s constellation, namely the second infolding and the two outfoldings, to be used. Thus, all of the trichords produced in examples 4 - 9 are available to the composer. This expanded compositional constellation of the trichord {3} [8] would now consist of the basic form and six first-order derivatives. (Ex. 13)

---

1In making any reference to Bernard’s usage, his manner of labelling will be used.
Ex. 13

Expanded Constellation

{3}{8}

basic form

unfolding #1

{3}{5}

infolding #1

[8]{11}

outfolding #1

{3}{5}

unfolding #2

{5}{3}

infolding #2

{11}{3}

outfolding #2

Ex. 14

basic form: {XY},{YZ}

unfolding #1: {XY}, {XZ}

unfolding #2: {YZ}, {XZ}

infolding #1: {XY}, [{YZ}-{XY}] if {XY} < {YZ}

or

{YZ}, [{XY}-{YZ}] if {XY} > {YZ}

infolding #2: [{YZ}-{XY}], {XY} if {XY} < {YZ}

or

[{XY}-{YZ}], {YZ} if {XY} > {YZ}

outfolding #1:{YZ}, {XZ}

outfolding #2:{XZ}, {XY}

^Note the analogous either/or in Bernard's infolding formula.
The formulae for producing first-order derivatives need to be similarly expanded. Formulae for outfoldings need to be derived and the formulae for infoldings need to be altered due to the new intervallic ordering. There is no longer any need for the ordering qualification to the representation of the basic form. The formulae for the two unfoldings remain the same. (Ex. 14)

Folding pitches of a tetrachord is slightly more complex than that of a trichord, but the procedures are basically the same. Let us examine these technique's application to a tetrachord first within a spatial context such as Bernard's, and then within a freer, compositional context. Starting with a basic form tetrachord [1][2][5] consisting of the pitches Bb4, B4, E5 and F#5 (Ex. 15) we begin by performing the unfolding technique on the inner pitches.

**Ex. 15**

![Ex. 15]

[1][2][5]

Rotating B4 around Bb4 results in A4 which produces tetrachord [1][2][6]. (Ex. 16)

**Ex. 16**

Unfolding #1

![Unfolding #1]
Unfolding B4 around the other outer pitch, F#5, produces C#6, generating the tetrachord [2][6][7]. (Ex. 17)

Because there are now four pitches instead of three, there now exists a further unfolding possibility of rotating one middle pitch around the other. We can now fold B4 around E5 to produce A5 and the tetrachord [2][3][6]. (Ex. 18)

These three different unfolding possibilities can now be applied to the second inner pitch, E5. These three foldings produce tetrachords [1][6][7], [1][2][7] and [2][4][7]. (Exs. 19, 20, and 21)
The infolding techniques are similarly expanded because of the nature of the larger collection. Each outer pitch can be rotated around both of the middle pitches. Beginning with Bb4, folding it around B4 results in C5 and the tetrachord [1][2][4]. (Ex. 22)

Infolding Bb4 around E5 produces Bb5, an identical pitch-class but a different pitch because of its registral change, a change that is important to a spatial outlook. The tetrachord thus generated is [2][5][6], showing the difference produced by the registral shift from the basic form [1][2][5]. (Ex. 23)
Rotating F#5 around E5 produces D5, resulting in tetrachord [1][2][3]. (Ex. 24)

Infolding F#5 around B4 gives us E3 and the tetrachord [1][5][6]. (Ex. 25)

As in the tetrachord generated by the second unfolding of E5 above, we have generated a pitch duplicating another pitch in the same tetrachord an octave away — F#4 and F#5 in tetrachord [2][4][7] and E4 and E5 in tetrachord [1][5][6]. Again, since it is Bernard’s spatial application we are examining, this duplication of pitch-classes holds no significance. The pitches are, for now, merely representations of tetrachord forms.
Since there can only be two outer pitches no matter how big the collection, there can only be two remaining outfoldings. Rotating Bb4 around F#5 produces D6 and tetrachord [2][5][8] and outfolding F#5 around Bb4 likewise produces D4 and tetrachord [1][5][8]. (Exs. 26 and 27)

Ex. 26
Outfolding #1

[1][2][5] [2][5][8]

Ex. 27
Outfolding #2

[1][2][5] [1][5][8]

If we take the tetrachords that were generated above and examine their pitch-class content, rather than the spatial interval content that Bernard was concerned with, we find a new series of relationships. Forte’s method of classification produces a group of pitch-class sets that can be reduced to only a small group of prime forms.3 This is in sharp contrast to the number of different tetrachord forms under Bernard’s system that the folding operations produced. The following chart lists the tetrachordal constellation that was generated above and its classification in both Bernard’s and Forte’s system along with the set’s prime form. (Ex. 28)

