TWELVE-TONE RHYTHMIC STRUCTURE AND ITS APPLICATION TO FORM: TIME-POINT NESTING AND ROTATION IN *SPIN*

by

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ABSTRACT OF THE DISSERTATION

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In the mid-twentieth century, as harmonic aspects of musical composition became increasingly complex and algorithmically structured, composers experimented with equally rigorous methods of determining rhythm. In Europe, "total serialism," a system in which duration is associated with pitch class, was introduced by Olivier Messiaen and later employed by Pierre Boulez. In America, Milton Babbitt experimented with similar duration rows before introducing the seminal "time-point" system, in which durational interval is associated not with pitch class, but with interval class. This shift in thinking allowed rhythmic rows to function isomorphically with their pitch class counterparts, and provided the means for meaningful manipulation of rhythm by the classic twelve-tone operations originated by Arnold Schoenberg, as well as by subsequent transformational methods.

The problem of large-scale structure in serial music is of great concern to Charles Wuorinen, who introduced the concept of using time-point intervals, in a modulus-free

environment, to determine a composition's large-scale dimensions. While Babbitt's structural forms are often amalgamations of durational or time-point rows, and many of Elliott Carter's works are structured on multiple polyrhythms, Wuorinen uses time-point intervals to determine the lengths of large compositional sections, dividing each of these sections similarly, then often producing a composition's surface with still another level of time-point division. This "nesting" approach guarantees motivic self-affinity, from a composition's deep structure to its surface.

By layering two or more strands of multilevel time-point divisions across the length of a composition or movement, a composer can create a rich counterpoint of rhythmic interaction on several temporal scales. Such an approach constitutes an explicit recognition of the notion that rhythm is form in the small, and form is rhythm in the large. *Spin* comprises four similar time-point strands, time-shifted and cyclically arranged to contribute to the overall shape and structure of the composition.

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I am very fortunate to have had four years of private study with Charles Wuorinen, whose uncompromising musical standards will forever be an inspiration. From Wuorinen I have learned to appreciate the difference between art and entertainment—that art demands an active relation with those who perceive it. To this end, an artist must craft his work meticulously, carefully considering the formal, dramatic, and perceptual implications of every compositional aspect. It is this aesthetic that forms the basis for the essay that follows.

Finally, for their unwavering support and encouragement over the course of my academic career, I offer heartfelt thanks to Thomas L. Davis, Rosalia LaBella, and James L. and Angela C. Romig.

TABLE OF CONTENTS

Abstract	ii
Acknowledgments	iv
1. The Duration Row and the Time-Point System	1
2. Form: Olivier Messiaen and Pierre Boulez	15
3. Form: Milton Babbitt and Elliott Carter	23
4. Form: Charles Wuorinen	32
5. *Spin*: Nesting, Rotation, and Deletion	39
6. *Spin*: Transposition Arrays and Modulus Arrays	53
7. *Spin*: Orchestration, Contextual Choice, and Modification	68
8. Toward a Common Practice	77
Appendix 1. *Spin*: Source Strand Sections and Subsections	87
Appendix 2. *Spin*: Graph of Rotated Strands	91
Appendix 3. *Spin*: Transposition Arrays	92
Appendix 4. *Spin*: Modulus Arrays	94
Appendix 5. Milton Babbitt's Report to the Dissertation Committee	96
Bibliography	98
Spin (score)	107
Sonnet (score)	139
Sonnet No. 2 (score)	141
New York Minute (score)	146
Variations for string quartet (score)	147

Twelve-Tone Rhythmic Structure and its Application to Form:
Time-Point Nesting and Rotation in *Spin*

1. The Duration Row and the Time-Point System

In the mid-twentieth century, as harmonic aspects of musical composition became increasingly complex and algorithmically structured, composers experimented with equally rigorous methods of determining rhythm. In Europe, "total serialism," a system in which duration is associated with pitch class, was introduced by Olivier Messiaen and later employed by Pierre Boulez. In America, Milton Babbitt experimented with similar duration rows before introducing the seminal "time-point" system, in which durational interval is associated not with pitch class, but with interval class. This shift in thinking allowed rhythmic rows to function isomorphically with their pitch class counterparts, and provided the means for meaningful manipulation of rhythm by the classic twelve-tone operations originated by Arnold Schoenberg, as well as by subsequent transformational methods.

The problem of large-scale structure in serial music is of great concern to Charles Wuorinen, who introduced the concept of using time-point intervals, in a modulus-free environment, to determine a composition's large-scale dimensions. While Babbitt's structural forms are often amalgamations of duration or time-point rows, and many of

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By layering two or more strands of multilevel time-point divisions across the length of a composition or movement, a composer can create a rich counterpoint of rhythmic interaction on several temporal scales. Such an approach constitutes an explicit recognition of the notion that rhythm is form in the small, and form is rhythm in the large. *Spin*[1]—my quartet for flute, violin, cello, and one percussionist playing both vibraphone and marimba—comprises four related time-point strands, time-shifted and cyclically arranged to contribute to the overall shape and structure of the composition.

* * *

The first attempts to manipulate rhythmic information similarly to pitch information were accomplished with duration rows. These ordered sets of durations were used like scales and combined with pitch rows[2] to create the first multi-serial compositions. Messiaen's *Mode de valeurs et d'intensités*[3] is such a composition, controlling not only rhythm, but dynamics and articulation with serial rows. Robert Sherlaw Johnson, in his

1 New Brunswick, New Jersey: Parallax Music Press, 1999.

2 Throughout this paper, the terms "row" and "series" are used, interchangeably, to describe any specific ordering of the twelve pitch classes. The broader term "set" refers to any unordered collection of (any number of) pitch classes. For a discussion of the term "set," see Allen Forte, *The Structure of Atonal Music* (New Haven and London: Yale University Press, 1973), 1-3. Milton Babbitt, however, uses the term "set" strictly as a synonym for "series."

3 Paris: Durand and Cie, 1950.

book *Messiaen*, provides a succinct explanation of the work's association of pitch and rhythm.

> There are three twelve-note groups or series, each consisting of all the notes of the chromatic scale. Each note is fixed in register, so that the first group covers the upper range of the keyboard…, the second group the middle range…, and the third group the middle to lower ranges…on the piano.…
>
> Each group is assigned a chromatic[4] series of twelve durations—the first group from one to twelve demisemiquavers [thirty-second notes], the second from one to twelve semiquavers [sixteenth notes], and the third from one to twelve quavers [eighth notes]. These durations, in ascending order of value, are assigned to the notes of each group in descending order. The lowest notes of the piano, which have the greatest sustaining power, are therefore the longest, and the highest are the shortest. As some of the durations are invariably common to more than one group (the quaver, for instance, occurs in all three), there are a total of twenty-four different durations.[5]

Johnson is quick to note that *Mode de valeurs* is not truly a serial composition if serial composition is defined as an ordered progression of events (pitch, rhythm, etc.). The musical events in *Mode de valeurs* are not always employed in strict sequential order, but what is significant is that each specific pitch is consistently associated with one, and only one, duration (as well as with one dynamic and one articulation) over the span of the work. In the end, it seems that Messiaen found this compositional plan too limiting, as he never returned to total serialism in subsequent works.

Though Messiaen did not continue composing with the total serialism method, *Mode de valeurs* was a major influence on Pierre Boulez, who adopted and adapted Messiaen's

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4 "Chromatic" is a misleading term; the type of series employed here is better defined as "additive," as the numbers determining the series are simply sequential.

5 Robert Sherlaw Johnson, *Messiaen* (Berkeley and Los Angeles: University of California Press, 1975), 105.

rows of pitch and duration to create *Structures Ia*[6], a seminal composition in the development of isomorphism between rhythm and pitch.

In *Structures Ia*, Boulez employs one row of twelve pitch classes and one row of twelve durations, combining them—as separate elements—to create the composition. Boulez's technique varies from that of Messiaen in that it allows for specific pitch classes to have variable durations over the course of the composition, these durations determined according to how pitch rows and duration rows are combined.[7] For the pitch and rhythm material of *Structures 1a*, Boulez borrows one of the three pitch rows composed by Messiaen for *Mode de valeurs* (0, 11, 6, 5, 4, 3, 1, 10, 9, 7, 2, 8), and one row of durations, ranging consecutively from one to twelve thirty-second notes. Dominique Jameux suggests that "Boulez's use of 'borrowed' material…had the practical advantage of eliminating any subjective or personal factors from his experiment at the outset."[8]

To further insure variation in pitch and rhythm association (which is lacking in Messiaen's *Mode de valeurs*), classic twelve-tone transformations (retrograde, inversion, and retrograde inversion) are employed—on both pitch rows and duration rows—to create three additional basic row forms. To determine the inversion form of the row, Boulez begins on the first pitch of the original form of the row and successively reproduces its intervals in "inverted" form—that is, he reverses the interval's linear direction (up or down). Boulez's methods of deriving retrograde and retrograde inversion forms of the row are self-explanatory.

6 Part 1a of *Structures: premier livre* (London: Universal Edition, 1955).

7 A table that illustrates the combinations of pitch rows and duration rows in *Structures Ia* can be found in Dominique Jameux, *Pierre Boulez*, trans. Susan Bradshaw (London: Faber and Faber, 1991), 275.

8 Jameux, *Ibid.*, 269.

To derive still more rows of pitch information Boulez transposes each of these four basic forms (S,[9] R, I, RI) to each of the twelve chromatic transposition levels.

In the case of rhythm, Boulez does not attempt to transpose but instead rotates[10] the elements of the duration rows, producing twelve different rows, each beginning on the consecutive pitches of the series.[11]

original row	0	e	6	5	4	3	1	t	9	7	2	8
first rotation	e	6	5	4	3	1	t	9	7	2	8	0
second rotation	6	5	4	3	1	t	9	7	2	8	0	e
third rotation	5	4	3	1	t	9	7	2	8	0	e	6
fourth rotation	4	3	1 etc...									

Perhaps Boulez used this system of rotation because he was aware of the problems met when one attempts to transpose duration rows in the classic manner. These difficulties will be discussed later.

By transposing (in the case of pitch) and rotating (in the case of rhythm) each of the four forms to each of the twelve chromatic pitch levels, Boulez has at his disposal forty-eight distinct (but related) rows of pitch and rhythm with which to work. As with Messiaen's first experiment in total serialism, Boulez also employs rows to determine dynamic markings (using a series of twelve dynamics ranging from *pppp* to *ffff* and including "quasi *p*" and "quasi *mf*") and articulations.

9 The symbol 'S' represents the original form of a given row. In this case the 'S' stands for "set," but composers and theorists also regularly use 'O' (for "original") and 'P' (for "prime") to designate this set.

10 Jameux refers to these rotations as "transpositions."

11 Ernst Krenek writes extensively about the process of rotation—both in *Structures Ia* and in his own works—in the article "Extents and Limits of Serial Techniques" originally published in *The Musical Quarterly* 46 (1960): 208–230; entire volume reprinted as *Problems of Modern Music*, ed. Paul Henry Lang (New York: W.W. Norton, 1960).

Both *Mode de valeurs* and *Structures 1a* are relatively short works. Though the serial systems that inform the compositions are complicated, they do not specifically address questions of large-scale form. Each composer approaches form differently, and these formal aspects will be addressed later.

In America, Milton Babbitt had a similar interest in rows of duration, and first used the duration row in his *Three Compositions for Piano*,[12] a work that predates Messiaen's *Mode de valeurs* by two years. Instead of using a series of twelve durations, Babbitt employs a duration row of four elements (5, 1, 4, 2) to create the surface-level rhythms of the piece. To determine the inversion form of this row, Babbitt subtracts each number from six (inversion equals complementation mod 6). The retrograde and retrograde inversion forms are self-explanatory.

form	durations
P	5 1 4 2
R	2 4 1 5
I	1 5 2 4
RI	4 2 5 1

Note that in all four forms of Babbitt's duration row, the first and second pairs of numbers total six. This is significant, as it divides the total span of the duration row (twelve beat units) into equal halves, and these halves remain consistent under all transformations. Note also that these pairs of numbers consistently reverse order under inversion (P to I, R to RI).

To apply the duration rows to the surface of his composition, Babbitt created four "attack sets," in which each of the four forms of the row is used differently to produce rhythm.

12 Hillsdale, New York: Boelke-Bomart, 1957.

attack set	location	characteristics
P (5 1 4 2)	mm. 1–2	groups of 16th notes separated by longer notes
RI (4 2 5 1)	m. 10	even 16th notes phrased in groups
I (1 5 2 4)	m. 11	chords articulated at time-points
R (2 4 1 5)	m. 41	staccato chords articulated at time-points

In attack set P, Babbitt creates groups of sixteenth-note attacks (the number of which reflect the numbers of the P duration row: 5, 1, 4, 2) separated with a space created either by an elongation of the last note of a sixteenth-note group, or by adding a rest. These spaces between sixteenth-note groups, though, are not of consistent length. After the first five sixteenth notes (representing the duration of 5), there is a space of four sixteenths before the next attack: a single sixteenth note representing the duration of 1. But after this single sixteenth note, there is a space of only two sixteenths before the next group: four sixteenth notes representing the duration of 4. There are four sixteenths of space separating these four sixteenth notes from the final two, and a duration of two sixteenths after that. It is noteworthy that this seems to be a fairly arbitrary way of representing the duration row: though each group is heard as a distinct number of attacks, there is no obvious representation of the durations of the set (5, 1, 4, 2). It is curious that Babbitt arranged these groups of attacks as he did: had he included one extra sixteenth of space in between the iterations of 5 and 1, and had he removed a sixteenth note of space between the iterations of 1 and 4, the total duration of each group of attacks would correspond exactly to the ratio of 5, 1, 4, 2. That is, each group of sixteenth notes followed by its associated space (in the form of an elongated note or a rest) would correspond to the 5, 1, 4, 2 proportion: 10, 2, 8, and 4 sixteenth notes.

Attack set RI is a better representation of its durations, as the accent that the pianist will naturally apply to the first note of each phrase-group will articulate durations nicely.

Attack sets I and R are represented by chords set at time intervals that reflect the duration rows. In both sets, each duration of the row is represented by an equivalent number of sixteenth notes holding that amount of musical space before the next chord is iterated. The only difference between attack sets I and R (apart from their two distinct sets of durations—1, 5, 2, 4; and 2, 4, 1, 5, respectively) is that the chords of attack set I are sustained (until the next attack) and the chords of attack set R are played staccato and separated by the appropriate number of sixteenth rests. The methods of determining attack sets I and R foreshadow those used in the time-point system, which will be discussed later.

Babbitt's *Composition for Four Instruments*[13] is another work that uses a row of four durations: 1, 4, 3, 2. As in the *Three Compositions*, Babbitt employs the classic forms of this row, this time using five as the modulus from which to determine inversion (complementation mod 5).

form	durations
P	1 4 3 2
R	2 3 4 1
I	4 1 2 3
RI	3 2 1 4

The duration rows produced here are similar to those of *Three Compositions for Piano* in that the first and second pairs always total the same number (five, in this case) and this number is half of the total durational span. Again, pairs of durations reverse order under inversion.

In his String Quartet No. 2,[14] Babbitt utilizes a duration row of twelve events, derived from the work's pitch row by simply associating pitch-class numerals with duration.[15]

13 New York: Theodore Presser, 1948.
14 New York: Associated Music Publishers, 1967.

As with the four-note duration rows discussed previously, Babbitt has chosen a row for String Quartet No. 2 that divides evenly into two halves, each with the same total duration (thirty-nine): 11, 2, 10, 3, 12, 1 and 7, 9, 4, 8, 6, 5.

The problem with duration rows is that though they seem similar to pitch rows expressed by the same numeric notation, they do not function the same way when transformed by classic twelve-tone operations. Even transposition, a seemingly simple transformation, creates significant problems. When a row of pitches is transposed, intervallic relationships stay the same. This is why a given melody is instantly recognizable at any pitch level: it is the intervals between the pitches, not the pitches themselves that we remember. Transposition of pitch is traditionally thought of as a process by which musical information—melodic or harmonic—is moved up or down by a set amount, preserving musical contour. The process of transposition as defined in twelve-tone theory, however, is a considerably more abstract concept that does not take contour-preservation into account. Described mathematically, the more abstract definition of transposition comprises a simple process of addition: transposition adds, to each note of a series, a constant number of half steps (corresponding to the desired level of transposition) and this calculation is done mod 12 to account for octave-equivalence. Considering the preceding definition, it is apparent that transposition of a twelve-tone row does not take anything other than pitch class into account. Melodic contour—whether a pitch class progresses up or down to the next pitch class of the

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[15] This technique is also employed by Karlheinz Stockhausen in *Kreuzspiel* (London: Universal Edition, 1960), in which the initial rhythmic line in the tumba drums explicates the composition's row: a steady stream of sixteenth-note triplets is divided between high and low drums, with the higher of the two articulating the duration row and the lower drum filling in the spaces. The row—2, 8, 7, 4, 11, 1, 12, 3, 9, 6, 5, 10—is articulated starting in measure 1 and ending in the middle of measure 7. Note, though, that after the row has been sounded once in the tumbas, the role of these instruments changes. No longer articulating a duration row, the drums begin a progression that runs through a different duration row: a simple progression from one to twelve.

row—is not part of the definition. This is precisely why transposition, described as an arithmetic operation, provides no isomorphic relation between rhythm and pitch: in the realm of rhythm, "transposition" produces a shifting rotation of duration.

The process of inversion, when applied to the rhythmic domain, proves to be a thorny problem as well. In the domain of pitch, the built-in modulus (the octave) allows for inversion: a pitch's inversion is found by "subtracting" it from the octave (obtaining its complement, mod 12). In the case of rhythm, inversion is only feasible if an artificial modulus (usually twelve) is employed. It makes perfect sense that the interval of a minor sixth and the interval of a major third are inversionally related: when measured in an ascending direction, there are eight half steps (a minor sixth) in the interval formed between B natural and G natural. When the same two pitch classes are measured in a descending direction, the interval formed contains four half steps (a major third). The two intervals—found by measuring both the ascending and descending intervallic distances between the two pitches—add together to form the octave. In what way, though, is a half note (eight sixteenth notes) the inversion of a quarter note (four sixteenth notes)? Though the two durations concatenate to form the modulus, the modulus itself is insignificant. What is meaningful in the realm of pitch (a major third and a minor sixth—or any pair of inversional equivalents—will always form an octave when added together) is quite trivial in the realm of rhythm.

The problems of transposition and inversion are avoided in Babbitt's early compositions, in which duration rows are transformed differently from pitch rows. In the *Composition for Four Instruments*, for example, there is no transposition (by any means) of the duration rows, and the inversion of duration rows is determined by a modulus (five)—distinct from and independent of the pitch modulus—chosen to serve specific structural and aesthetic purposes.

Still, Babbitt wished to compose works with a more meaningful association of rhythm and pitch, and he discovered the method to do so in the time-point system.

* * *

The time-point system is described—primarily as a means for determining rhythm in electronic composition—in Babbitt's article "Twelve-Tone Rhythmic Structure and the Electronic Medium."[16] In this article, Babbitt lays the groundwork for the time-point system, in which ordered progressions of durations are derived not from pitch class (as is the case with duration rows), but rather from interval class. In his article, Babbitt outlines the problem.

> The construction of a quantitative temporal system by interpreting pitch numbers as temporal values, since order numbers themselves are "ordinal" temporal values, and thus constructing a "twelve-tone rhythmic system" can be viewed either as a reinterpretation of pitch numbers so as to assure isomorphism between the two systems, or as assigning temporal interpretations to the uninterpreted terms of the finite numerical equal difference structure of which both the pitch and rhythmic systems will be exemplifications. It seems reasonable to require, in the light of the preceding discussion, that such an interpretation satisfy a number of general conditions. It must not reduce the possibilities or range of applicability of such qualitative temporal characteristics as those discussed above; it should provide only a substitution for the relation of precedence and antecedence of a relation of measured precedence and antecedence. It must interpret the entire extensional meaning of pitch-class numbers and those concepts which are formulated in terms of pitch-class numbers. It must provide for such concepts being endowed with an interpretation tenable in terms of musical perception, so that the system so constructed will be autonomously closed, not merely by formal analogy with the pitch-classes, so that the totality of, at most, 48 temporally founded sets which can be formed from a given set will be justifiably separable from the 12! permutations of the temporal equivalents of pitch-class numbers, and so

16 In *Perspectives of New Music* 1/1 (1962): 49–79; reprinted in *Perspectives on Contemporary Music Theory*, ed. Benjamin Boretz and Edwin Cone (New York: W.W. Norton, 1972), 148–79.

> that the invariants associated with the transformations of the pitch system will have independent analogs in the temporal system.[17]

And, finally, the problem's solution:

> To this end, since duration is a measure of distance between time points, as interval is a measure of distance between pitch points, we begin by interpreting interval as duration. Then, pitch number is interpretable as the point of initiation of a temporal event, that is, as a time-point number. If this number is to be further interpretable as a representative of an equivalent class of time points and the durational interval with regard to the first such element, it is necessary merely to imbed it in a metrical unit, a measure in the usual metrical sense, so that a recurrence of a succession of time-points is achieved, while the notion of meter is made an essential part of the systematic structure.[18]

Note that the time-point system, like time itself, employs durational intervals derived from pitch interval in one direction only: forward. To represent this fact musically, time-point intervals are always measured between pitches—whether notated on a staff or by pitch-class numbers—in an ascending direction. For example, an ascending semitone of pitch is made equivalent to one durational unit in the time-point system, while a descending half-step is made equivalent to eleven durational units (representing eleven ascending semitones). This is necessary to allow for octave-equivalence in pitch-class notation, in which a pitch class represents any and all possible locations of that pitch class on the pitch continuum. Therefore, the time-point interval between, say, C sharp and A natural is always eight, whether ascending or descending. Note, though, the primacy of ordering in the time-point system: if the order of these pitches—C sharp and A natural—is reversed, the resulting ordering of the pair of pitches—A natural and C sharp—will always form a time-point interval of four, whether ascending or descending.

17 Babbitt, *Ibid.*, 61.

18 Babbitt, *Ibid.*, 63.

Babbitt's article goes on to explain that time-point rows need not necessarily be associated with the pitch rows from which they are derived, and that time-point rows can even be applied to other aspects of composition.

> It must not be inferred that this time-point system merely because it is equivalent to the twelve-tone pitch system, and for purposes of explanatory simplicity has been described by analogical reference to the pitch system, implies a one-to-one compositional application of the two systems. The rhythmic system is closed, and as its structure is independent of pitch clarification, it can be applied as independently as the pitch system. Thus, a time-point of a set can represent the point of initiation of a single pitch, the repetition of a pitch, or a pitch simultanaeity, but it can fulfill also this function with regard to timbre, register, dynamic level, etc. Indeed, it is the polyphonic structure, not the simple coordination, between the pitch system and the time-point system that the formulation of this latter makes most valuable, and the structured rhythmic counterpoint of these dimensions is a question of compositional applications, and is a subject for, at least, another article.[19]

One such "article" is Charles Wuorinen's book, *Simple Composition,*[20] in which Wuorinen outlines a complete system of composition based on time-point principles. In Wuorinen's description of the time-point system, he stresses a significant difference in his approach as compared to Babbitt's. Wuorinen notes that rhythm has no intrinsic modular unit equivalent to the octave. Babbitt deals with this situation by asserting a constant temporal modulus (for instance: the musical examples provided in "Twelve Tone Rhythmic Structure…" are consistently in 6/8 time, with the sixteenth note equal to one time-point unit). Wuorinen recommends a more flexible approach.

> As we attempt to transfer characteristics of the pitch system into time-organizing terms, we therefore will have to impose an "artificial" modular division scheme on the flow of musical time. But since this imposition is special to every particular work, rather than general and independent (the way the pitch octave is), questions about its size, the number of its

19 Babbitt, *Ibid.*, 71–72.

20 New York: Longman, 1979; reprinted New York: C.F. Peters, 1979.

> internal intervallic divisions, and even whether it should be constant in magnitude, are all open, contextual, and subject to local transformation.
>
> To effect our relational transfer, then, we have to assert a modulus for the flow of time, to correspond to the pitch octave. The most obvious way to do this (and the one followed by Babbitt in his development of the system) is to select a modulus (therefore of constant size), divided internally into twelve equal parts. Then the time continuum will be divided intervallically mod 12 just as is the pitch continuum and the twelve internal divisions of the time modulus will therefore make up twelve time-point classes, which can be correlated 1:1 with the twelve pitch classes. But always bear in mind that while the mod 12 pitch system is external, in Western music, to the specific piece, the temporal modulus is a "personal" choice—and its justification is logic and convenience, not convention and tradition. Even within this framework, moreover, time points could be nicely represented mod 6, mod 4, or mod 3, and still make all the relational transfers we have been anticipating take place without difficulty. Indeed, the time-point system is often used this way.[21]

Simple Composition, in addition to being a clarification and expansion of time-point principles, discusses the application of time-point theory to large-scale structure, and it is this aspect of the work that is most important to the discussion of form presented here. Before examining Wuorinen's, and then my own, application of twelve-tone rhythmic structure to large-scale form, a brief look at the structures of early examples of total serialism will show the significance of Wuorinen's contributions.

21 Wuorinen, *Ibid.*, 132–133.

2. Form: Olivier Messiaen and Pierre Boulez

In his article *Schoenberg is Dead,*[22] Pierre Boulez criticizes the inventor of the twelve-tone system for not fully realizing the implications of the row and for using it only as a highly chromatic theme to be forced into musical forms of the past, ignoring the possibility of the row being used on a structural level.

> What, then, was his ambition, once the chromatic synthesis has been established through the series, or in other words, once this coefficient of security had been adopted? To construct works of the same essence as that of those in the sound-universe he had just left behind, works in which the new technique of writing should "prove its worth." But could that new technique produce convincing results if one did not take the trouble to explore the specifically serial domain in the structures? And I understand the word "structure" as extending from the generation of the constituent elements to the total architecture of a work. In short, a logic of engendering between the serial forms, properly speaking, and the derived structures was generally absent from Schoenberg's preoccupations.
>
> And there, it seems, you have what led to the decrepitude of the larger part of his serial *oeuvre*. The preclassic or classic forms ruling most of the architectures have no historic link to the dodecaphonic discovery; thus an inadmissible hiatus is produced between infrastructures related to the tonal phenomenon and a language in which one again perceives the laws of organization summarily. Not only does the proposed project run aground—such a language was not consolidated by such architectures—but also the opposite happens, which is to say that those architectures annihilate the possibilities of organization inherent in the new language. The two worlds are incompatible, and Schoenberg had attempted to justify one by the other.

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22 In *Réleves d'apprenti*, ed. Paul Thévenin (Paris: Le Seuil, 1966); published in English as *Notes of an Apprenticeship*, trans. Herbert Weinstock (New York: Alfred A. Knopf, 1968).

> One cannot call that procedure valid, and it produced results that could have been anticipated: the worst sort of misunderstanding.[23]

Boulez is not alone in noting that Schoenberg's attempts to fit twelve-tone ideas into classic forms did not usually pan out. Both Boulez and Messiaen, in their serial works, avoided the classic archetypes used by Schoenberg, and it is interesting to examine the form of Messiaen's *Mode de valeurs et d'intensités* and Boulez's *Structures 1a*, both early examples of compositions utilizing duration rows. It is also significant to realize that for each composer, these works constituted a *ne plus ultra* of serial organization, and that both men relaxed their methods in subsequent compositions.

As mentioned, *Mode de valeurs* is technically not a serial composition, if serial music is defined as music in which ordered sets of pitches remain constant. What remains constant in Messiaen's piece are the durations, dynamics, and articulations associated with the specific pitches (that is, discrete pitches—not merely pitch classes). These durations, dynamics, and articulations are fixed for the entire composition, but pitch order is chosen intuitively by the composer: rows, and sections of rows, are freely mixed. Johnson summarizes:

> …in *Mode de valeurs*, the parameters of each note are fixed and its order in relation to the other notes is free. Any number of notes, from two to twelve, can be selected from each of the three groups which comprise the mode, before repetitions occur. Only the traditional serial limitation against the simultaneous sounding of the same note in different octaves is preserved, and this is necessary in order to maintain the homogeneity of the three-part texture.
>
> There is no trace of sectional form, which is so characteristic of Messiaen's other work, and there is no thematic working. Some note-patterns do tend to recur, however, especially descending sequences of different lengths from the top note of each series: this is common to all three strands. At eight points in the composition all twelve notes of one of the three groups appear in succession, but in only one part at a time. The notes of each group are permutated in a type of symmetrical order at

23 Boulez, *Ibid.*, 272.

> each appearance, but in three cases the symmetry is slightly disturbed, apparently in order to avoid sounding a note at the same time as another part.[24]

Despite the practice of avoiding pitch repetition, the resulting composition has a statistical quality, and would likely not sustain interest were it to go on much further. With no changes in tessitura (all three ranges are in action at all times), density (fixed durations do not allow for any pauses), dynamic, or articulation (there are wide extremes of both dynamic and articulation marks, but no one dynamic or articulation remains in effect long enough to impress upon the memory), the work sounds like an exercise. *Mode de valeurs* is, after all, an "etude" for rhythm[25], and though Messiaen never returned to such a strict association of musical elements, this work provided the starting point for the serial techniques of Boulez.

Structures 1a is one of the most analyzed three and a half minutes of music in the contemporary repertoire[26]. By divorcing rhythmic rows from pitch rows and combining them indirectly, Boulez begins to solve some of the aesthetic problems posed by *Mode de valeurs*. As mentioned previously, Boulez, in *Structures 1a*, limits himself to one pitch row and one duration row, but he modifies these rows by the classic twelve-tone forms (retrograde, inversion, and retrograde inversion) and by transposition (or, in the case of rhythm, rotation), to arrive at multiple permutations.

Dominique Jameux, in *Pierre Boulez*, has written an extensive analysis of the work, recognizing eleven sections and pointing out the important fact that:

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24 Johnson, *Ibid.*, 106–107.

25 *Mode de valeurs* is the second of four pieces collectively titled *Études de rythme*.

26 Jameux notes: "These two hundred or so seconds have become legendary. Few contemporary scores have so often been quoted, referred to and analysed: Ligeti, Roman Vlad, Donald Mitchell, Marc Wilkinson, and Edward T. Cone are just some of the well–known specialists who have each added to the impressive body of analytical literature provoked by this one piece" (Jameux, *Ibid.*, 51).

> Even if *Structure 1a* was written during a single night by means of the simple development of a strict serial programme designed to eliminate subjectivity, it remains only one of the millions of possibilities at his disposal: Boulez has made a choice—whether consciously or unconsciously. It is important to understand the nature of these choices, in order if possible to derive an aesthetic for these three-and-a-half minutes of music.[27]

An important choice made by Boulez is one of density of musical information. The static quality produced by Messiaen in *Mode de valeurs* is avoided (at least somewhat) in *Structures 1a* by the fact that some sections (of the eleven outlined by Jameux) contain more rows than others: some as few as one or two, others as many as six. Over the course of the eleven sections, all forty-eight variants of the pitch row are heard.

Another choice made by Boulez is the number of duration rows used. Instead of accompanying the forty-eight distinct pitch rows with the forty-eight distinct duration rows, as might be expected, he employs far fewer rhythmic rows, using some of them more than once. Again, Jameux:

> One may imagine that there are to be forty-eight duration series corresponding to the forty-eight serial statements which are the fibres of the pitch space in *Structure 1a*. However, Boulez begins with a first section comprising two series of pitches and one of durations, he divides the first part of the second section into three sub-sections, using, (a) four series of pitches and two series of durations, (b), three series of pitches and one of durations, and (c) one of each. The third main section comprises six pitch series but only one of duration. For the forty-eight pitch series there are a mere twenty-six corresponding duration series.[28]

An examination of *Structures 1a* shows that even in a supposedly "rigid" structural environment, choice is a significant factor. Though compositional pre-planning determined the materials and basic structure of the composition, Boulez exercised a

27 Jameux, *Ibid.*, 274.

28 Jameux, *Ibid.*, 279.

significant degree of choice when realizing the complete composition. We will speak more of deviation from a rigid compositional structure later, but first it is interesting to examine the compositional directions taken by Boulez after his experiments in total serialism.

Around the time of *Structures 1a*, Boulez published the notorious article, "Eventuellement" (Possibly).[29] In this article, he decrees that serialism is the only possible future for music, and makes his often-quoted statement that "Any musician who has not experienced—I do not say understood, but in all exactness, experienced—the necessity for a dodecaphonic language is USELESS. For his whole work is irrelevant to the needs of his epoch."[30] In "Eventuellement," Boulez pays homage to Messiaen, as one would expect, but he also speaks glowingly of the work of John Cage, with whom he was involved in a correspondence at the time.[31] Cage was working on serial procedures of his own but was also experimenting with factors of randomness and chance in composition.

Shortly after "Eventuellement," Boulez relaxed his serial methods to create his best-known work, *Le Marteau sans maître,*[32] and—perhaps due to Cage's influence—started thinking about chance operation and its application to his own compositional strategies.[33] Only five years after the publication of *Structures 1a* and "Eventuellement," Boulez published an article titled "Aléa" (Risk),[34] in which he espouses the use of chance procedures in composition. He is careful to distinguish between "pure" chance—the type

29 Though most French–English dictionaries indicate that "eventuellement" should be translated as "possibly," Susan Bradshaw translates it as "eventually" in her translation of Jameux, *Ibid.*

30 *Notes of an Apprenticeship,* 148.

31 This correspondence is published as *The Boulez-Cage Correspondence*, ed. Jean-Jacques Nattiez, trans. Robert Samuels (Cambridge, England: Cambridge University Press, 1993).

32 Vienna and London: Universal Edition, 1957.

33 It must be noted, however, that Boulez was vehemently opposed to Cage's specific methods of using chance. Though both men were experimenting with similar techniques, each came at the topic of chance from widely differing aesthetic directions.

34 Published in *Réleves d'apprenti, Notes of an Apprenticeship*, and in *Perspectives of New Music* 3/1 (1964): 42–53.

often employed by John Cage—and "controlled" chance, but the change in tone—this from the man who wrote "Eventuellement"—was striking.

The Third Sonata for Piano,[35] which Boulez composed in 1956–57, features a variable "road map" for the performer to follow, choosing his own path through the composition.[36]

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35 Vienna and London: Universal Edition. *Trope*, 1961, and *Constellation/Constellation-Miroir*, 1963. A fragment of *Antiphonie* was published under the title of *Sigle*, 1968, then withdrawn.

36 Boulez originally intended for the Third Sonata to comprise five 'formants' (movements): A) *Antiphonie*; B) *Trope*; C) *Constellation* or *Constellation-Miroir*; D) *Strophe*; and E) *Séquence*. Boulez requires only that *Constellation* (or its *Miroir*) be performed as the third movement, yielding the following possible combinations of formants: ABCDE, ABCED, BACDE, BACED, EDCBA, EDCAB, DECBA, and DECAB. At the present time, only two formants of the work—*Trope* and *Constellation-Miroir*—are complete, and are typically performed with *Constellation-Miroir* as the final movement. *Trope* comprises four sections of its own: *Parenthése*, *Glose*, *Commentaire*, and *Texte*. *Trope* is published in a spiral binding with no cover-page, allowing any section to be performed first without altering the order of succession. This creates four possible combinations (rotations) of order, but Boulez also allows the performer the option of performing *Glose* before or after *Commentaire* so that there are eight possibilities in all: PGCT, PCGT, CTPG, CGTP, GCTP, GTPC, TPGC, and TPGC. Jameux (*Ibid.*, 306-07) explicates the structure of the *Constellation(-Miroir)*: "The structural fragments of *Constellation*, to be called respectively A, B and C, are played in the order C, B and A in *Constellation-Miroir*, but within these structural fragments the chronology and direction of events remains unchanged, and is still read from left to right.… *Constellation* (or its *Miroir*) is printed on nine large and separate sheets…headed A to I, on which five main structures are set out: three are structures of 'points,' printed in green, and two are structures of 'blocks,' printed in red. Points and blocks are perceptibly different in style. The five main structures are played alternately, beginning and ending with a structure of points. They are preceded (*Constellation*) or followed (*Constellation-Miroir*) by a brief sixth structure called *mélange*, comprising three sequences of points and three of blocks (with colours reversed): this 'microcosm of the whole' (Boulez) is like an ante-chamber, coming from or leading to *Trope*. Within these five main structures the performer can to a certain extent choose his route, or at least, the means of linking the various fragmentary structures available within the large blocks or points. There is a supervised freedom, obeying a 'highway code' that suggests certain sequences, ordains some, forbids others. Boulez directs that everything has to be played, and each sub-structure is entirely written out. Finally, certain optional possibilities within the sub-structures are left to the performer's discretion, as in [certain sub-structures] where he can either play or omit the lower system."

The idea that a performer could be trusted to determine a work's form suggests that Boulez considered overall form to be of little importance. And conversely, that Boulez did not support "pure" chance—composing and notating individual musical sections precisely and meticulously—suggests that he considered individual moments of a piece to be of primary importance.

Charles Rosen, in his short article titled "The Piano Music," found in *Pierre Boulez: A Symposium*,[37] discusses *Structures 1a* in terms of form, and seems to think it perfectly logical that the seemingly rigorous organization of *Structures 1a* led naturally to the less rigorously structured works that followed, and finally to the idea of moment-form,[38] in which large-scale form is left ultimately to the performer.

> …the four independent series [pitch, rhythm, dynamics, and articulation] have been considered as the *form*—predetermined—of the piece, whereas they are only elements of its morphology. The series is not conceived merely as an ordering of the elements, but as itself a fixed element; Boulez attempts to carry out what Webern had only started. The extreme nature of the work lies in this: that its form is minimal—not zero, but the absolute minimum of form that arises from the interaction of the morphological elements without (or almost without) the composer's intervention. The purpose of the piece is to expunge the presuppositions

37 In *Pierre Boulez: A Symposium,* ed. William Glock (London: Ernst Eulenberg, 1986).

38 The aesthetic of "moment-form" was shared by Boulez's colleague Karlheinz Stockhausen, whose composition *Momente* celebrates the concept. In 1971, Stockhausen gave a lecture titled "Moment-forming and *Momente*," published in *Stockhausen On Music*, ed. Robin Maconie (New York and London: Marion Boyars, 1989), 63–64: "When certain characteristics remain constant for a while—in musical terms, when sounds occupy a particular region, a certain register, or stay within a particular dynamic, or maintain a certain average speed—then a moment is going on: these constant characteristics determine the moment. It may be a limited number of chords in the harmonic field, of intervals between pitches in the melody domain, a limitation of durations in the rhythmic structure, or of timbres in the instrumental realization. And when these characteristics all of a sudden change, a new moment begins. If they change very slowly, the new moment comes into existence while the present moment is still continuing." In Stockhausen's composition, *Momente*, so much is left to the discretion of the performers that there is no structure left to speak of, save those structures created anew at each performance.

> of a form that are traditionally embedded in the morphological elements, and thus to create the basis for a new language of music. Out of this came not only the rest of *Structures I* and *II* but other works, in particular the unfinished Third Sonata.
>
> From this point of view, the evaluations frequently offered of this introductory work, analyses which oppose the composer's total and 'responsible' control of his material to the actions of chance, are largely irrelevant. The musical events created by the interaction of the series do not in fact constitute a musical form, if by 'form' we mean strictly a temporal order of events in which the order itself has an expressive significance. The order of events is fortuitous in the sense that it is neither foreseen nor alterable by the composer, but this fortuity has no interest. The structure of the piece is not aleatory (although the temporal order of musical events may be said to be determined by chance) because the structure is not conceived as temporal, and the realization in sound—the performance—does not reflect the structure *directly*. It would be best to say that the interaction of the morphological elements does not create a temporal form, but indicates and exposes the possibilities of new forms. The opening piece is both an introduction and a demolition. It erases the last traces of thematic form that still attached themselves to the elements of music.[39]

Some might argue that so much reliance on chance—whether in the randomness of a complex but arbitrary structure, or in the freedom of a performer to control the order of musical events—constitutes irresponsibility on the part of the composer, who should be expected to precisely determine all of a work's content and form before passing the work on to the players. Milton Babbitt is one such composer, and a look at his formal principles show a marked aesthetic difference from the serial compositions of Messiaen and Boulez.

39 Rosen, *Ibid.*, 93–94.

3. Form: Milton Babbitt and Elliott Carter

An in-depth discussion of structure in the many compositions of Milton Babbitt is far beyond the scope of this paper, but it is important to discuss a specific characteristic of the way Babbitt applies twelve-tone rhythm to large-scale form: in general, a composition by Babbitt will include all possible permutations of any number of musical events—usually derived from a twelve-tone row. As Babbitt puts it, he wishes to "make music as much as it can be rather than as little as one can get away with."[40] Andrew Mead, in *An Introduction to the Music of Milton Babbitt*, uses the term "maximal diversity"[41] to describe Babbitt's desire to extract all possible variations from a small amount of music.

> A fundamental principle Babbitt derives from the very nature of the twelve-tone system is the idea of *maximal diversity*. A given aggregate achieves its nature from the interior disposition of pitch classes, using the maximum number of available pitch classes, and different configurations will yield aggregates of different natures. A row class contains the maximum number of different ways to transform a given ordering under a certain set of constraints. Babbitt has extended this idea to virtually every conceivable dimension in myriad ways throughout his compositional career. All sorts of aspects of Babbitt's music involve the disposition of all possible ways of doing something within certain constraints. Just as the particular disposition of pitch classes in an aggregate will give the aggregate its particular character, so the disposition of elements in another

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40 Milton Babbitt, *Words About Music*, eds. Stephen Dembski and Joseph N. Straus (Madison, Wisconsin: University of Wisconsin Press, 1987), 183.