---

Looking at Forte's classification of the tetrachords we find only five different set forms — 4-11, 4-Z15, 4-16, 4-22, and 4-27 (including their subsets such as 3-4 and 3-5) — generated in this constellation as opposed to the thirteen different forms engendered by Bernard's classification. The frequency of occurrence of sets 4-Z15 and 4-16 suggests establishing, in a composition, a pitch hierarchy around those two sets. 4-16, the basic tetrachord form from which the other tetrachords were derived, might be used as some sort of 'tonic', while 4-Z15 might be used as a 'dominant' to 4-16.
What concerns and interests the author as a composer is that these related collections of pitch-classes were generated in a fairly simple, logical fashion; all the sets grew from just one original set, allowing an organic basis for a composer's music. The collections are derived from an initial collection, not merely associated with it. The folding operations are performed on a registrally ordered collection of pitches, but the resultant pitches can then be moved to whichever octave the composer feels would be musically suitable, and in that sense are treated as pitch-classes. There is an intervallic relationship as well as a pitch-class relationship between collections generated using these folding techniques, and both of these relationships may be exploited by the composer. Of course, the further a pitch is relocated from its original octave (after folding) the less clear the intervallic relationship with the original set will be.

The unified nature of the constellation, as we have so far explored it, comes about partly from only one pitch being manipulated at a time. In a tetrachord, for example, there are always three common pitches between a set and the collection from which it is derived. This idea of common pitches and the idea of gradual pitch generation by manipulating one pitch at a time generates its own compositional possibilities. These further possibilities of the folding techniques are revealed when the folding techniques are explored without reference to compact constellations—groups of related sets. A single trichord (or larger collection) may generate a continually evolving line by repeated foldings.
Let us begin with the tetrachord \{1\} \{2\} \{2\} consisting of D5, Eb5, F5, and G5.\(^3\) (Ex. 29)

Ex. 29

\[
\begin{array}{c}
\text{[1][2][2]}
\end{array}
\]

We are now turning our attention towards a more melodic orientation rather than to the creation of individual tetrachord collections. Thus, the pitches of tetrachord \{1\} \{2\} \{2\} in example 29 is shown in temporal order, rather than being ordered from the lowest to the highest pitch. A melodic line can be created out of this initial tetrachord by rotating the pitches in sequence. The first pitch, D5 is rotated around one of the other pitches in the collection to generate the next pitch, continuing the sequence. Since the ordering has changed from the earlier registral orientation, the usefulness of the terms unfolding, infolding, and outfolding are not as beneficial as they have been. It will now be sufficient simply to call all the operations foldings. Folding D5 around G5 generates C6 as the next pitch in the sequence. (Ex. 30)

\(^3\)Bernard viewed trichords containing two of the same interval (e.g. [2][2]) to be a chain of that interval, rather than a trichordal grouping. Tetrachords that have two of the same interval, but not three (as in our example — [1][2][2]), could not be considered a chain, since the interval, obviously, changes. In addition, we are concerned more with the pitch content of the tetrachord here, rather than its intervallic content. Concern with the tetrachord's intervallic content is mostly confined to the foldings that are performed on the tetrachord.
The composer, as before, chooses which pitch of the tetrachord to rotate the initial pitch around. By folding just the first pitch around the axis of any of the other pitches in the tetrachord, an interlocking series of tetrachords is generated. Thus, each pitch of the initial tetrachord is, in turn, transformed.

To continue in the sequence, the composer now folds the first pitch of this generated tetrachord, what was the second pitch in the initial tetrachord. G5, the new first pitch, rotated around Eb5 generates B4, and the tetrachord {1}2}{6}. (Ex. 31)

Ex. 31

Of course, since these foldings are being used as a compositional technique and no longer as an analytical tool, pitches are relocated to whatever octave the composer feels is appropriate. The above tetrachord — {4}{2}{7} — might thus be altered to tetrachord {2}{6}{1} by moving B4 to B5. (Ex. 32)

Ex. 32
Following these same procedures, folding successive first pitches of the successive tetrachords and shifting octaves when musically prudent, produces the following line from tetrachord \{1\}[2][2]. (Ex. 33)

Ex. 33

The foldings, in order from the initial trichord and the produced pitches are: D5 around G5 produces C6; G5 around Eb5 produces B4, which is shifted to B5; Eb5 around C6 produces A6, which is shifted to A5; F5 around A5 produces C#6; C6 around C#6 produces D6; B5 around C#6 produces Eb6; A5 around C#6 produces F6; and C#6 around F6 produces A6. In eight foldings, tetrachord \{1\}[2][2] has been transformed, respectively, to tetrachords \{2\}[2][5], \{2\}[6][1], \{4\}[2][1], \{2\}[1][1], \{2\}[2][1], \{3\}[1][1], \{1\}[1][2], and \{1\}[2][4]. Although the final tetrachord is a first-order derivative (transposed), not all of these tetrachords can be so derived from the original basic form. As in this example, transpositionally related tetrachords can be arrived at by the progressive actions of the folding techniques and a careful conscious use of them. Example 33 is taken from the piano part of the author's *Trio* for violin, cello, and piano. The same

\[\text{Ex. 33} \]