41 Mead is unsure whether he coined this term himself or borrowed it from Joseph Dubiel.

> domain can give that aspect of a composition its own character. Babbitt further composes his music so that these various domains interact: as we shall see later, he applies analogous configurations to various dimensions over a full range of time-spans, in ways that create associations and resonance throughout a composition.[42]

Babbitt's use of "maximal diversity" can be described as a concatenation of small musical iterations—no two exactly alike—that comprise a whole as do tiles of a mosaic. Joseph Dubiel, in a series of essays published in *Perspectives of New Music*, uses the phrase "the animation of lists" to describe the maximally diverse music of Babbitt.

> Each piece covers all the possibilities in whatever domain of possibility it defines—normally once each, but in any case never one more than another. A piece like *Composition for Four Instruments* could therefore be said to define and complete the "aggregate" of possible instrumental combinations; and while few of Babbitt's pieces lend themselves to that tidy characterization, almost all depend somehow on exhaustive lists.[43]

In support of this assertion, Dubiel discusses the formal design of Babbitt's *Composition for Four Instruments*, a work organized by a large-scale structure dependent on an exhaustive list.

> Not merely in its performance requirements is Babbitt's *Composition for Four Instruments* what he says it is, but in the most pervasive premises of its construction: its sections are defined by the selections possible from its quartet of flute, clarinet, violin, and cello, and it explores its set exclusively as a source of trichords for four-line derived-set arrays.[44]

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42 Andrew Mead, *An Introduction to the Music of Milton Babbitt* (Princeton, New Jersey: Princeton University Press, 1994), 19–20.

43 Joseph Dubiel, "Three Essays on Milton Babbitt (Part Three)," *Perspectives of New Music* 30/1 (1992): 83.

44 Dubiel, *Ibid.*, 82.

The chart below shows the instrumental combinations that make up the various sections of *Composition for Four Instruments*. In addition to the fact that each combination is used once and only once, note also that each pair of adjacent sections (1 and 2, 3 and 4, etc.) comprise exactly one occurrence of each instrument.[45]

section	measures	instruments
1	1–35	cl
2	36–59	fl, vln, vcl
3	60–88	cl, vcl
4	89–118	fl, vln
5	119–138	fl, cl, vln
6	139–163	vcl
7	164–185	fl, vcl
8	186–206	cl, vln
9	206–228	fl, cl, vcl
10	228–250	vln
11	251–289	vln, vcl
12	289–327	fl, cl
13	328–350	fl
14	350–368	cl, vln, vcl
15	368–405	fl, cl, vln, vcl

Babbitt orders his lists differently in each composition, and in later compositions the ordering procedures are far more complicated than those that govern the *Composition for*

45 The formula used to determine the number of discrete permutations is 2^n-1, where *n* represents the total number of instruments. The number 1 is subtracted to account for the null set, which—in the case of the *Composition for Four Instruments*—would produce the undesirable result of a sixteenth section of music in which none of the instruments participate.

Four Instruments.[46] But because "the animation of lists" involves the iteration of every possible compositional permutation, then the only area in which compositional choice comes into play is that of chronological ordering of these events. What is significant is that all possibilities and permutations are, in fact, present somewhere in the composition. By not repeating or deleting any variation, a sort of democracy of importance is achieved, and it is perhaps the responsibility of the listener to attach more or less significance to particular local events. Though the order of these events is fixed, and is presumably significant from structural and aesthetic points of view, the absence of an obviously perceptible hierarchy creates a situation not entirely dissimilar to that of Boulez's aleatoric compositions: the individual moments themselves take on more significance than their ordering in time and their relation to overall structure. Babbitt implies this primacy of the small iteration when responding to a question of form posed in a published interview with Charles Wuorinen.

> If one begins with and quickly departs from that notion of "form" which is that of a familiar pattern of dimensionally synchronous recurrences transportable from piece to piece where "content" (themes, motives, etc.) is installed, one may eventually arrive at my conception of "form," of large-scale structure which is all of the piece, a holistic unity in which the alteration of, say, a single note event (or any dimensional component of the "note") alters the "form," makes it "formally" another piece. However, the alteration of a note, inadvertently in performance,

46 Babbitt discusses the evolution of formal complexity in his works in an interview with Charles Wuorinen: "The punctuative discreteness of my *Composition for Four Instruments* soon receded in my music, and in my latest works, particularly those beginning with my Sixth String Quartet, the 'macrophrases'—or even '-phases'—are most immediately characterized by changes in the degree of interdependency among the pitch-class and temporal materials of the instrumental parts, with their constantly changing range of reference both proleptically and analeptically, by intimation and recollection. The total organicism, after which I always have strived, does not immediately manifest itself in such clearly reflected dimensions whose structures, though ultimately genidentical, are more often, or almost always, 'polyphonic,' rather than 'homophonically' coordinated." From Milton Babbitt and Charles Wuorinen, "In Search of the Ideal Listener," in *Musically Incorrect: Conversations About Music at the End of the Twentieth Century* (New York: C.F. Peters, 1998), 28–29.

> could be inferred to be a "wrong note" by the inter- and intra-dimensional redundancies; the probably correct and desired note would be inferable by a knowing listener.[47]

* * *

Before turning to Wuorinen's concept of form, and his method of applying twelve-tone principles to a composition's large-scale structure, it might be useful to examine, briefly, some of the organizational principles at work in the music of Elliott Carter. Carter is not a "serial composer." His works cannot be analyzed serially, and his methods are highly personal and quite different from those of Babbitt and Wuorinen. Still, because his music shares a similar tonal language to that of his colleagues, and since his works are widely known and admired, a brief description of his concept of large-scale structure is not out of place here.

Carter structures many of his instrumental compositions on what he calls "structural polyrhythms." The term is defined in David Schiff's *The Music of Elliott Carter*.

> Structural polyrhythm: a slow polyrhythm used as the background rhythmic structure of a piece. Carter first employed this idea in the Introduction and Coda to the *Double Concerto*; in his later music the calculation of a structural polyrhythm on graph paper is usually the first step in composition, a clear indication, if one were needed, that for Carter rhythm always comes first, albeit in a highly abstract form. In explaining a technique which may appear arcane, and which is rarely audible to the listener, Carter has said that he wanted to develop a more systematic way of approaching all the tempo relations in a piece, and also wanted to develop the structural equivalent of the slow phrase rhythms of tonal music. In practice Carter feels free to make the structural polyrhythm explicit at some points in a piece while not articulating it at others and he has also felt free to omit parts of the polyrhythm.[48]

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47 "In Search of the Ideal Listener," 25.

48 David Schiff, *The Music of Elliott Carter*, (Ithaca, New York: Cornell University Press, 1998), 46–47.

Carter writes of these structural polyrhythms as "speeds," and often assigns a different speed (derived from a polyrhythmic ratio) to each instrument of an ensemble. A simple example would be the relationship of eighth notes to eighth-note triplets: a 2:3 ratio that can be expressed in metronomic speed—say, sixty and ninety beats per minute. The *Double Concerto,*[49] mentioned in Schiff's definition of "structural polyrhythm," features a highly complex collection of polyrhythmic ratios that produce ten different "speeds," outlined by Carter in a 1970 essay.

> The work is built on a large plan, somewhat like that of Lucretius's *De rerum natura*, in which its cosmos is brought into existence by collisions of falling atoms, in the music by ten superimposed slowly beaten out regular speeds—five for the harpsichord and its orchestra on one side of the stage, and five for the piano and its orchestra on the other side of the stage. A musical interval is associated with the attacks of each of these and used in the introduction as if it were a percussive sound.[50]

Specific details of the introduction's plan are explicated by Schiff.

> Carter gives the percussion simultaneous accelerations and ritards which converge as a climax at bar 5. As this intersection subsides, two pulses emerge in a ratio of 49:50 (fifteen sextuplet semiquavers against twenty-one quintuplet semiquavers, at metronome speeds of 24.5 and 25 respectively). These nearly indistinguishable pulses, introduced by rolled cymbal and snare drums, begin to be orchestrated at bar 11, as the 24.5 pulse is transformed into a tremolando minor second in the harpsichord's orchestra, and the 25 pulse is heard in a tremolando major second in the piano's orchestra; the intervals sound like overtones of the percussion. Gradually the other intervals are placed in orbit, all emanating from unpitched percussion at widening speed ratios:

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49 New York: Associated Music Publishers, 1964.

50 "The Orchestral Composers Point of View." In *The Orchestral Composer's Point of View: Essays on Twentieth Century Music by Those Who Wrote It*, ed. Robert Stephan Hines (Norman: University of Oklahoma Press, 1970), reprinted in *Collected Essays and Lectures, 1937–1995*, ed. Jonathan W. Bernard (Rochester, New York: University of Rochester Press, 1997), 243.

Bar 13–14	Perfect fourth (28)	Major seventh (21 7/8)	32:25
Bar 16–17	Tritone (29 1/6)	Major sixth (21)	25:18
Bar 20–23	Minor third (19 4/9)	Perfect fifth (31.5)	81:50
Bar 35–36	Minor seventh (17.5)	Major third (35)	2:1

> The soloists enter with tremolandos, gradually building materials and gestures out of the intervallic atoms, but also forming larger character-patterns, forecasting later events.…Meanwhile, the twin intervallic systems begin to approach two points of simultaneous accent.…The two ratio systems approach their rhythmic unisons in different ways. One system of pulses, related by ratios of whole numbers, approaches a unison attack on the downbeat of bar 45. The composite rhythm formed by these pulses produces a pattern of constant acceleration, heard clearly in the piano. The other system of pulses forms a pattern of accelerating acceleration, that is, the rate of acceleration is not constant but increases. These pulses collide at the downbeat of bar 46, and then continue to form a pattern of deceleration played by the harpsichord in bars 47 and 48.[51]

This technique of multilayered speeds is complicated, to be sure, but it serves to produce large-scale forms in many of Carter's compositions by giving him a sort of scaffold on which to hang the surface-level behaviors of the various instruments and their associated pitch intervals. The success of his work, though, is a result of the personal choice that he exercises when choosing the structural ratios involved, and his methods of arranging the multiple "speeds" in such a way as to control their times of coincidence and their times of divergence. This technique lends a distinctively dramatic quality to many of Carter's works, as different polyrhythmic speeds—often associated with a specific pitch interval or collection of pitch intervals—give each instrument of an ensemble a certain character, and Carter goes to great lengths to reinforce the dramatic interactions between these characters. Carter's String Quartet No. 2[52] is one such "dramatic" composition using different "time-worlds" to create different instrumental personalities. Schiff explains:

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51 Schiff, *Ibid.*, 246–47.

52 New York: Associated Music Publishers, 1961.

> The four characters are archetypical musicians—the first violin is a virtuoso, interested mainly in showing off, the viola is a bit too-consistently doleful, the cello self-indulgently romantic: the second violin, like a composer, tries to create order among its narcissistic neighbors. Psychologically the four could be termed manic, compulsive, depressive, hysterical. But perhaps more relevantly to the specific forms the characters take on in the music, the four instruments exist in independent time-worlds—like the mysterious figures in Kafka's parables. The first violin plays in a fragmented way, making sharp contrasts between fast and slow motion; it seems to be unaware of time. The second violin recalls Carter's description of the French organist's improvisations, 'ticking away like a complicated clock, insensitive to the human meaning of its minutes and hours.' The viola, playing with a constant expressive rubato, stretches and bends clock-time to match its moods, while the cello accelerates and ritards in great sweeping arcs, imposing its own subjective time-experience on the others, until it finally draws them all into a speeding whirlpool.[53]

In a 1989 interview, Carter discusses the inspiration for his Second String Quartet.

> Each instrument has its own vocabulary, and the quartet opens with a display of its vocabulary, in a kind of synthesis of what is to follow. Naturally, each instrument is characterized in different ways, not only by its intervals and rhythms, but also by procedures such as pizzicato, glissando, alternation of long and short notes, and so forth. And it was just this multiplicity of characterizations that enabled me to undertake the project of such dramatic complexity, rather than working only with the rhythmic articulation, as I had in the First Quartet.
>
> That idea of dramatic contrast between the instrument/characters comes to me from very early ideas, extrapolated from thoughts about music drama. I'm thinking of the orchestras that play in different rhythms in the ballroom scene in Mozart's *Don Giovanni*, the scene in Verdi's *Otello* where Iago and Otello spy on Cassio and Desdemona, or the scene from *Boris Godunov* where a double action develops in the inn at the frontier. I often thought about such things while composing my Second Quartet, because seeing one thing in the context of another is, to my mind, extraordinarily important. You end up seeing one situation as commentary on the other, and your vision becomes richer and more fully articulated.[54]

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53 Schiff, *Ibid.*, 73–74.

54 *Elliott Carter: In Conversation with Enzo Restagno for Settembre Musica* 1989, trans. Katherine Silberblatt Wolfthal, I.S.A.M. Monographs: Number 32 (Brooklyn: Institute for Studies in American Music, 1989), 63.

To this day, Carter continues to use the technique of structural polyrhythm to create "double action." A recent work of Carter's, *Con Leggerezza Pensosa*,[55] is as seemingly simple as the *Double Concerto* is seemingly complex, but it, too, relies on a structural polyrhythm for its overall shape. According to Schiff: "The rhythmic sketches for this piece have not survived, but it may be built on a 50:48:45 ratio."[56] Whatever the initial ratio was, the result of this structural polyrhythm is that each of the three instruments has a characteristic metrical unit to determine its perceived "speed." The cello is consistently notated in sixteenth-note quintuplets, the violin is consistently in sixteenth notes, and the clarinet is consistently in eight-note triplets. In addition, each instrument is assigned a portion of the all-interval twelve-note harmony heard in measures 3–6. The intervals 9, 2, 4, 5, 11, 6, 3, 10, 8, 7, and 1 are divided between the instruments as follows: the first four intervals (9, 2, 4, 5) for the cello; the following five intervals, beginning with the last of the cello's (5, 11, 6, 3, 10) for the clarinet, and the last four intervals (10, 8, 7, 1) are assigned to the violin. Note that the clarinet's five intervals form a "link" with those of the string instruments by including one from the violin and one from the cello.

Carter has developed a structural system that has allowed him to compose a wide variety of pieces over a period of many years. Messiaen and Boulez attempted, in their own manners and with varying degrees of success, to do the same thing but eventually abandoned total serialism for other techniques. Babbitt has applied the principle of maximal diversity to produce a multitude of compositions, rich in permutational abundance, but has chosen not to apply twelve-tone rhythmic structure directly and explicitly to overall form. It is in the works of Charles Wuorinen that we see a direct correspondence of twelve-tone rhythmic structure to large-scale form, and we are fortunate to have as our guide his 1979 book, *Simple Composition*.

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55 New York: Hendon Music: Boosey and Hawkes, 1991.
56 Schiff, *Ibid.*, 143.

4. Form: Charles Wuorinen

Using Babbitt's time-point system as a starting point, Charles Wuorinen's *Simple Composition* outlines techniques for applying twelve-tone rhythmic structures to large-scale formal aspects of composition. Though Wuorinen has employed many different methods of organizing his various compositions, an overall constant has been his use of a technique he calls "nesting," in which time-point divisions are applied over multiple temporal scales across the course of a composition. As a variation of this technique is used in *Spin*, an outline of Wuorinen's description of the method is germane here.

It is in Chapter 12, "Formal Organization: Extending the Time-Point System," that Wuorinen describes his technique for composing from the large to the small, but it is early in the book that he expresses the rationale for doing so. Composition is unlike aural perception in that it is not a time-dependent process. That is, a listener hears a composition in sequential order from beginning to end, but it is essential that a composer, while composing, be aware of the composition in its entirety at all times.

> Analysis claims to explicate music, usually by appealing to what can be heard in it. In other words, it links itself to musical perception. With these claims we have no quarrel, although a word of caution is in order: however useful analytic studies may be for general musical understanding and culture, they have only a very limited application to the act of *making* music itself. It is tempting to think that because one has "understood" an analysis, one has understood the work of music itself. But even if this were so, it would not prepare one to create a new, as yet non-existent work.
>
> Be this as it may, there is a more dangerous claim sometimes advanced for analysis. It is the assertion that analysis is "de-composing," the

> retrograde of the compositional process. This claim, which is usually made by non-composers, must be resisted. Why is this so? Composition is *not* the reverse of perception; pieces cannot be written as if composing were a slow-motion form of listening. Listening to what? Something which does not yet exist? Listening to a piece of music is a *time-dependent*, one-directional activity. You cannot hear a piece backwards, you cannot make events come faster to you than the rate at which they are being performed—even if you know what is coming. But composing, and the musical perceptions of the composer, should be *time-independent*—in the sense that, unlike a listener, the composer has a total, instantaneous sense of his piece and the relationships it contains.[57]

This simple observation about a composer's ability to perceive a piece as a whole forms the basis for Wuorinen's discussion of "nesting," in which a composer starts first with a large-scale formal outline, then gradually fills in detail—the complete work gradually appearing and becoming more defined much like a blurry image coming into correct focus.

The first step of the nesting process is to determine large-scale sectional divisions using time-point interval, expressed without modulus. The example given on page 150 of *Simple Composition* is a row (0, 8, 10, 5, 3, 7, 6, 2, 1, 11, 9, 4) that yields a total time-point interval total of ninety-six (8, 2, 7, 10, 4, 11, 8, 11, 10, 10, 7, 8). Note that the sum of time-point intervals includes the interval from the last pitch (4) back to the first (0) to make a total of twelve intervals. In the example provided by Wuorinen, each time-point unit is made equivalent to ten quarter notes, such that the result is a span of 960 quarter notes, divided by time-points into 80 + 20 + 70, etc. This succession of durational intervals, expressed as beats, spans the entire composition-to-be.

The second step of the nesting process is to divide each of the twelve sections by the same time-point intervals or, more specifically, by the proportions of those time-point intervals. Thus, a division of the first section (eighty quarter notes) by the proportions

57 Wuorinen, *Simple Composition*, 11–12.

of the time-point intervals produces a succession of fractions: 6 and 2/3, 1 and 2/3, 5 and 5/6, etc.

Completion of the first two steps of division results in twelve large sections, each divided into twelve more, for a total of 144. The third and final step of the nesting process is to divide each of these 144 sections one last time, again by the same time-point proportions, to produce what will become the surface time-points of the composition. Wuorinen, at this step, advocates the use of approximation to avoid ridiculously complicated surface rhythmic detail, recommending an aliquot distribution of the twelve time-points over very small second-level segments.

Wuorinen summarizes the nesting method thus:

> We began with the largest dimension—the total duration of the composition, as projected in our initial planning. This total duration we then divided up into time intervals proportional to and in the same order as those of the pitch-class set we had selected for the work—thus retaining the time-point system's principle of correlating pitch interval with time interval; but we noted the important difference of abandoning the notion of a temporal modulus. Then we repeated the division process twice more, and achieved a highly detailed division for the flow of time in our piece, so detailed that we would be entitled to regard the finest divisions as foreground rhythm. Then we decided on what to attach to the time-points which these manifoldly nested interval successions had located for us—usually pitch classes, generated according to some reasonable successional scheme from the composition's pitch-class set and its derivatives.[58]

Pitches may be attached to time-points in many ways: one way utilizes a simple one-to-one relationship (one time-point receives one pitch); another way is to use a scheme (the simpler the better, usually) that allows for attaching more than one pitch to time-points. Wuorinen gives examples of the latter,[59] but also stresses that the former system does not preclude the creation of simultaneities. He points out that surface-level time-

58 Wuorinen, *Ibid.*, 157.

59 Wuorinen, *Ibid.*, 160.

points, especially ones close together in time, can be grouped to form chords. Or, even more simply, simultaneous sounding of pitches can be produced when durations of pitches attached to time-points overlap, forming chords contrapuntally.

> Another important distinction to make is that surface-level divisions are not necessarily determiners of duration: And once again we must emphasize that the large sectional divisions, and their smaller internally nested intervals of time, do *not* represent durations. They denote the locations of time-points, whose meanings have yet to be determined. It is most likely that the smallest divisions will be regarded as marking the starting points of tones, but—for example—the notated durations in our third-level examples do not indicate or imply that the arrival of one time point terminates what the preceding time point had initiated.[60]

Another noteworthy technique, and one used to a significant degree in *Spin*, is the practice of unfolding two or more strands of nested time-points at the same time. In an example from *Simple Composition*, Wuorinen combines a set of S time-points (containing eighty-four intervallic units) and its related set of R time-points (containing sixty intervallic units). By assigning a value of five beats to each S time-point unit (for a total of 420), and a value of seven beats to each R time-point unit (also a total of 420), both strands are made unfold over the same span of time. Rhythmic interest is created by the combination and interaction of the two strands. Another example from *Simple Composition* shows a four-strand combination comprising the S, I, R, and RI forms.

An example of a two-strand composition is Wuorinen's *Arabia Felix,*[61] in which the instrumental sextet is divided into two trios: ringing instruments (vibraphone, guitar, and piano) and non-sustaining instruments (flute, violin, and bassoon). Each instrumental group articulates the time-points of one strand of time-point information.

It is essential to note that the nesting method as outlined by Wuorinen is far from Messiaen's and Boulez's goal of total serialism. Though Wuorinen's system allows the

60 Wuorinen, *Ibid.*, 154.
61 New York: C.F. Peters, 1974.

composer strict control of structure, pitch, and foreground and background rhythm, it leaves many important compositional factors—register, articulation, and dynamics, to name only a few—to the good taste of the composer (guidelines and exercises to help develop this acumen are provided in earlier chapters of *Simple Composition*). And when time-point intervals are, in fact, used to govern other compositional aspects (in *Arabia Felix,* for example, where register and pitch-duplication are also controlled by time-point intervals), Wuorinen recommends their application over a large time-scale for general musical effect, as opposed to the wild note-to-note dynamic changes often seen in the serial music of Boulez or Babbitt. Additionally, Wuorinen states in his book's "Valedictory" that these practices can—after a composer has gained experience—be internalized, and that more intuitive music can eventually be produced.[62]

> In the last chapter [on Form] we described methods for producing the large shape of pieces. What this really means is that we have sought devices that can integrate our fairly clear intuitive perception of what is an appropriate way to express pitch-class relations already established in the small dimension with a sense of what an appropriate large shape for such moment-to-moment relations might be. But—and particularly after a certain amount of experience—is it not also possible to make such large shapes directly, by intuitive and contextual response to the pitch-class arrays themselves? Certainly it is, but the beginner might be well advised not to assume that such a skill is inborn, just because it is non-verbal. He will need some years of discipline in more fully rationalized methods before he attempts to scale these heights.…
>
> The question of "rigor" is often raised these days, and my suggestions that rationalized methods of composition may be succeeded by more "direct" ones no doubt may lead to invoking it here as well. But I believe that no compositional method can be "proved" to be worth anything in particular; it can only be shown to produce pieces which, subjectively, are considered worthwhile. There is therefore nothing but practical value in

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62 A similar suggestion is made by Ernst Krenek in *Studies in Counterpoint* (New York: G. Schirmer, 1940), ix: "It is the belief of this author that, in a later stage of development, atonal music may not need the strict regulations of the twelve-tone technique. He anticipates that the essentials of this technique will grow into a sort of second nature. This consummation, however, will materialize only if the twelve-tone technique is constantly used as a training for composing in the atonal idiom, just as the theory of classical harmony is taught as an introduction to 'free' tonal composition."

> compositional method. No virtue inheres *a priori* in any specific procedure for composing. But all the methods and principles outlined in this book are based on many years of experience by many different composers. If their work is judged of value, then the methods may be so judged as well.[63]

The "methods and principles outlined in this book" are neatly summarized in five guidelines found at the end of *Simple Composition*'s chapter on "Form and Composition."

> 1. Compose from the large into the small. That is, fix in a general way the relations of the piece first. (Naturally, this may involve choosing specific motivic materials, 12-tone sets, and other fundamental constructs on which the piece is to be based; the fact that some of these may be represented as small-scale concrete musical entities does not diminish their generality.)
>
> 2. Try to keep all regions of the piece always in the same degree of completeness. As a rule, avoid defining one part precisely while at the same time leaving another blank. At the beginning of composing, let the whole work be vaguely defined in general terms. Let each subsequent operation apply over the whole work, or a major subdivision of it. Thus all regions of the piece gradually achieve concreteness at the same time.
>
> 3. To implement this second suggestion, above, make use of multiple successive drafts of the composition. Make an initial draft or diagram or outline governing the whole work. Then proceed to a preliminary sketch, which embodies only rough outlines. Do not fear repeated drafts, each of which is only a little more exact, precise, and complete than its predecessor. Often, writing things out again is the best way of clarifying problems, and renotating often brings insight in surprising ways.
>
> 4. By means of the foregoing three suggestions, view the piece whole and entire. At each stage of the compositional process, try to have the same degree of knowledge and awareness of all the regions of the work, the end as clearly (or as vaguely) as the beginning. This will give you a sense of the work independent of time; for you as its maker, it can all be encompassed instantaneously—you do not have to "listen" to it in your mind's ear to know what it contains. As we have observed at the beginning of this book, it is the instantaneous perception of all parts of the work at once, independent of time, which distinguishes composing from all other musical acts. The capacity to apprehend musical relations in this way is not encouraged in most musical and educational discourse. Alas! For it is vital to compositional success, and each one who would compose must find it in his own way and labor, alone, to sharpen its power.

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63 Wuorinen, *Ibid.*, 163–64.

> 5. A compositional method exists only to write pieces. It is not sacred, and when the piece has reached, through application of the method, a sufficient degree of completeness, it will begin to assert its own rights and needs. These may often seem to contradict the original method or call for changes in the work's design. Do not hesitate when such a situation arises. If the method has served long enough to allow the work it has produced to contradict it, it has more than fulfilled its function.[64]

The nesting process (especially when employed in multiple strands) and the compositional guidelines (including Number 5) listed above are essential to the composition of *Spin*, as will be seen in the following chapters.

64 Wuorinen, *Ibid.*, 147–48.

5. *Spin*: Nesting, Rotation, and Deletion

It goes without saying that the choice of a row on which to base a new work is a crucial part of the compositional process. This was certainly true in the early twelve-tone works of Schoenberg and his students,[65] but the composition of the initial row is even more important when a composer is planning to create a row that will define not only pitch, but rhythm and structure as well.

With *Spin,* I knew from the start that I would use time-point intervals to determine the lengths of large sections of the work, and chose the row accordingly. When using Wuorinen's nesting technique, each large-scale section of a composition—whether long or short—will contain roughly the same number of musical events. Therefore, the longer sections will be relatively sparse, the shorter ones relatively dense. Perceptually, dense sections will seem "fast," while sparse sections will seem "slow." Keeping these implications in mind, I composed the following row: 0, 5, 11, 1, 2, 10, 8, 3, 4, 6, 7, 9. These pitch classes yield the following time-point intervals: 5, 6, 2, 1, 8, 10, 7, 1, 2, 1, 2,

65 Schoenberg discusses the motivic function of the set in *Style and Idea* (Berkeley and Los Angeles, 1975), 219: "The basic set functions in the manner of a motive. This explains why such a basic set has to be invented anew for every piece. It has to be the first creative thought. It does not make much difference whether the set appears in the composition at once like a theme or a melody, whether or not it is characterized as such by features of rhythm, phrasing, construction, character, etc." Schoenberg's insistence that the row is merely a theme or motive is further evidenced by his thoughts on how rows are to be utilized in a composition: "You use the row and compose as you had done it previously.…Use the same kind of form or expression, the same themes, melodies, sounds, rhythms as you used before" (Schoenberg, *Ibid.*, 213).

3. Note that the twelfth interval is determined by measuring the intervallic distance from the last pitch class back to the first.[66] The following chart indicates, in a general way, the relative densities of the sections created by these time-points.

section	interval	density
1	5	moderate
2	6	moderate
3	2	high
4	1	high
5	8	low
6	10	low
7	7	low
8	1	high
9	2	high
10	1	high
11	2	high
12	3	high

Forming groups of adjacent sections according to density, we see that we have four large sections: a moderate introduction, a dense (perceptually fast) section, a sparse (perceptually slow) section, and a concluding dense (perceptually fast) section. Note that since the tempo will stay basically the same throughout, the interval numbers seen above can be used to calculate actual clock-time of the large sections of the piece. Of the forty-eight total time-point intervals, eleven comprise the first moderate section; three comprise the following high-density section; twenty-five comprise the following low-density section; and six comprise the final high-density section. Each time-point unit is made equal to twenty-four quarter notes (this will be explained later). Therefore, each time-

66 Wuorinen (*Ibid.*, 151) explains that "an eleven-interval division is perfectly reasonable, but the choice of twelve—the extra interval being that between the final and initial elements of the set—is suggested by traditional notions of closure and musical return, as well as by the arithmetic convenience that results from the fact that the sum of the twelve intervals thus defined is always an integral multiple of twelve."

point unit is equal to about twenty seconds of time at a tempo of quarter note equals seventy-two. We can therefore calculate the lengths of areas of similar density.

sections	time-point interval total	density	perceptual speed	time
1–2	11	moderate	moderate	3:40
3–4	3	high	fast	1:00
5–7	25	low	slow	8:20
8–12	9	high	fast	3:00

Note, though, that these times are not exact, nor will the boundaries between sections stay sharply defined as the composition process continues. After all, each of these sections will be varied internally by nesting and deletion (described later), and by the fact that four strands of this identical musical information, rotated in time, will combine to create the overall structure of the work.

Though the rhythmic implications of the row are extremely important in this composition, the pitch implications are equally so. Since melody and harmony (in the small and in the large) will be determined by this row, its intervallic make-up is important. This row contains a varied mix of adjacent intervals; looking at the linear (melodic) distribution of adjacent pitches, we see that all intervals are represented (assuming inversional equivalence as described by Allen Forte).[67]

67 Forte discusses inversional equivalence in the first chapter of his *The Structure of Atonal Music* (New Haven and London: Yale University Press, 1973).

interval class	adjacent occurrences
m2/M7	3
M2/m7	4
m3/M6	1
M3/m6	1
P4/P5	1
a4/d5	2

It is usually important for a row to contain a variety of intervals, but the distribution of intervals shown in the above chart is perhaps not as significant as it might first appear. Though the intervals shown are the ones produced by a linear iteration of the prime form of the row, simple transformations (retrogression, inversion, etc.) will yield different distributions of intervals, as will more complicated transformations (M7 operations, modulus array transformations, etc.) that will be discussed later. Further, the method used to apply these pitches to the time-points (also discussed later) will also provide opportunity for a wide variety of intervallic combination, both melodically and harmonically.

Returning now to the topic of overall form, we see that the rhythmic structure of *Spin* is created by two main techniques: nesting and rotation. Nesting, described earlier, is the process of creating self-affinity by embedding time-point intervals on multiple temporal scales. Rotation is a much simpler operation: in the case of *Spin* it is a matter of varying the starting and ending points of a nested strand. Throughout the composition, there is only one "source strand" of nested time-points, and the process of rotation is employed to create three additional strands for a total of four (one for each instrument). These four strands are identical in content, but their starting points differ as a result of rotation.

Spin's "source strand" is created by employing the nesting technique on three distinct levels. We will call these levels one, two, and three—level one forming the deepest structure (background) of the composition, and level three creating the work's surface (foreground).

Level one is created by the time-points of S—0, 5, 11, 1, 2, 10, 8, 3, 4, 6, 7, 9—which yield the following row of durational intervals: 5, 6, 2, 1, 8, 10, 7, 1, 2, 1, 2, 3. These twelve intervals are used to determine the largest sectional divisions of the "source strand." In *Spin*, each intervallic unit is made equal to twenty-four quarter notes. The number twenty-four is chosen for a variety of reasons,[68] but its main advantage is that a durational unit of twenty-four beats provides satisfactory results at the second and third levels of division (a significantly larger or smaller durational interval would result in unmanageably slow or fast surface rhythms). Applying the durational interval of twenty-four yields the following chart.

section	time-point interval	number of beats
1	5	120
2	6	144
3	2	48
4	1	24
5	8	192
6	10	240
7	7	168
8	1	24
9	2	48
10	1	24
11	2	48
12	3	72

For the second level of nested time-point division, each of the twelve sections is divided again by the same time-point intervals. To accommodate the different lengths of

68 As was seen earlier, a durational intervallic unit of twenty-four quarter notes creates an appropriate total time for the composition: approximately sixteen minutes. A durational intervallic unit of twenty-four also has the advantage of being easy to work with: it is evenly divisible by two, three, four, six, eight, and twelve.

various sections, slightly different methods are employed at the second level of division. For larger sections, like Section 2 (144 beats), time-point division is a relatively simple process. In this case, each time-point unit is made equal to three beats.

subsection	time-point interval	number of beats
2 – 1	5	15
2 – 2	6	18
2 – 3	2	6
2 – 4	1	3
2 – 5	8	24
2 – 6	10	30
2 – 7	7	21
2 – 8	1	3
2 – 9	2	6
2 – 10	1	3
2 – 11	2	6
2 – 12	3	9

Some of the large sections cannot be divided into sections defined by whole integers, but the exact proportion of time-points can easily be maintained by using fractions of beats. Section 7, for example, contains 168 beats. 168 divided by 48 (the sum of time-point intervals) is three and one half, so each time-point durational unit is made equal to three and one half beats. Section 7 (168 beats) divided by the time-point intervals 5, 6, 2, 1, 8, 10, 7, 1, 2, 1, 2, 3 yields the following result:

subsection	time-point interval	number of beats
7 – 1	5	17.5
7 – 2	6	21
7 – 3	2	7
7 – 4	1	3.5
7 – 5	8	28
7 – 6	10	35
7 – 7	7	24.5
7 – 8	1	3.5
7 – 9	2	7
7 – 10	1	3.5
7 – 11	2	7
7 – 12	3	10.5

Adjustments to this system must be made, though, to accommodate the smaller sections of level one. Because this is only the second of three levels of division, one must consider that the next level will contain yet another distribution of time-point intervals. For this reason, the second-level sections must not be made too small to accommodate twelve additional time-points on the next level of division. Consider first-level sections 2, 9, and 11, each of which contains forty-eight beats. At first glance, this seems a simple number to divide by the S time-points (which also total forty-eight). But dividing evenly would create three second-level sections with a length of only one beat, and this is too small a duration to accommodate the next level of divisions (fitting twelve time-points into one beat would require thirty-second note triplets). Taking this into account, I decided that the smallest allowable unit in level two would be one and one half beats (to be filled, in the third division, with twelve thirty-second notes). Adherence to this rule requires considerable adjustment of method when calculating second-level time-point divisions. Sections with a length of twenty-four beats (Sections 4, 8, and 10) require even more drastic modification to produce sections suitably sized to accommodate third-level division. Below are the adjusted time-point rows used in *Spin.*

original time-point row	5	6	2	1	8	10	7	1	2	1	2	3
adjusted for 48 beats	4	5	3	2	6	8	6	2	3	2	3	4
adjusted for 24 beats	2.5	2.5	1.5	1.5	2.5	3	2.5	1.5	1.5	1.5	1.5	2

As mentioned, these modifications keep the smaller second-level divisions to a length of one and one half (or more) beats, while still maintaining the basic proportions of the time-points.[69] Time-point proportions are represented more precisely in larger sections.

The third level of time-point division in *Spin* differs somewhat from the method outlined by Wuorinen in *Simple Composition* and discussed previously. Instead of dividing the third-level sections by the same time-points that determined the first and second levels of division, "classic" transformations (S, R, I, RI) of the basic time-points are used, in a rotating series. The first third-level section (of the 144) is divided by time-points of the S form (5, 6, 2, 1, 8, 10, 7, 1, 2, 1, 2, 3); the next consecutive third-level section is divided by time-points of the I form (7, 6, 10, 11, 4, 2, 5, 11, 10, 11, 10, 9); the next by R time-points (10, 11, 10, 11, 5, 2, 4, 11, 10, 6, 7, 9); and the next by RI time-points (2, 1, 2, 1, 7, 10, 8, 1, 2, 6, 5, 3). This cycle of four forms then repeats thirty-five times, covering all 144 second-level divisions. This deviation from Wuorinen's method is used to provide greater variety in third-level (surface) rhythm, while maintaining the integrity of the background form. Generally speaking, *Spin* is far less strictly organized on its surface (in terms of rhythm and pitch) than it is in its background structure.

Like the second level of time-point division, the larger third-level sections contain an exact representation of the divisional time-point intervals, but time-points are modified—again, maintaining a strong resemblance to the basic shape—in medium-length sections. In the smallest sections (one and one half beats, for example), time-points are equally spaced across the length of the section. These and other rhythmic modifications will be discussed later in greater detail.

69 A chart illustrating all second-level divisions is provided in Appendix 1.

Now that the "source strand"—comprising 1,152 beats (the forty-eight time-points of S, each made equal to twenty-four quarter notes) and containing 1,728 (twelve times twelve times twelve) time-point divisions—is complete, rotation is used to create the complete rhythmic map of *Spin.* The "source strand" can be seen, from beginning to end, in the percussion strand. The other three instruments use the same strand, but each uses a rotated version, starting (and, therefore, ending) in a different place along the continuum of the source strand. The rotation scheme is simple:

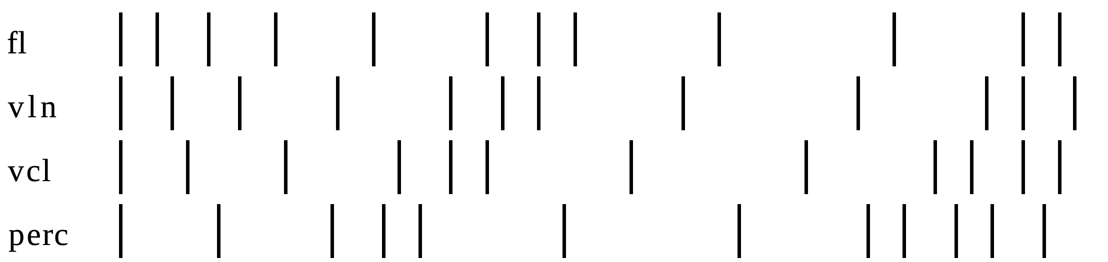
instrument	rotation	sections of source strand
percussion	none	1–12
cello	one position	12, 1–11
violin	two positions	11–12, 1–10
flute	three positions	10–12, 1–9

A graphic representation of the four rotated strands shows the progressions of sparse and dense sections as they sweep through the different instrumental strands that give *Spin* its basic rhythmic character. The table below shows the rotation of the source strand (note that the "first" section of the source strand is marked with an asterisk at the point where it occurs in each instrumental strand).

flute	1	2	3	5*	6	2	1	8	10	7	1	2
violin	2	3	5*	6	2	1	8	10	7	1	2	1
cello	2	5*	6	2	1	8	10	7	1	2	1	2
percussion	5*	6	2	1	8	10	7	1	2	1	2	3

The following is a graphic representation of the rotation scheme that shows the section-lengths spaced proportionately.[70]

70 A similar graph is provided in Appendix 2.

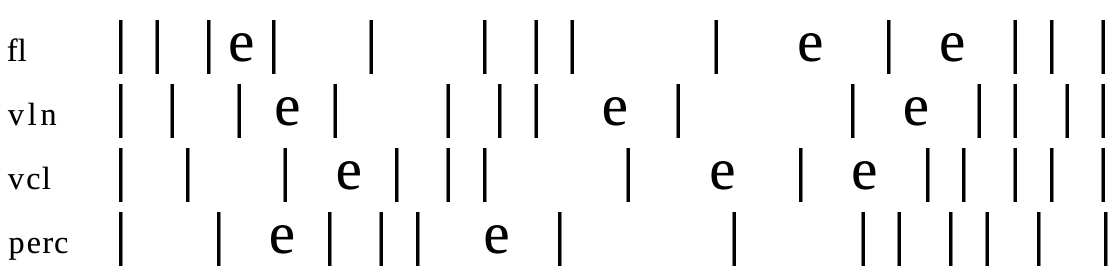


Note that by combining the rotated strands in this manner, the basic overall density progression of the "source strand" is evident but embellished by interaction between strands as areas of high density "pass" from one instrument to another.

Looking at the rotated strands of nested time-points, I decided to employ an additional technique to introduce more variety of both rhythm and instrumentation into the piece. To achieve this, I used a process of deletion—erasing certain time-point events (or, perhaps more precisely, assigning silence to certain time-points). As in the case of nested division, deletion is employed in varying manners on all three structural levels. Deletion at the first level provides orchestrational variety, allotting significant periods of silence to each instrumental strand at various times. Deletion is continued in the second- and third-level sections as well, producing variety of surface rhythm. The process of deletion is employed by designating each section (on all levels of division) either "empty" or "full." As will be explained, "full" sections are not entirely full, and "empty" sections are not entirely empty, as a result of an inverse relationship between methods of deletion at each structural level.

At the first divisional level, the twelve sections of each instrumental strand are assigned "full" or "empty" status. The flute, violin, and cello strands each contain nine "full" and three "empty" sections; the percussion strand contains ten "full" and two "empty" sections. (The percussion part, therefore, contains more events than the others.) These choices are not determined algorithmically, but contextually. The following charts show the distribution of "full" and "empty" sections in each of the four strands. Note that the section numbers provided in the first table correspond to the section numbers of each instrumental strand *after* rotation. That is, Section 1 contains a different number of beats in each instrumental strand, and only the first section of the percussion strand represents the first section of the "source strand." Note also that though it might initially appear, in the first chart below, that the flute, violin, and cello will all be "empty" at the same time (during the third section), remember that because each strand is composed of sections of varying lengths (or, rather, the same section lengths occurring at different times due to rotation), that each instrumental strand's third section will occur at a different point on the overall scale of time. This is made clear in the second chart, where "e" is used to indicate "empty" sections.[71]

instrument	"full" sections	"empty" sections
flute	1, 2, 4, 5, 6, 7, 8, 11, 12	3, 9, 10
violin	1, 2, 4, 5, 6, 8, 10, 11, 12	3, 7, 9
cello	1, 2, 4, 5, 6, 9, 10, 11, 12	3, 7, 8
percussion	1, 3, 4, 6, 7, 8, 9, 10, 11, 12	2, 5



For the second level of deletion, the twelve subsections of each "full" section are assigned "full" and "empty" designations according to the pattern of "full" and "empty" employed in the first level of division. The first-level sections designated "empty," though, are treated inversely at the second level of deletion: they are assigned "full" sections where "empty" sections would be were they first-level segments, and "empty"

71 A similar graph is provided in Appendix 2.

sections where "full" sections would be. This inverse process of deletion results in two (for the percussion) or three (for the other instruments) "full" second-level sections within each "empty" first-level section.