---

4 The first-order derivatives of tetrachord \{1\}[2][2] are (using Bernard's labelling convention): \{1\}[2][3], \{2\}[3][4], \{2\}[3] (with a duplication of G5), \{1\}[2][4], \{1\}[3][4], \{1\}[1][4], \{1\}[1][2], \{1\}[1][2] (with a duplication of Eb5), \{1\}[2][3], \{2\}[2][2] (Bernard would call this collection a chain of \{2\}'s), and \{1\}[2][5]. Note that with this basic form tetrachord, unlike the earlier example (\{1\}[2][5]), there are some tetrachordal forms that reoccur. This further demonstrates the special recurring properties of trichords and the unsystematic, unpredictable nature of tetrachords or other large collections.
Ex. 34

\( \text{mp} \)

\( \text{crescendo} \)

\( f \)
technique of deriving pitch-classes was used throughout the section from which example 33 is taken. A more complete excerpt is provided in example 34.

The tetrachord \{1\}{2}\{2\} brings up another difference between Bernard's analytical approach to collections and the technique of folding and a compositional use of the materials. The outer interval span of the tetrachord \{1\}{2}\{2\} is \[5\].\(^5\) According to Bernard, there is, "...consistent with Varèse's use of space and spatial concepts,...a lower limit on size of forms."\(^6\) Collections occupying a total space of less than \[6\] are not of analytical interest, partly because of their limited spatial occupation and partly because of their inability to travel quickly via rotations through the musical space. They can only move small distances consistent with their small intervals. Bernard terms these limited collections micro-structures and considers them "...static by-product[s] of trichordal form structure."\(^7\) For compositional purposes, (or, indeed for analytical approaches that do not focus on the spatial universe) such a distinction does not need to be made, as Bernard concedes.\(^8\) The same attitude holds true for Bernard's categorization of collections with the same interval content between its

\[^5\] The outer interval span is easily calculated by simply adding together all of the inner intervals. \[1\]+\[2\]+\[2\]=\[5\] This will, of course, work with collections of any cardinality.

\[^6\] Bernard, p. 98.

\[^7\] p. 99. The validity of this statement is questionable in light of a piece such as Density 21.5. The first third of this piece consists almost entirely of such 'micro-structures' and Bernard must make a disclaimer in his analysis (p.217-232) that in this section of the piece, "...trichordal forms play only a secondary role; instead micro-structures serve initially as the important groupings." (p.217) Disallowing micro-structures trichordal status does not seem justified in this context. They are merely different types of trichords that do not need to be segregated.

\[^8\] Bernard, see p. 99.
pitches as chains. They are merely just another type of pitch-class collection for composition.

All the relationships discussed so far have involved the folding of just one pitch of a collection. This simplifies the intervallic relationships between basic forms and their derivatives (whether in a constellation, or a continually expanding line). There are, of course, more choices available when folding more than one pitch of a collection, and this thereby allows the composer much more flexibility in arriving at any particular, desired sonority from any basic form, while still adhering to rotational relationships. Furthermore, the larger the cardinality of the grouping, and the more pitch-classes the composer chooses to derive at one time, the more options become available. Two possible approaches to folding more than one pitch of a collection at a time are herein described. If two pitches are to be folded, both pitches may be folded around any other pitch of the original collection. For example, let us begin with the tetrachord \{1\}{5}\{2\} containing the pitches Bb4, B4, E5 and F#5. (Ex. 35)

Ex. 35

\[
\begin{array}{c}
\{1\} \{5\} \{2\}
\end{array}
\]

Folding B4 around Bb4 produces A4. Simultaneously with this first folding, we also fold E5 around B4 to produce F#4. The tetrachord that is thus generated is \{3\}{1}\{8\} — F#4, A4, Bb4, and F#5. (Ex. 36)
That the two foldings are conceived as occurring simultaneously is important. If the foldings are thought of as occurring in succession, the above example would be impossible; E5 would have no B4 to rotate around since that pitch would already have been transformed to become A4. By imagining simultaneous foldings, it is even possible to fold every pitch in a collection to generate a new pitch-class collection that contains no common pitch-classes with the original. Starting with the trichord collection B4, C5, and D5 — \( \{1\} \{2\} \) — it is possible to produce the trichord Ab4, Bb4, and F5 — \( \{2\} \{7\} \). (Ex. 37)

Rotating B4 around D5 produces F5; rotating C5 around B4 produces Bb4; and rotating D5 around B4 produces Ab4. Looking at these two trichords with the restrictions of Bernard’s theories, there is no spatial connection between them. The newly generated trichord (\( \{2\} \{7\} \)) is neither a first-order derivative nor a second-order derivative of the original (\( \{1\} \{2\} \)). (Ex. 38) There is no intersection between the two trichords. Appropriation of the folding techniques has made a compositional connection between the pitch-classes of the two trichords viable.
Ex. 38

Basic form: [1][2] [2][7]

First-order derivatives: [1][3] [2][9]

The application of these abstract foldings to real music is shown in example 39. This excerpt is taken from the bass clarinet part of the author's *Symphony No. 2: Night Piece*. In mm. 19-21, the bass clarinet uses the pitch-classes generated from the trichords in the manner demonstrated above.

Ex. 39

The other possible approach to multiple foldings involves foldings in sequence, i.e. *not* simultaneously. If we take the tetrachord from example 35 above ({1}{5}{2} — Bb4, B4, E5, and F#5) and rotate B4 around Bb4, as we did previously we produce tetrachord {1}{6}{2} — A4, Bb4, E5, and F#5. (Ex. 40)
Ex. 40

We can now take F#5 and fold it around the newly generated pitch, A4. This generates C4 and the tetrachord \( \{9\}{1}\{6\} \). (Ex. 41)

Ex. 41

As in example 36, there are two common pitches between the two tetrachords, but the C4 in example 41 could only have been generated after A4 had been produced. Note that this procedure is different from the successive foldings performed in example 33. Here there is no musical ordering of the collection and any member of the collection may be folded around any other.

This technique is very useful when one or more pitches are to be held in common throughout a series of generated pitch-class collections (be they tetrachords, trichords, or what have you). A pitch (or pitches) is not folded — does not generate a new pitch — while the other pitches of the collection are folded successively or all at once. The unfolded pitch (or pitches) remains constant throughout successive generated collections. In this way a pitch center may be created.\(^9\) By retaining a particular pitch through

\(^9\)Although the word center might imply some concept of centricity, it is used here simply to denote a structural pitch, analogous to a tonic note (without, of course, that term's harmonic implications).
manifold foldings, moving the other pitches around it, as it were, an importance can be attached to that pitch. This can lead to a progressive motion away from and toward the central pitch, providing the possibility of setting up expectations in the listener and satisfaction when the expectation is realized, while still retaining the generative aspects of these folding techniques.

Example 41 gives an example of this. The excerpt is taken from the opening measures of the author’s *Trio* for violin, cello, and piano. Both of the initial tetrachords in the violin and cello part contain the pitch-class F#. The first tetrachord in the violin part is F#6, E6, Bb4, and B4, tetrachord form [1][2][5]. The first tetrachord in the cello part is F#2, G#2, F3, and D3, tetrachord form [2][3][6]. I decided to use this pitch-class as my focal point and to manipulate only the other pitches two at a time. The second violin tetrachord is generated by folding E6 around B5 and by folding B4 around Bb4 to produce F#3 and A4, respectively. All the pitches in this second tetrachord were then shifted to the musically appropriate octave. The second cello tetrachord was generated in similar fashion. G#2 is rotated around F#2 to produce E2 and F3 is rotated around D3 to produce B2. These pitches were also shifted by an octave.

This procedure was repeated twice more, generated tetrachords that all contained pitch-class F#. Whenever a pitch-class (other than F# of course) could be folded to generated another F#, as in the second violin tetrachord above, that option was taken. By repetition, this pitch-class was

---

10 This is, in fact the same tetrachord form and the same pitch-classes used in Exs. 15-27 and following examples above. To make this connection easier to see, and because of the, at times, large intervals that are used in this example, Bernard’s labels will be used for this example.
established as the focus for this section of the music. Only after I had established the importance of F# did I rotate that pitch to generate another. This created the expectation that F# would return. I then delayed its return until the final tetrachord of this opening phrase, fulfilling the expectation in a kind of cadence.
CHAPTER III
The Generation of Rhythm for Composition

Thus far we have limited our exploration of the possible uses of these folding techniques to the arena of pitch. With some adjustments, however, they may be applied to other aspects in the musical realm such as time. It may be possible, of course, to use these folding techniques similarly to the way that serial operations were applied to aspects such as timbre or dynamics. The numbers that are generated by the folding formulae above could be applied to a numbered series of dynamics or timbres or other codifiable musical aspect. Such aspects, however, do not contain any inherent quantifiable intervals and thus, such an application of the folding techniques would be artificial, at best, and would contain those aspects of serialism that have been objectionable to this author. Only rhythm, after pitch, provides a true, perceivable quality of interval, to the author.

There are two ways to consider the temporal aspect of music for composition, both of which can be manipulated by folding techniques. The first is to approach rhythm by locating the attack points of temporal units, pitches, or other musical events. This is a rhythm of accents, beats, and stresses. The second is to approach rhythm by considering the
duration of events. We shall look at a way that folding techniques can be used with the second approach later. With groupings of attack points, the folding methods used for pitches can be applied with little or no adaptations necessary. One would consider the intervals between attack points in terms of some basic rhythmic unit, and then take the interval values that result from this and use Bernard's formulae quoted above to arrive at the various derivatives. Since we are no longer dealing directly with pitch content, we can no longer talk of trichords, tetrachords, and so on. Instead, these rhythmic collections will be called trirhythms, tetrarhythms, etc., depending on how many rhythmic events the collection contains.