At the third level of division, the "full" sections are filled not with twelve time-points, but rather with only those time-points that correspond to the "full" sections of the larger divisions. For example, in the case of the violin strand—in which sections 3, 7, and 9 are designated "empty" at the first level of deletion—the third, seventh, and ninth time-points of each third-level time-point distribution (representing surface-level rhythmic activity) are deleted. According to this method, each "full" third-level division comprises ten (in the percussion) or nine (in the other instruments) time-points. Inversion of deletion is not employed in "empty" third-level sections, which are left completely empty regardless of instrumental strand.

As a result of the deletion process, each of the nine "full" sections in the flute, violin, or cello strand contain eighty-one time-points (nine "full" subsections, each with nine third-level time-points). Each of the three "empty" sections contains twenty-seven time-points (three "full" subsections, each with nine time-points). The percussion strand, with only two first-level deletions (as opposed to three for the other strands), has ten "full" sections of one hundred time-points (ten "full" subsections, each with ten third-level time-points), and two "empty" sections, each containing twenty time-points (two "full" subsections, each with ten time-points).

An interesting result of the inverse application of deletion is seen in the percussion strand, where there are two, as opposed to three, deletions at the first level. It is immediately apparent that this difference will result in a greater total of time-points for the percussion strand than for the other strands, but it is also noteworthy that less deletion at the first level results in more deletion at the second level: the "full" sections of the percussion strand are more full than those of the other instruments, but the "empty" sections are emptier, as there is less information to be inverted on the second level.

The final result of deletion, in all strands, yields the following totals of time-points:

instrumental strand	"full" sections (levels 1, 2, and 3)	"empty" sections (levels 1, 2, and 3)	total
flute	9 x 9 x 9 = 729	3 x 3 x 9 = 81	810 time-points
violin	9 x 9 x 9 = 729	3 x 3 x 9 = 81	810 time-points
cello	9 x 9 x 9 = 729	3 x 3 x 9 = 81	810 time-points
percussion	10 x 10 x 10 = 1000	2 x 2 x 10 = 40	1040 time-points

The application of pitch information (in the form of note-lists) to these 3,470 time-points will be discussed in the next chapter.

Another problem of surface rhythmic detail is the question of determination of time signature. In tonal music, meter interacts with rhythm and harmony to produce tension or repose. In highly chromatic music, where rhythm and rhythmic phrase-lengths often interact in complex ways, the listener is often unaware of time-signature. This fact gives the barline far less importance, structurally speaking, than in earlier tonal music.

In the music of Babbitt, time signatures often reflect modular length, and stay constant for extended periods. In the music of Wuorinen, time signatures often reflect second-level divisions. That is, the time-point interval proportions are directly associated with the lengths of measures within a given section. In the case of *Spin*, neither of the above methods is feasible. As is the case in many of Wuorinen's compositions, *Spin*'s durational unit is constantly changing, and there are often four temporal moduli (one for each strand) in use at the same time. This causes Babbitt's approach to time-signature to be ineffective in the case of *Spin*. But Wuorinen's approach to meter—making it reflective of second-level division—will not work either. The problem is that there are always four second-level divisions (in each of the instrumental strands) at any given time, and they do not often line up neatly.

The time signatures in *Spin* are determined by the combined rhythmic interaction of all four strands. They reflect the lengths of rhythmic phrases on the surface of the composition but have no structural significance other than that they reflect sections of rhythmic activity (or inactivity) and conveniently delineate these sections for the performers.

It might be worthwhile to mention still another approach to time signature, seen in works by Elliott Carter. Carter often (especially in later pieces) maintains a constant time signature throughout entire sections, movements, or even complete compositions. The barlines do not reflect the complicated rhythmic structures on which the works are based, nor do they reflect surface-level rhythmic phrases. Their regularity, however, can be a great aid to performers, especially when pieces are performed without a conductor.

6. *Spin*: Transposition Arrays and Modulus Arrays

There are two types of note-lists used in *Spin.* The less complicated of the two is produced by a simple formula that, over the course of its run, utilizes every "classic" form of the row (S, I, R, RI), each at all twelve possible transpositions. I call this formula a transposition array. To create the transposition array, the four classic forms at the twelve possible transpositions (forty-eight rows in all) are arranged in four twelve-by-twelve boxes as follows:

Box 1 (twelve-by-twelve) starts with a horizontal row containing one S form, followed by horizontal rows of I, R, and RI forms, consecutively—one each. This sequence is repeated twice more to produce a total of twelve horizontal rows (three each of S, I, R, RI). The transposition levels of each row form are derived from the pitches of S, applied to each of the twelve row forms consecutively.

Box 2 (twelve-by-twelve) is created the same way, with the crucial difference that the rotation of forms begins with I (as opposed to S, as in Box 1), then continues through R and RI before "looping back" to S. The transposition levels of the twelve row forms that comprise Box 2 are identical to those of Box 1. Because the row forms in Box 2 are in a different rotational order than the row forms in Box 1, though they share the same pattern of transposition levels, the resulting twelve rows are unique to Box 2.

Boxes 3 and 4 are created similarly, again with different rotations of forms (R, RI, S, and I for Box 3; RI, S, I, and R for Box 4) applied to the same transposition levels as the other boxes. The result is four twelve-by-twelve boxes that comprise, all together, the four forms of the row, each at all possible levels of transposition.

Box 1

S	0	5	e	1	2	t	8	3	4	6	7	9
I	5	0	6	8	9	5	3	t	e	1	2	4
R	e	9	8	6	5	t	0	4	3	1	7	2
RI	1	3	4	6	7	2	0	8	9	e	5	t
S	2	7	1	3	4	0	t	5	6	8	9	e
I	t	5	e	9	8	0	2	7	6	4	3	1
R	8	6	5	3	2	7	9	1	0	t	4	e
RI	3	5	6	8	9	4	2	t	e	1	7	0
S	4	9	3	5	6	2	0	7	8	t	e	1
I	6	1	7	5	4	8	t	3	2	0	e	9
R	7	5	4	2	1	6	8	0	e	9	3	t
RI	9	e	0	2	3	t	8	4	5	7	1	6

Box 2

I	0	7	1	e	t	2	4	9	8	6	5	3
R	5	3	2	0	e	4	6	t	9	7	1	8
RI	e	1	2	4	5	0	t	6	7	9	3	8
S	1	6	0	2	3	e	9	4	5	7	8	t
I	2	9	3	1	0	4	6	e	t	8	7	5
R	t	8	7	5	4	9	e	3	2	0	6	1
RI	8	t	e	1	2	9	7	3	4	6	0	5
S	3	8	2	4	5	1	e	6	7	9	t	0
I	4	e	5	3	2	6	8	1	0	t	9	7
R	6	4	3	1	0	5	7	e	t	8	2	9
RI	7	9	t	0	1	8	6	2	3	5	e	4
S	9	2	8	t	e	7	5	0	1	3	4	6

Box 3

R	0	t	9	7	6	e	1	5	4	2	8	3
RI	5	7	8	t	e	6	4	0	1	3	9	2
S	e	4	t	0	1	9	7	2	3	5	6	8
I	1	8	2	0	e	3	5	t	9	7	6	4
R	2	0	e	9	8	1	3	7	6	4	t	5
RI	t	0	1	3	4	e	9	5	6	8	2	7
S	8	1	7	9	t	6	4	e	0	2	3	5
I	3	t	4	2	1	5	7	0	e	9	8	6
R	4	2	1	e	t	3	5	9	8	6	0	7
RI	6	8	9	e	0	7	5	1	2	4	t	3
S	7	0	6	8	9	5	3	t	e	1	2	4
I	9	4	t	8	7	e	1	6	5	3	2	0

Box 4

RI	0	2	3	5	6	1	e	7	8	t	4	9
S	5	t	4	6	7	3	1	8	9	e	0	2
I	e	6	0	t	9	1	3	8	9	e	0	2
R	1	e	t	8	7	0	2	6	5	3	9	4
RI	2	4	5	7	8	3	1	9	t	0	6	e
S	t	3	9	e	0	8	6	1	2	4	5	7
I	8	3	9	7	6	t	0	5	4	2	1	e
R	3	1	0	t	9	2	4	8	7	5	e	6
RI	4	6	7	9	t	5	3	e	0	2	8	1
S	6	e	5	7	8	4	2	9	t	0	1	3
I	7	2	8	6	5	9	e	4	3	1	0	t
R	9	7	6	4	3	8	t	2	1	e	5	0

The reason for grouping these forty-eight row forms into four twelve-by-twelve boxes[72] will be made clear later on, when methods of reading these boxes, and applying them to time-points, are discussed.

72 These twelve-by-twelve boxes are not traditional twelve-tone matrices: all horizontal rows contain complete series, but most vertical columns do not.

A considerably more complicated method of deriving some of *Spin*'s note-lists is the "modulus array,"[73] a technique I developed to provide pitch repetition while maintaining the sequential order of the row.

The surface of a musical composition produced with standard twelve-tone rows has a certain sound to it: generally speaking, all twelve pitches will be heard before a pitch is repeated.[74] Using the transposition array discussed previously, and reading its rows horizontally, pitch repetitions (or recurrences of a pitch with only a few other pitches in between) will be found only at the boundary-points between two row-forms, and even then there will never be more than two occurrences of the same pitch in any contiguous segment of twelve pitches.

If a composer employs rows with built-in pitch repetitions, the musical surface of a composition changes significantly: certain pitches take on momentary hierarchical importance when they are repeated, especially if this repetition occurs at the top or bottom of the range. To produce this type of sound in his compositions, Milton Babbitt uses what he has termed "weighted aggregates."[75] An aggregate is a representation of pitch classes generated by different (but usually related) twelve-tone rows, and a weighted aggregate is one that contains repetition of at least one pitch. Babbitt's procedures for producing weighted aggregates vary from composition to composition, and are often quite complicated. Generally speaking, Babbitt's weighted aggregates are produced by partitioning[76]—the creation of new series by concatenation of small portions of other series. As Babbitt explains, the use of weighted aggregates and their

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73 The modulus array is not an array of moduli, but an array of pitches produced by moduli.

74 Though this is a broad generalization, it is true that the original goal of twelve-tone composition was to remove all hierarchy of pitch-class by keeping all twelve tones in constant rotation. Babbitt states, though, that "The idea that you can't repeat a note until you've heard all twelve notes is nothing but a legend." (*Words About Music*, 43.)

75 For further discussion of weighted aggregates, see Babbitt's article, "Since Schoenberg," *Perspectives of New Music* 12/1–2: 3–28.

76 Babbitt discusses partitioning in *Words About Music*, 85-120.

resulting pitch repetitions will "affect the sound of the piece like crazy," [77] and it is this effect that I desired for *Spin.*

Weighted aggregates, though, are not—technically speaking—series. They comprise ordered groups of pitches, but the pitches within each group are not strictly ordered. Thus, weighted aggregates progress from one pitch-group (usually two, three, or four pitches partitioned out of another series) to another. For *Spin,* I wanted to produce the effect of weighted aggregates and their resultant pitch repetitions, but I did not want to obscure relationship to the original row by using partitioning. To accomplish these goals, I developed the modulus array.

A modulus array uses moduli derived from time-point intervals to produce a twelve-by-twelve array of twelve-note rows, all of which contain at least one pitch-duplication (and therefore, at least one pitch-omission). The rows produced by the modulus array are not weighted aggregates as defined by Babbitt, as they are not formed from partitions of other rows, but rather are produced by a transformation of complete row forms.[78] Another important difference is that the rows of a modulus array, because they are derived from ordered rows instead of partition-sections, retain at least some semblance of order-significance.

The construction of a modulus array is relatively simple. The first step is to transform twelve identical iterations of a series by using its twelve consecutive durational intervals as moduli. This produces at least one pitch-repetition (and, therefore, one pitch omission) in each row.

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77 *Words About Music,* 101.

78 In response to a letter in which I outline my modulus array transformation, Babbitt explains that "If 'aggregate' has any stability as a term, it is to designate a partially ordered combination of related series, usually of twelve or more elements. What you have produced are, strictly speaking, series (for they are linearly ordered), and such series as you have produced are (that is, have been) termed: 'series with repetitions,' and I suspect this is the best one can do." (Letter to author, December 1999)

The following chart shows the first step in creating a modulus array with the S form of the row used in *Spin.*

0	5	e	1	2	t	8	3	4	6	7	9	--- mod 5 --->	0	0	1	1	2	0	3	3	4	1	2	4
0	5	e	1	2	t	8	3	4	6	7	9	--- mod 6 --->	0	5	5	1	2	4	2	3	4	0	1	3
0	5	e	1	2	t	8	3	4	6	7	9	--- mod 2 --->	0	1	1	1	0	0	0	1	0	0	1	1
0	5	e	1	2	t	8	3	4	6	7	9	--- mod 1 --->	0	0	0	0	0	0	0	0	0	0	0	0
0	5	e	1	2	t	8	3	4	6	7	9	--- mod 8 --->	0	5	3	1	2	2	0	3	4	6	7	9
0	5	e	1	2	t	8	3	4	6	7	9	--- mod 10 --->	0	5	1	1	2	0	8	3	4	6	7	9
0	5	e	1	2	t	8	3	4	6	7	9	--- mod 7 --->	0	5	4	1	2	3	1	3	4	6	0	2
0	5	e	1	2	t	8	3	4	6	7	9	--- mod 1 --->	0	0	0	0	0	0	0	0	0	0	0	0
0	5	e	1	2	t	8	3	4	6	7	9	--- mod 2 --->	0	1	1	1	0	0	0	1	0	0	1	1
0	5	e	1	2	t	8	3	4	6	7	9	--- mod 1 --->	0	0	0	0	0	0	0	0	0	0	0	0
0	5	e	1	2	t	8	3	4	6	7	9	--- mod 2 --->	0	1	1	1	0	0	0	1	0	0	1	1
0	5	e	1	2	t	8	3	4	6	7	9	--- mod 3 --->	0	1	1	1	2	1	2	0	1	0	1	0

The next and final step is to transpose the resulting horizontal rows, using the consecutive transposition levels of the initial row.

0	0	1	1	2	0	3	3	4	1	2	4	--- T0 --->	0	0	1	1	2	0	3	3	4	1	2	4
0	5	5	1	2	4	2	3	4	0	1	3	--- T5 --->	5	t	t	6	7	9	7	8	9	5	6	8
0	1	1	1	0	0	0	1	0	0	1	1	--- T11 --->	e	0	0	0	e	e	e	0	e	e	0	0
0	0	0	0	0	0	0	0	0	0	0	0	--- T1 --->	1	1	1	1	1	1	1	1	1	1	1	1
0	5	3	1	2	2	0	3	4	6	7	9	--- T2 --->	2	7	5	3	4	4	2	5	6	8	9	3
0	5	1	1	2	0	8	3	4	6	7	9	--- T10 --->	t	3	e	e	0	t	6	1	2	4	5	7
0	5	4	1	2	3	1	3	4	6	0	2	--- T8 --->	8	1	0	9	t	e	9	e	0	2	8	t
0	0	0	0	0	0	0	0	0	0	0	0	--- T3 --->	3	3	3	3	3	3	3	3	3	3	3	3
0	1	1	1	0	0	0	1	0	0	1	1	--- T4 --->	4	5	5	5	4	4	4	5	4	4	5	5
0	0	0	0	0	0	0	0	0	0	0	0	--- T6 --->	6	6	6	6	6	6	6	6	6	6	6	6
0	1	1	1	0	0	0	1	0	0	1	1	--- T7 --->	7	8	8	8	7	7	7	8	7	7	8	8
0	2	2	1	2	1	2	0	1	0	1	0	--- T9 --->	9	e	e	t	e	t	e	9	t	9	t	9

An important property of the modulus array can be illuminated by comparing it with an array comprising the non-reduced forms of the row, transposed to the same pitches used to transpose the rows of the modulus array. This allows us to see which pitches are changed and which pitches are invariant when transposed S row-forms are run through the S time-point-interval moduli of the modulus array.

Transposed Series

0	5	e	1	2	t	8	3	4	6	7	9
5	t	4	6	7	3	1	8	9	e	0	2
e	4	t	0	1	9	7	2	3	5	6	8
1	6	0	2	3	e	9	4	5	7	8	t
2	7	1	3	4	0	t	5	6	8	9	e
t	3	9	e	0	8	6	1	2	4	5	7
8	1	7	9	t	6	4	e	0	2	3	5
3	8	2	4	5	1	e	6	7	9	t	0
4	9	3	5	6	2	0	7	8	t	e	1
6	e	5	7	8	4	2	9	t	0	1	3
7	0	6	8	9	5	3	t	e	1	2	4
9	2	8	t	e	7	5	0	1	3	4	6

Modulus Array / # of Invariants

												# of Invariants
0	0	1	1	2	0	3	3	4	1	2	4	5
5	t	t	6	7	9	7	8	9	5	6	8	6
e	0	0	0	e	e	e	0	e	e	0	0	2
1	1	1	1	1	1	1	1	1	1	1	1	1
2	7	5	3	4	4	2	5	6	8	9	3	8
t	3	e	e	0	t	6	1	2	4	5	7	10
8	1	0	9	t	e	9	e	0	2	8	t	7
3	3	3	3	3	3	3	3	3	3	3	3	1
4	5	5	5	4	4	4	5	4	4	5	5	2
6	6	6	6	6	6	6	6	6	6	6	6	1
7	8	8	8	7	7	7	8	7	7	8	8	2
9	e	e	t	e	t	e	9	t	9	t	9	2

Comparing the two boxes, we find that there are forty-eight pitches unchanged by the modulus array. This is not particularly surprising, as we understand that the only notes to "pass through" the moduli comprising the modulus array are the ones that are within the span of the moduli applied to each row. It makes sense that the number of invariant pitches, then, is equal to the total sum of the moduli (which is equal to the total sum of the durational intervals). What is perhaps more surprising, though, is that these forty-eight invariant pitches comprise an aliquot distribution of the total chromatic (four of each pitch class). This holds true in any modulus array: the number of invariant pitches between non-modulated transpositions and the modulus array will always be equal to the sum of the durational intervals used as moduli. The reason for this is easy to grasp if we think of the durational intervals as points on a linear continuum not reduced mod 12.

mod 12	0	5	11	1	2	10	8	3	4	6	7	9	(0)
no modulus	0	5	11	13	14	22	32	39	40	42	43	45	48

When seen in this modulus-free format, it is obvious that each horizontal row of the modulus array "keeps" (allows "through" the modulus) only the pitches that lie within the durational intervals outlined above. This is illustrated by the following chart, which—in the final column—shows that the first row keeps pitches 0 through 4, the second row keeps pitches 5 through 10, the third 11 and 0, etc., until the total of forty-eight (four iterations of the series 0 through 11) is reached.

row of array	modulus	invariant pitch classes	transposition	transposed invariants
first	5	0–4	0	0–4
second	6	0–5	5	5–10
third	2	0, 1	11	11, 0
fourth	1	0	1	1
fifth	8	0–7	2	2–9
sixth	10	0–9	10	10–7
seventh	7	0–6	8	8–2
eighth	1	0	3	3
ninth	2	0, 1	4	4, 5
tenth	1	0	6	6
eleventh	2	0, 1	7	7, 8
twelfth	3	0–2	9	9–11

It is also possible to create modulus arrays using pitch rows and time-point rows that are not isomorphically related. For example, a modulus array could be constructed by running R pitches through S time-points. Though this technique will often produce interesting note-lists filled with pitch-repetition, its integrity is questionable as the pitches and moduli have little in common, and the consistency of the total chromatic (when comparing invariants) is not preserved.

The question now is how these transformations of pitch rows are to be applied to the surface of the composition. The two types of arrays used in *Spin*—transposition arrays and modulus arrays—are written in twelve-by-twelve boxes for a reason: they can be read either in horizontal rows or in vertical columns, each producing vastly different results.

Reading a transposition array horizontally results in a progression of complete series, each containing the total chromatic. As was mentioned earlier, pitch repetition will occur occasionally at boundaries between rows, but the general effect is one of "all the notes, all the time." This is a familiar sound in twelve-tone music.