Take the trirhythm \{3\}|{8}\ where an event occurs three rhythmic units after an initial event, and then a third event occurs eight rhythmic units after the second event. For our example, let the rhythmic unit be a quarter note, and the event be a quarter note. The rhythmic collection \{3\}|{8}\ would thus be: (Ex. 43)

\[
\begin{align*}
\text{Ex. 43} \\
\frac{1}{4} & - \frac{1}{4} \ ? \ ? \ \cdot \\
\{3\}|{8}
\end{align*}
\]

Like the compositional approach to pitch collections, rhythmic collections will be labelled by the order that the intervals occur, keeping with the compositional version of the labelling of pitch collections rather than Bernard's. \{3\}|{8}\, above, is different from \{8\}|{3}\; a distinction is made. (Ex. 44)
It is, again, attack points that determine the boundaries of the rhythmic interval, thus the event's duration, in this case the quarter note, is not considered separate from the duration of the rhythmic interval. The event occurs within the duration between one attack point and another. Between the first quarter note's attack point and the second quarter's attack point, there is an interval of three quarter notes. Between the second quarter note's attack point and the third quarter note's attack point there is an interval of eight quarter notes. If the composer is concerned solely with a rhythm of attack points, any event of any duration could serve to demonstrate the attack point. The events could have different durations on each occurrence without losing the relationships, after all, any duration has just one attack point. In addition, the basic rhythmic intervallic unit could be varied from rhythmic collection to rhythmic collection, although it must remain constant within a rhythmic collection if the collection's intervals are to be perceived in the intended proportion. For example, if the basic rhythmic unit for the trirhythm \{3\}{8} was a quarter note for \{3\} and an eighth note for \{8\} the perceived intervals would be equivalent to \{3\} quarter notes and \{4\} quarter notes. (Ex. 45)
If the basic units remains the same through all intervals in a collection, then the intervallic proportions would remain the same no matter how much time each collection occupied. Relative relationships between collections would remain valid.

A rhythmic constellation is similar to the expanded pitch constellation that was noted above. A rhythmic constellation of attack points consists of two unfoldings, two infoldings, and two outfoldings. The folding formulae for rhythmic collections is the same as the formulae for the expanded pitch constellation given in example 14, above. A rhythmic constellation is similarly a basic form and its six first-order derivatives.

Applying these foldings to trirhym {3}{8} (Ex. 43 above) will demonstrate the techniques in a rhythmic application. Unfolding the second event around the first produces trirhym {3}{11}. (Ex. 46)

Ex. 46

Unfolding #1

\[
\begin{array}{cccccccc}
\cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\
\{3\}&{8} & | & {3}\cdot{11}
\end{array}
\]

The second unfolding (that of rotating the second event around the third event) produces trirhym {11}{8}. (Ex. 47)

Ex. 47

Unfolding #2

\[
\begin{array}{cccccccc}
\cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\
{3}\cdot{8} & | & {11}\cdot{8}
\end{array}
\]
Infolding the first event around the second will produce trirhythm \{3\}{5}, and infolding the third event around the second will produce \{5\}{3}. (Exs. 48 & 49)

Ex. 48
Infolding #1
\[ \begin{array}{c|c|c}
\text{J} & \text{J} & \text{J} \\
\hline
\text{J} & \text{J} & \text{J} \\
\end{array} \]
\{3\}{8} \quad \{3\}{5}

Ex. 49
Infolding #2
\[ \begin{array}{c|c|c}
\text{J} & \text{J} & \text{J} \\
\hline
\text{J} & \text{J} & \text{J} \\
\end{array} \]
\{3\}{8} \quad \{5\}{3}

Outfolding number one, rotating the first event around the third will produce trirhythm \{8\}{11}. (Ex. 50) Finally, the second outfolding, rotating the third event around the first, will produce trirhythm \{11\}{8}. (Ex. 51)

Ex. 50
Outfolding #1
\[ \begin{array}{c|c|c}
\text{J} & \text{J} & \text{J} \\
\hline
\text{J} & \text{J} & \text{J} \\
\end{array} \]
\{3\}{8} \quad \{8\}{11}

Ex. 51
Outfolding #2
\[ \begin{array}{c|c|c}
\text{J} & \text{J} & \text{J} \\
\hline
\text{J} & \text{J} & \text{J} \\
\end{array} \]
\{3\}{8} \quad \{11\}{3}
The rhythmic folding techniques and formulae would naturally apply to both a constellational usage of rhythmic collections as well as a continually expanding rhythmic series akin to that demonstrated with pitches in examples 29-32.

The other way to consider the temporal aspect of music for composition is in rhythms of durations, rather than rhythms of attack points. With durations, the entire length of a temporal unit is considered as its rhythm. Example 52 illustrates a durational trirhythm of six, two, and three durational units, where the durational unit is an eighth note. Durational sets will be labelled by the durations of its components within square brackets, thus, the trirhythm in example 52 is [6,2,3].

Ex. 52
\[ \begin{align*}
\cdot & \quad \cdot \quad \cdot \\
[6,2,3]
\end{align*} \]

This fundamental change in the way of looking at rhythm allows durational rhythmic collections to be treated differently from attack point rhythmic collections. In a collection of attack point rhythms, the collection was always considered as a whole. There could be no delay from one attack point to a following attack point within the rhythmic set. Such a pause would lengthen the interval between the two attack points, thereby altering the identity of that collection and destroying any relationships that it had had with other collections. Considering a rhythm of durations, however, allows the possibility of pauses between members of the same rhythmic set. A collection’s identity would be the series of the durations of its members. Thus, example 53 has the same durational
rhythm as example 53 above, even though there are rests separating the members of the durational set.

Ex. 53

\[ \begin{align*}
\text{[6,2,3]} \\
\end{align*} \]

As in the above example, the size of the intervening rests is not relevant and can be variable, although they should not be too large if the composer wishes the individual durations to be perceived as part of the same grouping.

The different nature of a rhythm of durations also requires a different treatment of the folding techniques. There are many possible ways of treating the material, but the following methods are those that the author has found most useful in his compositions. Although there are no intervals between set members to guide the rotations, there is an interval within each member: the member's duration. To work the folding operations on durational collections, the collections are considered without any intervening rests between its component members. After the foldings have been accomplished, composers add whatever pauses between individual durations that are appropriate. Folding durations around one another is now a matter of looking at their various start- and end-points, and moving these along a timeline in relation to the duration which is being folded around. Beginning with the durational trirhythm \([6,2,3]\), the first unfolding is accomplished by rotating the second duration around the first. (Ex. 54) This leaves a gap between what was the first duration and the last duration. The former first duration (6) now expands to fill that gap, which leaves us with a durational trirhythm of \([2,8,3]\).
The second unfolding rotates the second duration around the third duration, generating the durational trirhythm [8,3,2] by having the original first duration, again, fill in the intervening gap. (Ex. 55)

In the case of infoldings, there is no intervening gap to fill, just the opposite. Durations will be shortened by the overlaying of durational values that infolding incurs. Rotating the first duration (6) around the second (2) overlaps the third (3), they can both be seen as starting at the same time. To rectify this situation, the remaining value for the longer duration will be heard as commencing only when the shorter has ended. Thus, this first infolding produces the durational trirhythm [2,3,3]. (Ex. 56)
points of the (originally) first and third durations that occur at the same time. In this case, the longer duration shall be heard as concluding when the shorter duration begins. With our durational trirhythm [6,2,3], this second infolding produces the durational trirhythm [3,3,2]. (Ex. 57)

Ex. 57
Infolding #2

\[
\begin{array}{c|c}
[6,2,3] & [3,3,2] \\
\hline
\cdot \quad \cdot \quad \cdot \\
\cdot \quad \cdot \quad \cdot
\end{array}
\]

The two outfoldings are comparably simple. Folding the first duration around the third merely transfers that duration to last in the grouping, generating, in our example, the durational trirhythm [2,3,6]. (Ex. 58)

Ex. 58
Outfolding #1

\[
\begin{array}{c|c}
[6,2,3] & [2,3,6] \\
\hline
\cdot \quad \cdot \quad \cdot \\
\cdot \quad \cdot \quad \cdot
\end{array}
\]

Folding the third duration around the first similarly transfers it to the beginning of the grouping, generating, in our example, the durational trirhythm [3,6,2]. (Ex. 59)

Ex. 59
Outfolding #2

\[
\begin{array}{c|c}
[6,2,3] & [3,6,2] \\
\hline
\cdot \quad \cdot \quad \cdot \\
\cdot \quad \cdot \quad \cdot
\end{array}
\]

The two outfoldings result merely in a reordering of the durational trirhythm's components.
Since we have looked at rhythm a new way with these durational trirhythms, we must also derive new formulae for mathematically deriving durational constellations. Instead of calculating the foldings using the distance between elements in the collections, the new formulae must manipulate the durational values of the elements themselves. Thus, in a durational trirhythm where the first duration is labelled $a$, the second duration is labelled $b$, and the third duration is labelled $c$, the formulae in Example 60 provide a means of calculating a durational constellation of trirhythms.