If a transposition array is read vertically, however, a very different musical surface is produced. Because the horizontal rows are based on a rotation of row forms, the resulting vertical columns do not necessarily comprise the total chromatic and repetition of pitch often occurs within them. On a larger scale, though, an aliquot distribution of the total chromatic remains within the twelve-by-twelve box. Because each horizontal row is a complete series containing the total chromatic, a vertical reading of the box's twelve columns—though replete with local pitch repetition—will contain, within 144 pitches, exactly twelve representations of each pitch class. This makes the vertical reading of a transposition array similar to a process of rotation: twelve complete series, each series comprising the total chromatic, are rearranged by an ordered rotational scheme that results in unequal pitch distribution per twelve notes.[79]

Modulus arrays, on the other hand, do not have an equal distribution of pitches in twelve-pitch rows, in twelve-pitch columns, or even in the entire 144-pitch twelve-by-twelve box. Though the transposition arrays are read both horizontally and vertically in *Spin*, modulus arrays are read in only one direction: vertically. A horizontal reading of a modulus array would result in extensive local pitch-repetition. A horizontal row at mod 1, for example, produces twelve consecutive repetitions of the same pitch; a row at mod 2 produces six repetitions each of two pitches. When read in vertical columns, however, the pitch-repetition of the modulus array is not as extreme on a local level (per twelve pitches, for example) but takes on more significance at a general perceptual level (per twelve-by-twelve box). The reason for this lies in the way listeners perceive and attach significance to pitch repetition.

79 These resulting "series with repetitions" are actually much closer to Babbitt's definition of weighted aggregate than are the rows produced by the modulus array. The partitions of rows used to create the vertical columns in the transposition array, though, are single pitches, as opposed to the partitions of two, three, or four pitches that comprise the segments of traditional weighted aggregates.

As mentioned above, a horizontal reading of a modulus array will occasionally result in twelve consecutive occurrences of the same pitch. Were this to happen on the surface of a musical composition this phenomenon might be interpreted by the listener in any number of ways. If the twelve identical pitches were heard spaced evenly over a relatively short span of time, a listener might perceive the sequence as one pitch event sustained by varied articulation and the significance of the repetition would be lost. It is my opinion that pitch repetition is far more effective (perceptually speaking) if the repeated pitches are heard as consistent recurrences, popping up regularly but intermittently, and with other pitches in between. That is, a listener will comprehend that a certain pitch is more prevalent, statistically, than others.

Consider, now, a modulus array read vertically: the horizontal rows of twelve identical pitches mentioned above would now be spaced in such a way that every twelfth note of the array (read vertically) will be the same. This, of course, is in addition to all the other repetitions of that pitch likely to be found elsewhere in the modulus array. The persistence of certain pitches over the course of a relatively long period of time (per 144 notes as opposed to twelve) will seem more structurally significant to the listener than will a momentary flurry of consecutive repetitions of the same pitch.

Another feature of reading modulus arrays vertically is that certain twelve-note columns will contain the total chromatic. A horizontal reading will never produce more than eleven distinct pitches before repetition occurs (because, by definition, no row passes through a mod-number greater than eleven). A vertical reading guarantees a complete series in the first vertical column of each twelve-by-twelve box, and other verticals can also contain the total chromatic, depending on the time-point interval total of the row used to create the modulus array.

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As discussed, three types of pitch arrays are used to create note-lists in *Spin*: transposition arrays read horizontally, transposition arrays read vertically, and modulus arrays read vertically. The question, then, is how to apply these arrays to the existing time-points produced by nesting, rotation, and deletion.

The method used to apply pitch to time-points might at first seem obvious. A common misconception about the time-point system is that time-point rhythms and the pitches from which they are derived are necessarily equivalent. Babbitt explains that "It must not be inferred that this time-point system…implies a one-to-one compositional application of the two systems. The rhythmic system is closed…[:] it can be applied as independently as the pitch system."[80] Pieces can, of course, be composed using a one-to-one relation of pitch rows to their isomorphic rhythmic rows, but this is not necessary, or even desirable. Though we have used pitch information to determine some structural and rhythmic principles, there is no compelling reason to link the two on the composition's surface. After all, rhythm will produce certain distinct motives, and pitch will produce certain distinct motives (some melodic, some harmonic). A combination of the two—as opposed to a one-to-one relationship—will often create more interesting situations than will a strict relationship (as seen in the Boulez and Messiaen examples mentioned previously). For example, assuming a temporal modulus of twelve sixteenth notes, the interval of a major third (four half steps) would always be separated by the distance of one quarter note (four sixteenth notes) if a strictly isomorphic association of rhythm and pitch was employed. Over the course of a long composition, this direct relationship of pitch to time-points would likely become tiresome.

As mentioned, the three pitch array types found in *Spin* have distinct characters. The transposition array read horizontally can be considered the most "stable" of the types: it maintains the total chromatic every twelve notes, with only occasional pitch repetition at boundaries between rows. A transposition array read vertically is less "stable": pitch

80 *Twelve-Tone Rhythmic Structure and the Electronic Medium,* 71–72.

repetitions abound, though an aliquot distribution of the total chromatic is still maintained every 144 notes. A modulus array (always read vertically in the case of *Spin*) is the least "stable" of the three arrays: pitches repeat often, and an aliquot distribution of the total chromatic is not maintained within the 144-pitch twelve-by-twelve box (though at least one of its twelve-note vertical columns will contain the total chromatic).

Over the course of *Spin*, there are two long-term progressions from "less stable" to "stable," the first with M7 row forms, and the second with standard row forms. The M7 transformation is a relatively simple process of multiplication. Each pitch of the row is multiplied by seven, then reduced mod 12 to create a new row. The M7 transformation is also called the "circle of fifths" transformation, as its operation will change a chromatic scale into a circle of fifths, as seen in the following chart.

chromatic scale	0	1	2	3	4	5	6	7	8	9	10	11
multiplied by 7	0	7	14	21	28	35	42	49	56	63	70	77
mod 12	0	7	2	9	4	11	6	1	8	3	10	5

Note that the M7 transformation leaves half the pitches (the even numbers) unchanged, while the other half of the pitches are transposed by a value of six (the interval of the tritone). This is the case every time that M7 is employed. Here is the S form of the *Spin* row, modified by M7.

S	0	5	11	1	2	10	8	3	4	6	7	9
M7	0	11	5	7	2	10	8	9	4	6	1	3

Though none but M7 is employed in *Spin*, there are other multiplicative transformations available to composers. M5, a transformation in which each pitch is multiplied by five (mod 12), is inversionally related to M7. The following chart shows the relationships between a chromatic scale and its M7 and M5 transformations. Note that the pitches produced by M5 are the inversions of those produced by M7. Note also the justification for M5's other name: the "circle of fourths" transformation.

chromatic scale	0	1	2	3	4	5	6	7	8	9	10	11
M7	0	7	2	9	4	11	6	1	8	3	10	5
M5	0	5	10	3	8	1	6	11	4	9	2	7

The M5 transformation causes eight pitches to change (compared to six for M7), but the total chromatic is maintained. Other multiplicative transformations—M2, M3, M4, M6, M8, M9, and M10—will result in rows that do not contain the total chromatic. Note that M1 results in no change to pitches, and that M11 is simply inversion.

M7 is used on all the arrays that comprise the first half of *Spin*'s master note-list, while the original arrays comprise the second half.

Section A	M7 modulus arrays	read vertically
	M7 transposition arrays	read vertically
	M7 transposition arrays	read horizontally
Section B	modulus arrays	read vertically
	transposition arrays	read vertically
	transposition arrays	read horizontally

Each of the six sets of arrays (four twelve-by-twelve boxes each) contains 576 pitches, resulting in a total of 3,456 ordered pitches.[81] The total number of time-points comprising the rhythmic map is 3,470. With a difference of only fourteen between total pitches and total time-points, it is a relatively simple matter to make some minor adjustments to the system that allow the two to line up. Two extra iterations of the S

81 Charts illustrating all the transposition and modulus arrays used in *Spin* are provided in Appendices 3 and 4. Note that there are four array-sets (each comprising four twelve-by-twelve boxes), not six. This is because the transposition array-sets are each used twice: read once vertically, and once horizontally.

form of the row are added to the end of the note-list to complete the designation of pitches to time-points, and to form the work's concluding chord.

The question of how pitches are to be applied to time-points is an interesting one. Since we have noted that rhythms do not need to be attached to the pitches from which they were derived, a number of possibilities become available.

It would be possible to attach pitches discretely to each of the individual linear rhythmic strands of the piece. In *Spin*, for example, one portion of the note-list could be attached to the flute strand, another portion to the violin strand, etc. Perceptually, though, this method is somewhat problematic: will the listener be able to comprehend four simultaneously unfolding strands of discrete pitch information? A potentially more important question, as it pertains not to the perceptual abilities of the listener but to the structural coherence of the composition, is that of harmonic (as opposed to melodic) interval: as we've mentioned, a melody is not so much a succession of pitches as it is a succession of intervals. Therefore, if two discrete pitch strands are heard simultaneously, the listener is hearing not just the intervals formed *within* each melodic line but also the intervals formed *between* the two melodic lines as well. These somewhat randomly produced simultaneously sounding intervals, whether pleasing or displeasing to the composer, are not part of the (presumably) carefully planned pitch-scheme of the composition. This situation is not necessarily undesirable, but it must be noted and considered by the composer. With *Spin*, I chose to use a system that would avoid this situation.[82]

It is to counteract this problem of renegade intervals formed haphazardly by the interaction of linear note-lists that Wuorinen often advocates the "spraying" of a note-list onto all instrumental strands at once, chronologically. That is, Wuorinen recommends that composers apply one strand of pitches to all rhythmic strands of the composition as

82 My *Sonnet No. 2* (1999) for unaccompanied flute, on the other hand, does in fact comprise two simultaneously unfolding strands of pitch, as will be discussed later.

they occur sequentially in time. Therefore, the string of notes will jump from instrument to instrument, preserving the intervallic content (whether melodic or harmonic) of the note-list. When two or more time-points occur simultaneously, the required pitches are simply assigned—one each—to the strands involved. Later, in the composing-out process, these simultaneously sounding pitches may be traded between the instruments to produce the desired harmonic effect. Pitch-order is maintained.

It is this "spraying" technique that is used in *Spin.* A single master note-list—shown above in its two identical progressions from "unstable" to "stable"—is applied chronologically to every time-point of the composition.

In concluding this discussion of pitch information in *Spin*, it is noteworthy that every pitch in *Spin* is notated with a separate accidental (a natural, a sharp, or a flat). This notational practice, first used by Schoenberg and now employed by a handful of composers, is useful in that it avoids questions of whether accidentals are to "carry through" the measure. Interestingly, I have found that performers seldom even notice the difference, and when it is pointed out to them, they are usually amenable to the practice. Further, as an aid to performers, it is always better to use "common" accidentals (F natural instead of E sharp, for example) and, whenever possible, intervals and chords should be spelled to clearly express the relative size of the intervallic relationship of their constituent pitches. These questions are addressed by Wuorinen in *Simple Composition.*

> A remark should be made on the spelling of pitches in a world without the *a priori* functional relations of the tonal system, in which the twelve tones are in constant circulation. Two principles should be observed:
>
> 1. Place an accidental before *every* note head, in the manner of the examples [in *Simple Composition*]. This removes all possible ambiguity about whether a note is sharp, flat, or natural; and the visual consistency the practice produces more than makes up for the slight extra labor in writing.…
>
> 2. Spell intervals in the way that most closely correlates their actual size with their representation on the staff: Thus, generally write B-flat/D-

> flat rather than A-sharp/D-flat, etc. Often, consistency in this regard is impossible, but the general principle is still valid.…[83]

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83 Wuorinen, *Ibid.*, 9–10.

7. *Spin*: Orchestration, Contextual Choice, and Modification

Nesting, rotation, and deletion define most of *Spin*'s orchestrational landscape, determining which instruments are active at any given moment. Still, there are a few decisions that are made contextually, based only generally, if at all, on the overall structure as determined by time-points.

Though note durations are not serially determined, none have been extended long enough to affect the general permutation of instrumental combination as defined by the basic rhythmic map. That is, no long notes extend significantly into spaces that are structurally determined to be "empty."

The choice of vibraphone or marimba in the percussion strand is partly determined by large-scale structure. The vibraphone, an instrument with sustaining capability, is employed in the longer (sparser) sections, while the marimba, with its quick decay, is used in the shorter (denser) sections. The vibraphone, of course, can be played staccato (by playing technique and/or mallet choice), but as this is not the characteristic sound of the instrument, staccato notes are kept to a minimum. Conversely, the marimba can create the illusion of sustain through use of the roll, but again this technique is rarely employed in *Spin.* In the first and last large-scale sections of the percussion strand (which are of medium density), the percussionist plays marimba and vibraphone, but never both at the same time: there is always at least a beat or two in which to switch instruments.

The following chart indicates the orchestration of the percussion part from section to section. Note that because this is the percussion strand, these sections also correspond to the original "source strand."

section	number of beats	instrument
1	120	mba + vibr
2	144	vibr
3	48	mba
4	24	mba
5	192	vibr
6	240	vibr
7	168	vibr
8	24	mba
9	48	mba
10	24	mba
11	48	mba
12	72	mba + vibr

Though it may initially appear that the marimba is used far more often than is the vibraphone, note that the vibraphone is used exclusively in the four longest sections of the strand, and that the 744 beats that comprise these four sections account for nearly sixty-five percent of the entire composition. Adding in the two sections that include both vibraphone and marimba, it is obvious that the percussionist spends most of the time at the vibraphone. On the other hand, notice that the percussionist plays more complete sections, and therefore more actual time-point events, at the marimba. Also note that the two "empty" sections, each containing only twenty time-point events (as opposed to one hundred in the "full" sections), are Sections 2 and 5, both of which are assigned to the vibraphone. The following chart shows the relationship of vibraphone and marimba in terms of number of beats, and number of time-points (given in raw numbers and in percentages).

instrument(s)	sections	total beats	total time-points
marimba	3, 4, 8, 9, 10, 11	216 (19%)	600 (58%)
vibraphone	2, 5, 6, 7	744 (64%)	240 (23%)
marimba and vibr.	1, 12	192 (17%)	200 (19%)

Orchestration of the other instruments is linked very closely to the original structural plan, but a certain exception is made fairly consistently: once the rhythmic map has determined the general orchestration of a given measure or group of measures, I have allowed myself the freedom to exchange events between instruments. If, for example, the original rhythmic map has determined that a certain portion of the work is a duet between, say, flute and cello, I do not strictly maintain the division of notes between those two instruments as defined by the strands. That is, if a pitch does not work well in the cello (perhaps for reasons of register), I will place it in the flute line. The important factor is that the section of music has been determined to be a duet between cello and flute, and this orchestrational combination is maintained, though specific notes are distributed for best overall musical effect. Note that this does not significantly alter the original scheme of pitch-to-time-point distribution. Melodic and harmonic implications of the note-list are still truly represented. The only modification is one of timbre, and that modification is only at an extremely local level.

A number of compositional decisions in *Spin* are not based on time-points at all. These elements of the composition serve to amplify or diminish—as aesthetics dictate—aspects of the composition that are serially defined. As has already been mentioned, durations are not prescribed by any pre-compositional system. By freeing this aspect of composition, it is possible to create chords that extend certain harmonies, or rhythms that downplay others, to best serve the linear or harmonic direction of the pitches and rhythms that have been determined by time-point relationships.

As we have seen in the work of Boulez and Babbitt, dynamics, too, can be serialized. In *Spin,* they are not. It would be very difficult to perceive four simultaneously unfolding strands of serialized dynamic markings (not to mention the strain this would place on performers); the result would be a statistical artifact, as opposed to a musical expression, as each measure would likely contain many extremes of dynamic range. Even if an ordered series of dynamic indications was "sprayed" on the time-points in the manner of pitch, this too would present extraordinary perceptual difficulty for the same reasons. Furthermore, dynamic markings are relative and do not have the defined boundaries that allow pitch and rhythm to function serially. The dynamics in *Spin* have been selected to reinforce relationships between instrumental combinations produced by nesting and rotation. Dynamics also serve as broad determiners of compositional effect: general shifts from soft to loud, loud to soft, etc., lend musical cohesion and dramatic direction to the algorithmically produced confluence of rhythms and pitches.

Articulation is another aspect of *Spin* that is not serially determined. Marks for staccato, legato, tenuto, etc., are used to articulate surface-level rhythm, define phrases, and indicate broad aspects of compositional direction.

The question of tempo is potentially stickier. It would seem that for the note-to-note relationships derived from time-points to be effective, the rate of unfolding must be reasonably consistent. In the case of *Spin*, the tempo is the same throughout, with exceptions only during solo passages marked *molto espressivo*, when the player (or conductor) will feel free to momentarily adjust the tempo for aesthetic reasons. The only notated change in tempo is found at the double bar before the work's conclusion, where the small jump in tempo is intended to intensify excitement as all instruments play through dense segments of their strands.

As we now turn to discussion of some fairly significant modifications to the original sketches on which *Spin* is based, we must recall Wuorinen's suggestion that "when the piece has reached, through application of the method [nesting], a sufficient degree of completeness, it will begin to assert its own rights and needs."[84] Most of the major structural modifications to *Spin* appear in the realm of rhythm.

Rhythm in *Spin* is derived from time-point nesting, rotation, and deletion, but we recall from earlier in the discussion that certain modifications are made during the nesting process. In very short subsections, an even distribution of the twelve attacks (before deletion) is substituted for a distribution that takes time-point proportions into account. For example, some subsections are only three eighth notes in length. As it is unreasonable to divide this—maintaining a strict relationship to the divisional time-points—without notating "impossible" rhythm (extraordinarily difficult for performers to execute and for listeners to hear), evenly spaced thirty-second notes are employed instead. And in subsections of slightly greater length, the time-point divisions are modified to reflect the general characteristics of the time-point proportions that they represent without creating durations so short as to make accurate performance—and, perhaps more important, perception—unlikely.

Another rhythmic modification used extensively in Spin is the forcing of a "triplet feel" on the rhythms of certain measures. Late in the compositional process (after, as Wuorinen would say, the composition began to assert its own rights and needs), I decided that every measure with an eighth-note time-signature "denominator" would be modified so that all rhythm within would fit into a quantization of sixteenth-note triplets. Doing so foreshadows the work's conclusion, at which time measures of triple feel predominate and eventually lead to the streams of sextuplets that fill the final measures. The triplet feel modification also carries an articulative component, as staccato marks are used on sixteenth-note triplets to turn these short measures into bouncy interjections with a marked difference in character from the measures around them.

It is interesting to note here that the measures chosen for transformation to a triplet feel are not in any way based on divisions made by time-points, but rather are determined

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84 Wuorinen, *Ibid.*, 148.

by measure-divisions, which are made solely for the players' convenience. At the time that meter signatures were determined, I had no idea that I would eventually be selecting certain measures for this triplet transformation. This intuitive contextual modification, though not algorithmically determined, creates interest and lends cohesion as the triplet sections anticipate the work's conclusion.

Another deviation from the structural plan was mentioned previously, in the chapter on orchestration: when musically necessary, pitches are traded between instrumental strands. At other times, pitches are simply stolen from other lines, never to be returned. These occasional deviations—again, made once the piece had reached a high degree of completeness—do not significantly affect the overall orchestration, but they do have the helpful effect of maintaining a directed musical line at the local level.

I likewise deviated from the original structural plan in very dense sections, in which pitches are often left out to avoid excessive repetition—repetition not created qua repetition (as with modulus arrays), but repetition occurring coincidentally as a result of time-point density. An example can be found in the final section of the piece, where the note-list comprises horizontally-read transposition arrays. The pitch rows that inform the horizontally-read transposition arrays each comprise the total chromatic, without much repetition, but in the high densities of the concluding sections, pitch repetitions are created by density, not by algorithmic transformation. Because of this, removal of some of these repeated notes does not affect the large-scale structure. This process of removing certain repetitions of pitch results in a sort of partitioning: if a specific pitch class is found in both the cello strand and the flute strand in close proximity, it is simply assigned to one and deleted from the other (unless the linear directions of the two lines are such that they can each sound the note in the same octave). If this technique is employed too often, it will decrease the significance of the note-lists (which are carefully designed to produce, or not produce, the very pitch repetition in question), but occasional contextual deviations allow for better articulation of the overall musical shape.

In *Spin*, there are two portions of the work that contain interesting modifications of the original compositional scheme. The first is found in measures 222–227. In the preliminary sketches, this portion of the composition is extremely sparse; all instruments are in the middle of long sections of the source strand, and the process of deletion creates additional space between time-point events. In the original rhythmic map, measure 222 is scored for vibraphone solo, and there are no other time-points, in any instrumental strand, for twenty-five beats (beginning in measure 223) afterward. This large hole—which became known as The Great Divide in rehearsals for the work's premiere performance[85]—created by the process of nesting, rotation, and deletion—poses a significant compositional problem.

I thought of four possible ways to deal with the gap in the middle of my composition. One possibility was to simply close the gap by deleting those twenty-five beats from the score. This did not seem appropriate, however, as the process of nesting, combined with deletion, was deliberately designed to produce an extreme thinning of texture in the middle of the composition. I had not realized just how much thinning there would be, but I still wanted to remain true to this important structural feature.