Ex. 60

basic form: \([a,b,c]\)

unfolding #1: \([b, a+b, c]\)
unfolding #2: \([a+b, c, b]\)

infolding #1: \([b, c, a-c]\) if \(a > c\)

\[or\]

\([b, a, c-a]\) if \(c > a\)

infolding #2: \([a-c, c, b]\) if \(a > c\)

\[or\]

\([c-a, a, b]\) if \(c > a\)

outfolding #1: \([b,c,a]\)
outfolding #2: \([c,a,b]\)

As with attack point rhythmic collections, continually folding rhythmic sequences could be generated by methods analogous to those outlined in examples 29-33. Durational variation and development could also be
achieved merely by changing the basic rhythmic unit between durational collections.

As previously stated, with a rhythmic constellation of attack points, it is possible for any manner of events to occur at the attack points. With a rhythmic constellation of durations, it is possible to have rests between individual durations of a collection. These treatments make it possible to combine the two types of rhythmic constellations. The members of a durational collection are used as the events of an attack point constellation. If we take the attack point trirhythm from example 43 above, \( \{3\} \{8\} \), and make the basic rhythmic unit a half note then the following collection of attack points results. (Ex. 61)

Ex. 61

\[
\begin{array}{cccccccc}
\text{\ding{192}}&\text{\ding{193}}&\text{\ding{192}}&\text{\ding{193}}&\text{\ding{192}}&\text{\ding{193}}&\text{\ding{192}}&\text{\ding{193}}
\end{array}
\]

\[\{3\}\{8\}\]

We can now place the members of durational trirhythm \([6,2,3]\) from example 52 above at the attack points of trirhythm \(\{3\}\{8\}\). Assume a basic rhythmic unit of an eighth note for trirhythm \([6,2,3]\). This results in the following rhythmic collection. (Ex. 62)

Ex. 62

\[
\begin{array}{cccccccc}
\text{\ding{192}}&\text{\ding{193}}&\text{\ding{192}}&\text{\ding{193}}&\text{\ding{192}}&\text{\ding{193}}&\text{\ding{192}}&\text{\ding{193}}
\end{array}
\]

\[\{3\}\{8\}/[6,2,3]\]

The relationships of both types of rhythms remain clear in this way. The attack points are in the same place as they always were, and the rhythmic durations are also unchanged.
Thus far, the musical examples we have looked at have shown only a localized usage of these techniques. It is possible, and even highly desirable, to apply the relationships that the foldings generate to the larger structuring of a piece. Example 42, above, demonstrates one way in which a center could be developed by selective rotations, although that example is, admittedly, on a relatively small scale. The tonic that it creates applies only to that one section and does not carry throughout the piece.\(^1\) It is certainly no great trial, however, to set up such a focus, or a hierarchy of rotationally related foci, for an entire piece. For example, take the trichord from example 3, [3][8]. Represent this trichord by the pitches F\(_4\), Ab\(_4\), and E\(_5\). (Ex. 63)

\[
\text{Ex. 63}
\]

\[
\begin{figure}
\centering
\includegraphics[width=0.5\textwidth]{example63}
\caption{Ex. 63}
\end{figure}
\]

\([3][8]\)

\footnote{Although the relationship to F\# is exploited during the recapitulation at the close of the piece.}
The first-order derivatives of this particular trichord are the trichord forms [3][11], [8][11], and [3][5] represented by the pitch collections (D4, F4, and E5), (F4, E5, and C6), and (Ab4, B4, and E5), respectively. If we now consider all the pitches generated as pitch-classes, we end up with a collection of pitch-classes that may now be used as centers. The pitch-classes of the basic form — F, Ab, and E — would be primary foci, and the pitch-classes that were derived solely from the first-order derivative trichords — D, C, and B — would be secondary foci.

A similar structural usage can be seen in the final section of the author's Symphony No. 2: Night Piece. Instead of using Bernard's constellation, a larger collection of trichords was created by rotating two pitches of the primary trichord during every transformation. Because this is a relatively large scale use of the rotation techniques, the length of the music needed prohibits quotation here. Refer to measures 365-427 in the score to the symphony.

Ex. 64

The pitches of the basic form of this 'Kenney-constellation' (K-constellation) are Db4, Eb4, and E4 — {2}{1}. (Ex. 64) Each of these pitches was considered a pitch-class to be further treated as a structural center. Each center was taken in turn and the other pitches were folded in every possible way to create a collection of trichords containing that center. For example, if we take Db as the first center we can derive four new
trichords that contain Db. Rotating Eb\textsubscript{4} around E\textsubscript{4} generates F\textsubscript{4} and rotating E\textsubscript{4} around Db\textsubscript{4} generates Bb\textsubscript{3}. (Ex. 65)

Ex. 65

\begin{align*}
\{2\} \{1\} & \quad \{4\} \{3\} \\
\end{align*}

Rotating E\textsubscript{4} around Eb\textsubscript{4} generates D\textsubscript{4} and rotating Eb\textsubscript{4} around Db\textsubscript{4} generates B\textsubscript{3}. (Ex. 66)