A second possibility was to simply recognize the silence with twenty-five beats of rest (which, at a tempo of seventy-two beats per minute, would amount to about twenty seconds of silence). The third possibility was to pause at the divide, calling the rest of the composition Movement II.

None of the three possibilities mentioned above seemed like a good solution to the problem. Deletion of the space seemed too drastic a modification of the original structural plan, but a conductor beating twenty-five beats of silence smacks of Dadaism, which is certainly not the aim of the composition. Dividing the piece into two movements is

85 *Spin* was premiered in New York City on May 4, 1999 by the Society for Chromatic Art: John McMurtery, flute; Jennifer Williams, violin; Jeffrey Shah, cello; Tony Oliver, percussion; James Romig, conductor.

misleading: the two long spans of music separated by The Great Divide do not reflect large-scale sectional divisions in any of the strands, and the process of rotating the "source strand" to produce the other strands seems to necessitate the work being expressed in a single movement. So I opted for a fourth solution, which was to sustain the music from one side of the break to the other (bridging the gap, so to speak).

The first thought I had was to sustain the vibraphone, with a combination of rolling and sustain pedal, for the twenty-five beats in question. I quickly realized, however, that twenty seconds of ringing vibraphone—whether a single note, or a chord of two, three, or four pitches—would be monotonous. At this point, I made the decision to break the orchestrational pattern outlined by the original structural plan: instead of a vibraphone solo, I would use all the instruments of the ensemble to articulate this crucial portion of the structure. I decided that a four-note simultaneity—derived from the last four pitches of the vibraphone strand—would be sustained over the twenty-five-beat chasm. Rather than stretching one statement of the chord over the space, I decided to re-articulate the chord four times, each time changing the orchestration and shortening its duration. In addition to being far more practical for the flute player, this afforded the opportunity to maintain musical interest and to reinforce the notion that this passage constitutes a significant feature of the work's structure.

I decided that there would be four statements of the chord, and that each would be successively shorter in duration than the one before. In addition to the shortening of durations, each repetition of the chord spanning The Great Divide is successively softer, and differently orchestrated to produce changes in timbre. The vibraphone plays an identical F natural in all repetitions, but the other instruments play different notes of the chord in each repetition: the flute progresses from the top of the chord to the bottom, and the string instruments progress from low notes to high harmonics.

first iteration dynamic = *f*	D natural	flute
	E natural	violin
	B flat	cello
	F natural	vibraphone
second iteration dynamic = *mp*	D natural	violin
	E natural	flute
	B flat	cello
	F natural	vibraphone
third iteration dynamic = *p*	D natural	cello harmonic
	E natural	violin
	B flat	flute
	F natural	vibraphone
fourth iteration dynamic = *ppp*	D natural	violin harmonic
	E natural	cello harmonic
	B flat	flute
	F natural	vibraphone

Another portion of the composition that contains a great deal of modification is the concluding section (from approximately 277 to the end). As mentioned previously, all the measures with eighth-note denominators are forced into a sixteenth-note triplet feel. This rhythmic transformation is gradually applied to more and more measures until—starting in measure 300—the entire conclusion of the work is written in sixteenth-note triplets and multiples of the same (with the single exception of measure 307, in which a septuplet appears in the flute line).

Another modification found exclusively in the concluding section is that certain instrumental lines are doubled to reinforce the climactic feel of the ending. In certain cases, two instrumental strands are combined to create a single strand of pitch and rhythm, articulated simultaneously by both instruments. In other cases, a structurally produced rest of a few beats' length in one strand is filled in with a doubling of melodic information from another strand. This is justified by the fact that, generally speaking, the work's formal plan calls for all instruments to be heard, in "full" and relatively dense sections, at the work's conclusion.

8. Toward a Common Practice

Early in *Simple Composition*, Wuorinen makes a fundamental distinction between composers of the past and composers of the present, observing that things were different "in earlier times, when individual composers made few, or no, fundamental choices of system or method, and when their task was mainly that of filling in and ornamenting the surface of a structure already given by convention and tradition."[86] Though he makes a point to note that "This, of course, in no way minimizes the greatness of the achievements of the Bachs, Mozarts, and Beethovens—nor our love for their works, as listeners," he urges composers to "try to be clear-headed about the circumstances in which they compose," and draws the conclusion that "The artists of the past were not burdened with the necessity of making basic decisions. We must make fundamental choices. *They* had security. *We* have freedom."[87]

By introducing the reader to his methods of composition—both on the small and large scale—Wuorinen outlines a "common practice" of his own, and admirers of his music see each new work as one in a long line, a "tradition" contained within the works of only one composer. In fact, many of Wuorinen's works share not just compositional technique but also compositional raw material. Certain pieces are related, in form, to others.

One technique of deriving a new piece from an old one is by applying an M5 or M7 transformation (described earlier) over the span of an entire compositional structure to

86 Wuorinen, *Ibid.*, 12.
87 Wuorinen, *Ibid.*, 13.

produce a new set of related time-points and pitches that can be re-formed into a new composition. Wuorinen's *Horn Trio*,[88] composed in 1981, was transformed by an R-M5 transformation to become *Horn Trio Continued*[89] in 1985.

Another method of constructing a composition is one that Wuorinen describes as "iterative." This is a way to structure a new work, or to create a new work from a segment of an old work. In an iterative composition, a segment of music is stretched or compressed a number of times to create sections of varying density. In addition to this time-stretching, additional transformations—transposition, multiplicatives, etc.—may also be employed. Wuorinen's *Fortune*,[90] composed in 1979, is a work in which multiple structural factors are at play, but one immediately noticeable is the recurrence of a tonal-sounding iteration first heard (as if in "F major") in the work's opening measures, and subsequently heard—in compressed and transposed form—as the work progresses.

My *Variations for string quartet*[91] is an example of iterative composition. Here the "iteration" is a short (one minute) piano piece written in 1996 titled *New York Minute*.[92] For the string quartet *Variations*, *New York Minute* is compressed or stretched (with a system—too complicated to discuss here—designed to compress rhythm asymmetrically but consistently) into seven sections. The lengths of the sections are based on a ratio of four to three: the one section larger than sixty beats is one and one third times as large; the smaller sections are progressively shorter by three quarters. These sections of progressively smaller size (80, 60, 45, 34, 26, 20, 15) are then intuitively arranged, non-sequentially, with the original iteration of sixty beats appearing as the work's finale. The following chart shows the movements of the *Variations* side by side with their quantities of beats and orderings in size.

88 New York: C.F. Peters, 1994.
89 New York: C.F. Peters, 1994.
90 New York: C.F. Peters, 1979.
91 New Brunswick, New Jersey: Parallax Music Press, 1999.
92 New Brunswick, New Jersey: Parallax Music Press, 1996.

movement	number of beats	rank in size (small to large)
I	45	5
II	20	1
III	80	7
IV	26	3
V	34	4
VI	20	2
VII	60	6

Another technique used by Wuorinen to produce new compositions is the derivation of new works from the structures, or portions of structures, of older works. An example is his *Rhapsody for Violin and Orchestra*[93] of 1983, which is derived from the pitch and time interval-successions[94] found in the violin solo section of his *Reliquary for Igor Stravinsky*[95] of 1975.

Two compositions of mine—*Sonnet*[96] and *Sonnet No. 2*[97] (for solo violin and solo flute, respectively)—are directly derived from the basic structure of *Spin*, and are discussed briefly here.

Sonnet, for unaccompanied violin, lasts approximately three and a half minutes and its structure is derived from the S time-points of the *Spin* row. For such a short composition, only two layers of nesting (as opposed to three for *Spin*) are required. The first level is based on the time-points of M7, and each time-point interval is equivalent to two quarter notes. On the next level of division, each successive section is divided by a rotation scheme of M7, M5, R-M7, and I-M5 forms to produce surface-level time-points. The pitches assigned to the time-points come from the standard (not M7) forms

93 New York: C.F. Peters, 1983.
94 The time-point intervals are augmented by a factor of sixteen.
95 New York: C.F. Peters, 1978.
96 New Brunswick, New Jersey: Parallax Music Press, 1999.
97 New Brunswick, New Jersey: Parallax Music Press, 1999.

of the row in rotation (S, I, R, RI) and transposed to the pitches of S-T9 (A natural), as seen in the following chart.

section	1st division	2nd division	pitch row	transposition
1	11 (22 beats)	M7 t-pts	S	A
2	6 (12 beats)	M5 t-pts	I	D
3	2 (4 beats)	R-M7 t-pts	R	A flat
4	7 (14 beats)	I-M5 t-pts	RI	B flat
5	8 (16 beats)	M7 t-pts	S	B
6	10 (20 beats)	M5 t-pts	I	G
7	1 (2 beats)	R-M7 t-pts	R	F
8	7 (14 beats)	I-M5 t-pts	RI	C
9	2 (4 beats)	M7 t-pts	S	D flat
10	7 (14 beats)	M5 t-pts	I	E flat
11	2 (4 beats)	R-M7 t-pts	R	E
12	9 (18 beats)	I-M5 t-pts	RI	F sharp

Double-stops are employed as two-voice counterpoint in longer sections, and as two-note chords in shorter sections. As is the case in *Spin*, note-durations are not algorithmically determined. (Register, dynamics, and articulations, too, are contextually chosen.) There are no deviations from the pitches outlined by the original structural plan, but modifications of rhythm similar to those employed in *Spin* can be found: time-points are spread evenly over very short sections, and time-point proportions are modified somewhat in sections of medium length. There are also a few places in the *Sonnet* where measures have been extended by a beat and/or fermati have been added for expressive emphasis.

Sonnet No. 2, for unaccompanied flute, also uses the *Spin* series as its structural basis, but instead of using the row as it appears in *Spin*'s "source strand," it employs the rotation found in *Spin*'s flute strand: 0, 1, 3, 6, 11, 5, 7, 8, 4, 2, 9, 10. The large-scale structure of *Sonnet No. 2* is considerably more complicated than that of the first *Sonnet*, as it combines multiple strands of nested rhythm.

The two strands that combine to form the surface rhythm of *Sonnet No. 2*, though, are not derived from the same source strand, modified by rotation, as is the case in *Spin.* Instead, the two strands that inform *Sonnet No. 2* are derived from the S and the M7 time-point intervals. The sums of these two strands of time-point intervals are unequal (forty-eight for S; seventy-two for M7), so to stretch them both over the same space each is assigned a different durational unit: each time-point interval of S is made equal to six beats; each time-point interval of M7 is made equal to four beats.

row form	number of time-points	beats per time-point	total beats
S	48	6	288
M7	72	4	288

Sonnet No. 2's second level of division is different from the division of the first level—and from all the divisions found in *Spin* (or in *Sonnet,* for that matter)—in that each section is divided into six (as opposed to twelve) subsections. In the S strand, the intervals used to divide the first section are the time-point intervals (1, 2, 3, 5, 6, 2) of the first hexachord of S. The second section is divided by the time-point intervals (1, 8, 10, 7, 1, 2) of the second hexachord of S. The third section uses the first hexachord's time-point intervals again, but this time rotated by one position: 2, 3, 5, 6, 2, 1. The fourth section then returns to the intervals of the second hexachord, also rotated: 8, 10, 7, 1, 2, 1. Subsequent sections continue—back and forth between the intervals of the first and second hexachords, each time rotated one more position. The M7 strand follows the same pattern, but with the intervals of M7 hexachords (rotations of 7, 2, 9, 11, 6, 2 alternating with rotations of 7, 8, 10, 1, 7, 2).

The third level of the time-point map also has six divisions, as opposed to twelve, but unlike level two there is no rotation, so the subsections of the S strand are divided, alternately, by 1, 8, 10, 7, 1, 2 and 1, 2, 3, 5, 6, 2 (remember, there is no rotation for subsequent iterations). The subsections of the M7 strand are divided, alternately, by 7, 8, 10, 1, 7, 2 and 7, 2, 9, 11, 6, 2.

The following chart shows the sectional divisions of the work's S and M7 strands.

section	number of beats	second-level divisions	third-level divisions
S–1	6	1 2 3 5 6 2	1 8 10 7 1 2
S–2	12	1 8 10 7 1 2	1 2 3 5 6 2
S–3	18	2 3 4 6 2 1	1 8 10 7 1 2
S–4	30	8 10 7 1 2 1	1 2 3 5 6 2
S–5	36	3 5 6 2 1 2	1 8 10 7 1 2
S–6	12	10 7 1 2 1 8	1 2 3 5 6 2
S–7	6	5 6 2 1 2 3	1 8 10 7 1 2
S–8	48	7 1 2 1 8 10	1 2 3 5 6 2
S–9	60	6 2 1 2 3 5	1 8 10 7 1 2
S–10	42	1 2 1 8 10 7	1 2 3 5 6 2
S–11	6	2 1 2 3 5 6	1 8 10 7 1 2
S–12	12	2 1 8 10 7 1	1 2 3 5 6 2
M7–1	28	7 2 9 11 6 2	7 8 10 1 7 2
M7–2	8	7 8 10 1 7 2	7 2 9 11 6 2
M7–3	36	2 9 11 6 2 7	7 8 10 1 7 2
M7–4	44	8 10 1 7 2 7	7 2 9 11 6 2
M7–5	24	9 11 6 2 7 2	7 8 10 1 7 2
M7–6	8	10 1 7 2 7 8	7 2 9 11 6 2
M7–7	28	11 6 2 7 2 9	7 8 10 1 7 2
M7–8	32	1 7 2 7 8 10	7 2 9 11 6 2
M7–9	40	6 2 7 2 9 11	7 8 10 1 7 2
M7–10	4	7 2 7 8 10 1	7 2 9 11 6 2
M7–11	28	2 7 2 9 11 6	7 8 10 1 7 2
M7–12	8	2 7 8 10 1 7	7 2 9 11 6 2

Each of the two strands is now divided into twelve sections, each of those sections divided into six subsections for a total of seventy-two subsections. Each subsection contains six time-points, for a total of 432 time-points per strand.

In this composition, I decided to experiment with applying pitches to the two time-point strands individually, as opposed to the "spraying" technique used in *Spin*. *Sonnet No. 2* uses two discrete strands of pitch information to create two-voice counterpoint in certain sections, and an unusual combination of ordered and unordered sequences of pitches in other sections.

Another experiment I made here involved the use of modulus arrays derived differently from those employed in *Spin.* As was mentioned previously, any combination of pitches and time-point intervals can be combined in a modulus array, and here I've used modulus arrays in which each of the four classic row-forms is filtered through the time-point interval moduli of S.

Because *Sonnet No. 2* uses two discrete strands of pitch information unfolding simultaneously, modulus arrays are read horizontally (as opposed to *Spin*, in which modulus arrays are read vertically). The extreme pitch repetitions inherent in the horizontal rows of the modulus array serve reinforce the notion of counterpoint between the two strands.

The following chart shows the note-lists assigned to the time-points of the two strands that make up the composition.

S strand	12 rows: S, I, R, RI rotations, transposed S pitches
	12 rows: S, I R, RI modulus arrays using S mod intervals
	12 rows: RI, I, R, S rotations transposed to RI-T2 pitches
M7 strand	12 rows: (S, R, I, RI)-M7 rotations, transposed M7 pitches
	12 rows: (S, R, I, RI)-M7 modulus arrays using M7 mod intervals
	12 rows: (RI, I, R, S)-M7 rotations, transposed to (I-M5)-T2 pitches

Throughout most of the composition, the two strands are combined to produce composite rhythm and intermingling of note-lists, but there are portions of the work in which I've chosen to emphasize the counterpoint between the two strands. Some of these sections are notated in two voices, with both voices staccato (m. 29, m. 35).

Other contrapuntal sections are notated in two voices, but with one voice written legato and the other staccato. The first occurrence of this technique can be found in measure 4, where—on beats two and three—the lower voice is written in long notes while the top is written in short staccato notes. As the flute is a monophonic instrument, what is notated is technically impossible. The notation gives a visual representation of the desired effect, however, and the following instruction is printed in the score: "To create the illusion of sustained sound in the lower voice, the staccato note in the upper voice is to be played as quickly as possible before returning to the lower note."[98] In addition to its first occurrence in measures 4–5, this notation is also employed in measures 21–24 and in measure 28. This technique is utilized primarily to emphasize note repetitions and recurrences—produced by the modulus array read horizontally—in one strand.

Of course, pitch repetition can also be emphasized in single-line notation by placing a regularly repeated note at the highest or lowest point in a given melodic phrase, and this happens throughout the work (measures 40–41, for example).

As with *Spin*, there is a slight tempo-change in the concluding section of *Sonnet No. 2*. The tempo of sixty-six is increased to seventy-two at measure 79 for no reason other than to intensify the high density of events that inform the work's conclusion.

* * *

A meaningful correlation of rhythm and pitch was the compositional goal of total serialism as envisioned by Olivier Messiaen and Pierre Boulez. Though *Mode de valeurs et d'intensités* and *Structures 1a* are attractive works and have been an important influence on later generations of composers, the methods used to create these pieces did not prove fruitful for producing further multi-serial works, as evidenced by the fact that neither composer continued down the path of total serialism. The time-point system has proved to be a far more effective method for dealing with the relation between rhythm and pitch,

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98 This notational technique is by no means unique to *Sonnet No. 2*. Two-voice writing can be found in virtuoso flute music written early in the twentieth century, and can also be found in contemporary works of Luciano Berio, Charles Wuorinen, and countless others.

as evidenced by the numerous and varied works that Milton Babbitt has produced over the course of his long and celebrated career. Equally prolific (if not more so) is Charles Wuorinen, who—by applying Babbitt's principles to both background and foreground compositional structures—has created a large repertoire of engaging and admired compositions.

In the preceding chapters, we have discussed the structural plan and methods used to create *Spin*, a work that attempts to use systems and techniques—first outlined by Babbitt and Wuorinen—to produce a work that correlates rhythm and pitch in a directed, meaningful, and aesthetically pleasing way. We have also discussed methods by which new pieces may be derived from the structures of older works by borrowing certain structural traits and modifying them with new algorithms. *Sonnet* and *Sonnet No. 2* share many characteristics—structural, harmonic, melodic, and rhythmic—with *Spin* while maintaining their own identities as distinct works.

In all the compositions discussed here—from the early serial works of Messiaen and Boulez, to the works Babbitt and Carter, to the "common practice" of Wuorinen, to *Spin* and its two offshoots—it is obvious that form is never far-removed from content, and vice versa. Recognition of this fact is essential to the success of any composer hoping to create meaningful, coherent new work. A final quote from *Simple Composition*:

> This scheme of things [nesting] begins to show a fundamental connection between foreground "rhythm" and background "form." Here we are proposing a specific method for compositional use that correlates them in a precisely defined way. But that does not alter the fact that in *all* music some correlation of these dimensions is at work, whether it has been consciously decided on or not. It should be clear that in using the term *form*, we are really only referring to a matter of scale or size. The crucial point is that rhythm and form are not different things but rather only the same basic thing expressed on different scales of size. Let us then, on this basis, eliminate once and for all the false distinction between "content" and "form"—as if there were a mystic elixir of artistic *content* which, if one could get hold of it, one would pour into bins of different shapes and sizes

to produce different *forms*. "Content" might then be redefined as small-scale form, "form" as large-scale content.[99]

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99 Wuorinen, *Ibid.*, 153–54.

Appendix 1. *Spin*: Source Strand Sections and Subsections

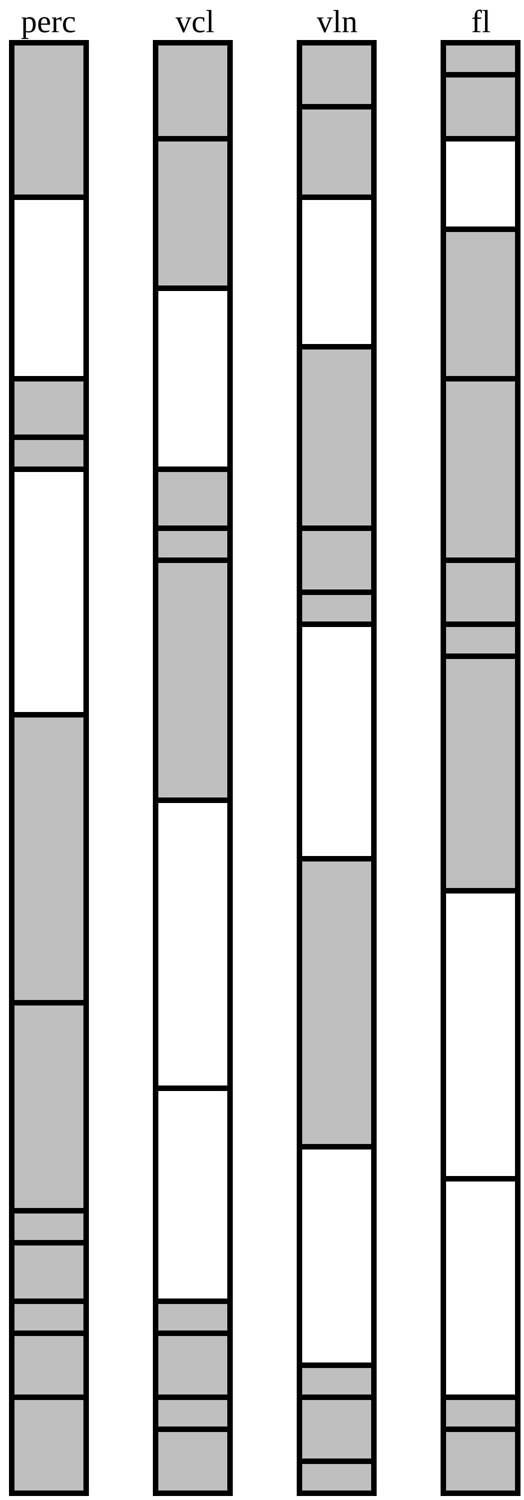
section	subsection	time-point interval	durational unit	total beats
Section 1 120 beats	1 – 1	5	2.5	12.5
	1 – 2	6	2.5	15
	1 – 3	2	2.5	5
	1 – 4	1	2.5	2.5
	1 – 5	8	2.5	20
	1 – 6	10	2.5	25
	1 – 7	7	2.5	17.5
	1 – 8	1	2.5	2.5
	1 – 9	2	2.5	5
	1 – 10	1	2.5	2.5
	1 – 11	2	2.5	5
	1 – 12	3	2.5	7.5
Section 2 144 beats	2 – 1	5	3	15
	2 – 2	6	3	18
	2 – 3	2	3	6
	2 – 4	1	3	3
	2 – 5	8	3	24
	2 – 6	10	3	30
	2 – 7	7	3	21
	2 – 8	1	3	3
	2 – 9	2	3	6
	2 – 10	1	3	3
	2 – 11	2	3	6
	2 – 12	3	3	9
Section 3 48 beats	3 – 1	5	variable	4
	3 – 2	6	variable	5
	3 – 3	2	variable	6
	3 – 4	1	variable	2
	3 – 5	8	variable	6
	3 – 6	10	variable	8
	3 – 7	7	variable	6
	3 – 8	1	variable	2
	3 – 9	2	variable	3
	3 – 10	1	variable	2
	3 – 11	2	variable	3
	3 – 12	3	variable	4

section	subsection	time-point interval	durational unit	total beats
Section 4 24 beats	4 – 1	5	variable	2.5
	4 – 2	6	variable	2.5
	4 – 3	2	variable	1.5
	4 – 4	1	variable	1.5
	4 – 5	8	variable	2.5
	4 – 6	10	variable	3
	4 – 7	7	variable	2.5
	4 – 8	1	variable	1.5
	4 – 9	2	variable	1.5
	4 – 10	1	variable	1.5
	4 – 11	2	variable	1.5
	4 – 12	3	variable	2
Section 5 192 beats	5 – 1	5	4	20
	5 – 2	6	4	24
	5 – 3	2	4	8
	5 – 4	1	4	4
	5 – 5	8	4	32
	5 – 6	10	4	40
	5 – 7	7	4	28
	5 – 8	1	4	4
	5 – 9	2	4	8
	5 – 10	1	4	4
	5 – 11	2	4	8
	5 – 12	3	4	12
Section 6 240 beats	6 – 1	5	5	13
	6 – 2	6	5	30
	6 – 3	2	5	`0
	6 – 4	1	5	5
	6 – 5	8	5	40
	6 – 6	10	5	50
	6 – 7	7	5	35
	6 – 8	1	5	5
	6 – 9	2	5	10
	6 – 10	1	5	5
	6 – 11	2	5	10
	6 – 12	3	5	15

section	subsection	time-point interval	durational unit	total beats
Section 7 168 beats	7 – 1	5	3.5	17.5
	7 – 2	6	3.5	21
	7 – 3	2	3.5	7
	7 – 4	1	3.5	3.5
	7 – 5	8	3.5	28
	7 – 6	10	3.5	35
	7 – 7	7	3.5	24.5
	7 – 8	1	3.5	3.5
	7 – 9	2	3.5	7
	7 – 10	1	3.5	3.5
	7 – 11	2	3.5	7
	7 – 12	3	3.5	10.5
Section 8 24 beats	8 – 1	5	variable	2.5
	8 – 2	6	variable	2.5
	8 – 3	2	variable	1.5
	8 – 4	1	variable	1.5
	8 – 5	8	variable	2.5
	8 – 6	10	variable	3
	8 – 7	7	variable	2.5
	8 – 8	1	variable	1.5
	8 – 9	2	variable	1.5
	8 – 10	1	variable	1.5
	8 – 11	2	variable	1.5
	8 – 12	3	variable	2
Section 9 48 beats	9 – 1	5	variable	4
	9 – 2	6	variable	5
	9 – 3	2	variable	3
	9 – 4	1	variable	2
	9 – 5	8	variable	6
	9 – 6	10	variable	8
	9 – 7	7	variable	6
	9 – 8	1	variable	2
	9 – 9	2	variable	3
	9 – 10	1	variable	2
	9 – 11	2	variable	3
	9 – 12	3	variable	4

section	subsection	time-point interval	durational interval	total beats
Section 10 24 beats	10 – 1	5	variable	2.5
	10 – 2	6	variable	2.5
	10 – 3	2	variable	1.5
	10 – 4	1	variable	1.5
	10 – 5	8	variable	2.5
	10 – 6	10	variable	3
	10 – 7	7	variable	2.5
	10 – 8	1	variable	1.5
	10 – 9	2	variable	1.5
	10 – 10	1	variable	1.5
	10 – 11	2	variable	1.5
	10 – 12	3	variable	2
Section 11 48 beats	11 – 1	5	variable	4
	11 – 2	6	variable	5
	11 – 3	2	variable	3
	11 – 4	1	variable	2
	11 – 5	8	variable	6
	11 – 6	10	variable	8
	11 – 7	7	variable	6
	11 – 8	1	variable	2
	11 – 9	2	variable	3
	11 – 10	1	variable	2
	11 – 11	2	variable	3
	11 – 12	3	variable	4
Section 12 72 beats	12 – 1	5	1.5	7.5
	12 – 2	6	1.5	9
	12 – 3	2	1.5	3
	12 – 4	1	1.5	1.5
	12 – 5	8	1.5	12
	12 – 6	10	1.5	15
	12 – 7	7	1.5	10.5
	12 – 8	1	1.5	1.5
	12 – 9	2	1.5	3
	12 – 10	1	1.5	1.5
	12 – 11	2	1.5	3
	12 – 12	3	1.5	4.5

Appendix 2. *Spin*: Graph of Rotated Strands



Appendix 3. *Spin*: Transposition Arrays

— Standard Forms —

S	0	5	e	1	2	t	8	3	4	6	7	9
I	5	0	6	8	9	5	3	t	e	1	2	4
R	e	9	8	6	5	t	0	4	3	1	7	2
RI	1	3	4	6	7	2	0	8	9	e	5	t
S	2	7	1	3	4	0	t	5	6	8	9	e
I	t	5	e	9	8	0	2	7	6	4	3	1
R	8	6	5	3	2	7	9	1	0	t	4	e
RI	3	5	6	8	9	4	2	t	e	1	7	0
S	4	9	3	5	6	2	0	7	8	t	e	1
I	6	1	7	5	4	8	t	3	2	0	e	9
R	7	5	4	2	1	6	8	0	e	9	3	t
RI	9	e	0	2	3	t	8	4	5	7	1	6

I	0	7	1	e	t	2	4	9	8	6	5	3
R	5	3	2	0	e	4	6	t	9	7	1	8
RI	e	1	2	4	5	0	t	6	7	9	3	8
S	1	6	0	2	3	e	9	4	5	7	8	t
I	2	9	3	1	0	4	6	e	t	8	7	5
R	t	8	7	5	4	9	e	3	2	0	6	1
RI	8	t	e	1	2	9	7	3	4	6	0	5
S	3	8	2	4	5	1	e	6	7	9	t	0
I	4	e	5	3	2	6	8	1	0	t	9	7
R	6	4	3	1	0	5	7	e	t	8	2	9
RI	7	9	t	0	1	8	6	2	3	5	e	4
S	9	2	8	t	e	7	5	0	1	3	4	6

R	0	t	9	7	6	e	1	5	4	2	8	3
RI	5	7	8	t	e	6	4	0	1	3	9	2
S	e	4	t	0	1	9	7	2	3	5	6	8
I	1	8	2	0	e	3	5	t	9	7	6	4
R	2	0	e	9	8	1	3	7	6	4	t	5
RI	t	0	1	3	4	e	9	5	6	8	2	7
S	8	1	7	9	t	6	4	e	0	2	3	5
I	3	t	4	2	1	5	7	0	e	9	8	6
R	4	2	1	e	t	3	5	9	8	6	0	7
RI	6	8	9	e	0	7	5	1	2	4	t	3
S	7	0	6	8	9	5	3	t	e	1	2	4
I	9	4	t	8	7	e	1	6	5	3	2	0

RI	0	2	3	5	6	1	e	7	8	t	4	9
S	5	t	4	6	7	3	1	8	9	e	0	2
I	e	6	0	t	9	1	3	8	7	5	4	2
R	1	e	t	8	7	0	2	6	5	3	9	4
RI	2	4	5	7	8	3	1	9	t	0	6	e
S	t	3	9	e	0	8	6	1	2	4	5	7
I	8	3	9	7	6	t	0	5	4	2	1	e
R	3	1	0	t	9	2	4	8	7	5	e	6
RI	4	6	7	9	t	5	3	e	0	2	8	1
S	6	e	5	7	8	4	2	9	t	0	1	3
I	7	2	8	6	5	9	e	4	3	1	0	t
R	9	7	6	4	3	8	t	2	1	e	5	0

— M7 Forms —

S	0	e	5	7	2	t	8	9	4	6	1	3
I	e	0	6	4	9	1	3	2	7	5	t	8
R	5	3	8	6	e	t	0	4	9	7	1	2
RI	7	9	4	6	1	2	0	8	3	5	e	t
S	2	1	7	9	4	0	t	e	6	8	3	5
I	t	e	5	3	8	0	2	1	6	4	9	7
R	8	6	e	9	2	1	3	7	0	t	4	5
RI	9	e	6	8	3	4	2	t	5	7	1	0
S	4	3	9	e	6	2	0	1	8	t	5	7
I	6	7	1	e	4	8	t	9	2	0	5	3
R	1	e	4	2	7	6	8	0	5	3	9	t
RI	3	5	0	2	9	t	8	4	e	1	7	6

I	0	1	7	5	t	2	4	3	8	6	e	9
R	e	9	2	0	5	4	6	t	3	1	7	8
RI	5	7	2	4	e	0	t	6	1	3	9	8
S	7	6	0	2	9	5	3	4	e	1	8	t
I	2	3	9	7	0	4	6	5	t	8	1	e
R	t	8	1	e	4	3	5	9	2	0	6	7
RI	8	t	5	7	2	3	1	9	2	0	6	7
S	9	8	2	4	e	7	5	6	1	3	t	0
I	4	5	e	9	2	6	8	7	0	t	3	1
R	6	4	9	7	0	e	1	5	t	8	2	3
RI	1	3	t	0	7	8	6	2	9	e	5	4
S	3	2	8	t	5	1	e	0	7	9	4	6

R	0	t	3	1	6	5	7	e	4	2	8	9
RI	e	1	8	t	5	6	4	0	7	9	3	2
S	5	4	t	0	7	3	1	2	9	e	6	8
I	7	8	2	0	5	9	e	t	3	1	6	4
R	2	0	5	3	8	7	9	1	6	4	t	e
RI	t	0	7	9	4	5	3	e	6	8	2	1
S	8	7	1	3	t	6	4	5	0	2	9	e
I	9	t	4	2	7	e	1	0	5	3	8	6
R	4	2	7	5	t	9	e	3	8	6	0	1
RI	6	8	3	5	0	1	e	7	2	4	t	9
S	1	0	6	8	3	e	9	t	5	7	2	4
I	3	4	t	8	1	5	7	6	e	9	2	0

RI	0	2	9	e	6	7	5	1	8	t	4	3
S	e	t	4	6	1	9	7	8	3	5	0	2
I	5	6	0	t	3	7	9	8	1	e	4	2
R	7	5	t	8	1	0	2	6	e	9	3	4
RI	2	4	e	1	8	9	7	3	t	0	6	5
S	t	9	3	5	0	8	6	7	2	4	e	1
I	8	9	3	1	6	t	0	e	4	2	7	5
R	9	7	0	t	3	2	4	8	1	e	5	6
RI	4	6	1	3	t	e	9	5	0	2	8	7
S	6	5	e	1	8	4	2	3	t	0	7	9
I	1	2	8	6	e	3	5	4	9	7	0	t
R	3	1	6	4	9	8	t	2	7	5	e	0

Appendix 4. *Spin*: Modulus Arrays

— Standard Forms —

S

0	0	1	1	2	0	3	3	4	1	2	4
5	t	t	6	7	9	7	8	9	5	6	8
e	0	0	0	e	e	e	0	e	e	0	0
1	1	1	1	1	1	1	1	1	1	1	1
2	7	5	3	4	4	2	5	6	8	9	3
t	3	e	e	0	t	6	1	2	4	5	7
8	1	0	9	t	e	9	e	0	2	8	t
3	3	3	3	3	3	3	3	3	3	3	3
4	5	5	5	4	4	4	5	4	4	5	5
6	6	6	6	6	6	6	6	6	6	6	6
7	8	8	8	7	7	7	8	7	7	8	8
9	e	e	t	e	t	e	9	t	9	t	9

R

0	0	9	7	6	1	1	5	4	2	8	3
t	8	7	5	4	t	e	3	2	0	6	1
9	9	6	4	3	t	t	2	1	e	5	0
7	5	4	2	1	7	8	0	e	9	3	t
6	6	t	8	7	7	7	6	t	8	9	9
e	e	0	0	e	0	0	0	e	e	e	0
1	3	2	4	3	4	2	2	1	3	1	4
5	3	2	0	e	5	6	t	9	7	1	8
4	4	1	e	t	5	5	9	8	6	0	7
2	6	5	3	2	7	3	7	6	4	4	5
8	e	t	8	2	0	9	1	0	t	9	e
3	4	3	t	9	5	4	8	7	5	e	6

I

0	0	1	4	3	2	4	2	1	6	5	3
7	8	8	0	e	9	e	t	9	7	0	t
1	8	2	2	1	3	5	t	9	7	6	4
e	6	0	e	9	1	3	8	7	5	4	2
t	1	e	1	0	0	t	e	t	0	e	1
2	3	3	3	2	2	2	3	2	2	3	3
4	6	5	5	4	6	8	8	7	5	4	7
9	4	t	9	7	e	1	6	5	3	2	0
8	3	9	9	8	t	0	5	4	2	1	e
6	1	7	6	4	8	t	3	2	0	e	9
5	0	6	6	5	7	9	2	1	e	t	8
3	t	4	5	4	5	7	3	e	9	8	6

RI

0	0	1	1	0	1	1	1	0	0	0	1
2	2	2	2	2	2	2	2	2	2	2	2
3	3	4	4	3	4	4	4	3	3	3	4
5	5	5	5	5	5	5	5	5	5	5	5
6	8	9	e	0	7	t	6	7	9	t	8
1	3	4	6	7	2	2	8	9	1	5	t
e	1	2	4	5	0	2	6	e	1	3	0
7	7	7	7	7	7	7	7	7	7	7	7
8	8	9	9	8	9	9	9	8	8	8	9
t	0	1	3	t	e	3	e	0	2	2	1
4	6	7	4	5	5	5	6	7	4	8	8
9	e	9	e	9	t	e	t	e	t	t	9

— M7 Forms —

S

0	0	5	7	2	t	8	9	4	6	1	3
e	4	4	0	1	3	1	2	3	e	0	2
5	6	6	6	5	5	5	6	5	5	6	6
7	e	0	7	9	t	8	9	e	1	8	t
2	5	7	9	4	4	2	3	6	8	3	5
t	e	3	5	0	t	6	7	2	4	e	1
8	8	8	8	8	8	8	8	8	8	8	8
9	1	2	9	e	0	t	e	1	3	t	0
4	5	5	5	4	4	4	5	4	4	5	5
6	t	e	6	8	9	7	8	t	0	7	9
1	2	2	2	1	1	1	2	1	1	2	2
3	5	8	t	5	4	e	3	7	9	4	6

R

0	0	3	1	6	5	7	1	4	2	8	9
t	t	1	e	e	t	0	e	2	0	1	2
3	3	6	4	9	8	t	4	7	5	e	0
1	1	4	2	2	1	3	2	5	3	4	5
6	4	9	7	0	e	1	6	t	8	2	3
5	5	6	6	5	6	6	6	5	5	5	6
7	9	t	8	9	8	t	t	7	9	7	8
e	e	2	0	0	e	1	0	3	1	2	3
4	4	7	5	t	9	e	5	8	6	0	1
2	6	5	3	2	7	3	7	6	4	4	5
8	8	8	8	8	8	8	8	8	8	8	8
9	t	9	t	9	e	t	e	t	e	e	9

I

0	0	0	0	0	0	0	0	0	0	0	0
1	2	2	6	5	3	5	4	3	1	6	4
7	8	2	0	7	9	e	t	3	1	8	4
5	6	7	5	5	7	9	8	8	6	6	9
t	e	1	e	0	0	t	1	t	0	1	e
2	3	3	3	2	2	2	3	2	2	3	3
4	5	e	9	2	6	8	7	0	t	4	1
3	4	5	3	3	5	7	6	6	4	4	7
8	9	3	1	8	t	0	e	4	2	9	5
6	7	8	6	6	8	t	9	9	7	7	t
e	0	6	4	e	1	3	2	7	5	0	8
9	t	t	e	t	e	t	9	e	9	e	9

RI

0	0	1	1	0	1	1	1	0	0	0	1
2	4	4	6	8	2	7	3	3	5	6	5
9	9	t	t	9	t	t	t	9	9	9	t
e	1	1	3	5	e	4	0	0	2	3	2
6	6	6	6	6	6	6	6	6	6	6	6
7	9	4	8	1	2	0	8	3	7	e	t
5	7	6	8	e	0	t	6	5	7	9	8
1	3	3	5	7	1	6	2	2	4	5	4
8	8	9	9	8	9	9	9	8	8	8	9
t	0	1	3	t	e	3	e	0	2	2	1
4	6	1	4	t	e	9	5	0	2	8	7
3	5	3	5	9	t	8	4	e	4	7	6

Appendix 5. Milton Babbitt's Report to the Dissertation Committee

April 24, 2000

Dear Professor Grave,

Allow me to apologize for this outmoded mode of communication, but it is the only one available to me at this time, and I did not wish to be obliged to postpone the opportunity to write with regard to James Romig's very impressive thesis. Time in the large and in the small, as well as other pressures, have prevented me from checking every word, every entry, but I had the occasion to examine significant segments of the document earlier, and I don't think that a detailed checking of every detail is necessary for one to grasp the structure, the quality, and the value of the dissertation. Each stage of that structure, from the analytically derived "premises," to the analytically motivated "speculative" extensions, to the realization, the instantiations in concrete compositions, is thoughtfully and thoroughly realized.

The analytical portion reflects and embodies a sophisticated knowledge of the literature, whose range is inferable from the extensive, always pertinent, bibliography. He has succeeded in conflating ideas and techniques into a coherent construal which makes this section of the thesis infinitely valuable as a thing in itself.

The progression from the syntactic to the semantic (the interpreted) poses no problems, but—advertently or inadvertently—the "pragmatic" phase induces a basic question which is often encountered but rarely faced in public discussion. For instance, on page 75, there is the statement that "twenty seconds of ringing vibraphone...would be monotonous." Here, apparently, is a normative appeal to a higher authority, which never before has been postulated, and whose criteria appear to take precedence over those implicitly or explicitly induced by the systematic and contextual implications of the evolved argument. This patching of the paradigm, those alternatives which are introduced, admittedly not entailed by the "original structural plan," suggests either that that plan be reconstructed in order not to produce such an undesirable consequence, or—better—that the "twenty seconds" would appear not to be monstrous in terms of their genesis within the plan, and that any ad hoc avoidance of them would be perplexing to the comprehending auditor.

In sum, I suspect—and hope—that this exceptional thesis will be in demand within the knowing musical community, for there is no other comparable document which presents understandingly such a range of musical thought, both in and about music, in "theory," application, and extension. Also, one hopes it will serve to inform those who, awarely or unawarely, have misrepresented absurdly the twelve-pitch-class syntax as—for instance— "inducing too fast a circulation of pitches"; it is not only that this thesis presents any number of counterexamples to that assertion and comparable others, but that by so doing it reveals, implicitly, the "type-token" confusion which has injected so much pretentious, loose talk by those who, apparently, never have faced the music or read the literature of that music.

Very truly yours,

Milton Babbitt

Conant Professor of Music, Emeritus

Princeton University

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