Ex. 66

\begin{align*}
\{2\} \{1\} & \quad \{3\} \{1\} \\
\end{align*}

The remaining two trichords result merely from exchanging rotations from the two pairs of rotations above. Rotating Eb\textsubscript{4} around E\textsubscript{4} and rotating E\textsubscript{4} around Eb\textsubscript{4} produce F\textsubscript{4} and D\textsubscript{4}. (Ex. 67)

Ex. 67

\begin{align*}
\{2\} \{1\} & \quad \{1\} \{3\} \\
\end{align*}

Rotating E\textsubscript{4} around Db\textsubscript{4} and rotating Eb\textsubscript{4} around Db\textsubscript{4} produce Bb\textsubscript{3} and B\textsubscript{3}. (Ex. 68)

Ex. 68

\begin{align*}
\{2\} \{1\} & \quad \{1\} \{2\} \\
\end{align*}
Continuing with this example, Eb₄ and E₄ were treated as Db₄ was, generating groups of pitch-class collections. Folding the basic form with Eb₄ as the center produced the pitch-class collections (Eb, D, F), (Eb, Bb, F), (Eb, D, G), and (Eb, Bb, G). (Examples 69-72 in their directly derived trichord forms.)

Ex. 69

\{1\}{2}

Ex. 70

\{5\}{2}

Ex. 71

\{1\}{4}

Ex. 72

\{4\}{5}

Folding the basic form with E₄ as the center produced only three different pitch-class collections (E, F, G), (E, B, G), and (E, B, F). (Ex. 71-3 in their directly derived trichord forms.)
These three groups of pitch-class collections, with centers on Db, Eb, and E, were then treated as key areas, one step removed from the basic form’s pitch-class collection from which everything was derived — Db, Eb, and E. Thus, the music moved away from the basic collection into these derived key areas, using each key area’s pitch collections as the local pitch material. After brief returns to, and subsequent movement away from, the basic collection, the section (and the piece) finally cadences on the basic form’s pitch-class collection.

A constellation of trichords, exactly as posited by Bernard, could itself provide overall harmonic structure. The basic form trichord would be analogous to a tonal I, and the first-order derivatives would be the dominant family to that ‘I’. Note that we are here talking specifically about trichord forms, without specific pitch representation. Thus, ‘I’ could be
transposed to whatever pitches were needed, creating a further possibility of key areas and modulations.

We have seen that attack point rhythmic collections can have any event occurring at their attack points. By using a basic rhythmic unit that is very large, the musical event that occurs on the attack points can be a phrase, or even an entire section of a piece. The large scale proportioning of a piece can thus be governed by rotationally related rhythmic collections. This proportioning could exist on several different levels, from this large scale usage, to the smallest rhythmic gesture. Identical rhythmic relationships could permeate the piece on any level.

The possibilities for large scale organization with various folding techniques are limited only to the composer's imagination. The above examples certainly do not exhaust this rich vein of possibilities. They are simply some of the ones that the author has either used or considered.
CHAPTER V
Conclusion

The techniques outlined above are intended to be used in the creative act of composition. Their starting point was a theoretical system of analysis, but the techniques used in that system have been extended and modified for their use in composition. At times, the compositional usage has shown only a superficial relationship to the analytical system but, like a second-order derivative, the relationships are nevertheless there, albeit remote. The analytical theory was developed by Jonathan Bernard for a very specific purpose. It was intended to help understand the music of just one composer: Edgard Varèse. The techniques that grew out of that theory have proven, however, to be of use to the composer in numerous ways. Admittedly, some of the uses to which the folding techniques have been put have been individual to the author, but the techniques are flexible enough that they can be readily adapted to suit most any need.

As with any collection of compositional techniques, they are not intended to show how to compose. They do not presume they that are the only correct way to compose. They are merely techniques available to the composer who is drawn to the relationships that the techniques create. The techniques are just that: compositional techniques. They are not a system or
a method. They do not, by themselves, provide the means for the creation of a musical composition, they merely provide the composer a means for manipulating two aspects of music: pitch and rhythm. They are used with any degree of strictness or freedom that is musically suitable for the composer. Music is, after all, far more than simply pitches and rhythms. Pitch and rhythm is sometimes not even the most important aspect that gives a piece of music its own identity. Think of all the music that was composed within a similar language and a similar style, namely tonality. While the harmonies, melodies and rhythms may have been similar, the best music always remained individual and unique, regardless of common ground.

The author, while developing these techniques, has experimented with different ways of using the material, and the procedures explored here have proved to be the most useful to him. Other ways of thinking about the material and using the techniques are certainly possible. It remains for each composer to find their own manner of using them. This can be said of any compositional system, of any age. As Schoenberg admonished composers who wished to use his twelve-tone techniques: “Take them and compose as you have always done.”
BIBLIOGRAPHY

