The Spectral Music of James Tenney

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Between 1971 and 2006, James Tenney created more than fifty significant works of what is now commonly called ‘spectral music’. In their materials and procedures, his compositions frequently paralleled, sometimes anticipated, and in some instances strikingly contrasted with spectralist developments in Europe. This article provides an analytical introduction to the spectralist component of Tenney’s large and varied output, and explores its emergence and place within a North American tradition of spectral music composition. Among the compositional concerns addressed are the duality of timbre and harmony, the harmonic series as a structural resource, the instrumental synthesis of speech, rhythmic analogs of spectral structures, the expansion of traditional harmonic means, and practical performance considerations.

Keywords: James Tenney; Spectral Music; Harmonic Series; Microtonality; Phenomenalism; Just Intonation

Introduction: Spectral Music

I regard as a necessary feature of ‘spectral music’ that it invoke Fourier spectral analysis as a conceptual point-of-reference. For music not meeting this minimal requirement, the term ‘spectral music’ would appear to be a misnomer. Surveys of more elaborated characterizations can be found in Fineberg (2000a) and Moscovich (1997). The following traits, at least, are commonly cited as typical of spectralist compositions, although they are not definitive and are not necessarily present together in any given work:

- A general preoccupation with the phenomenology rather than the semantics of sound.
- The use of the harmonic series as an intervallic resource.
- The orchestration of spectra in which instruments are assigned to individual spectral components such as partials; this includes so-called ‘additive instrumental synthesis’ in which such orchestration is guided by the spectrographic
analysis of acoustical sources, and orchestration of electroacoustic source materials by analogous means.

- An interest in the perceptual duality of timbre and harmony by way of which a given collection of tones might, depending on its specific constitution and the attitude of the listener, either perceptually fuse into a unitary percept with a characteristic steady-state timbre or alternatively might dissociate into multiple perceptually autonomous tones possessing a harmonic relationship.

- The musical application of various acoustical or psychoacoustical concepts including harmonic fusion, residue pitch, difference tones, Shepard-tone phenomena, and amplitude or frequency modulation, etc.¹

- The invocation of gradual formal processes that allow (and encourage) attention to subtle phenomenal details.

Discussions of spectral music have been dominated heretofore by developments in Europe (see, e.g., Fineberg, 2000b; Rose, 1996). Tenney’s œuvre, however, includes a great number of compositions involving all of the above characteristics, many of which parallel and some of which anticipate European developments. I have made the point elsewhere (Wannamaker, in press) that Tenney’s work spearheads a relatively undocumented North American school of spectral music composition that deserves to be recognized within the burgeoning discourse surrounding spectralism, and I do not propose to revisit that argument in detail here.² The following treatment is more concerned with a detailed exploration and appreciation of the music, addressing the spectralist signatures listed above among other noteworthy features. I hope that this analytical introduction to a representative few of Tenney’s many compositions will encourage further scholarly interest in this influential and rewarding body of work.

The selection of pieces addressed below is intended to broadly survey the many facets of Tenney’s spectralist output. Clang (1972) and QUINTEXT V (1972) are essential seminal works. Three Harmonic Studies, III (1974) and Spectral CANON for CONLON Nancarrow (1974) demonstrate the adaptation of frequency structures to temporal organization, while Three Indigenous Songs (1979) represents his interest in the instrumental synthesis of speech. Voice(s) (1984) exemplifies Tenney’s pieces employing tape-delay systems, while Spectrum 6 (2001) represents a late synthesis of techniques developed in various earlier stages of his career. The reader need not digest all of the corresponding sections in order, but may instead proceed à la carte if so desired.

The Evolution of an Aesthetic

Tenney’s spectral music was the product of a long and complex personal history reflecting his ongoing interests in both science and music. Born in 1934 in Silver City, New Mexico, his early academic studies included engineering at the University of Denver (1952 – 1954) as well as piano with Eduard Steuermann at the Juilliard School
(1954–1955). He subsequently studied composition and conducting at Bennington College (1956–1958) with Lionel Nowak and Henry Brant, respectively. His compositions from this period betray the influences of Arnold Schoenberg, Anton Webern and Edgard Varèse, as well as a pithiness and conceptual clarity that are also characteristic of his later work.3

In 1961, Tenney earned a master’s degree in composition from the University of Illinois at Urbana-Champaign, where he studied composition with Kenneth Gaburo and electronic music with Lejaren Hiller. His master’s thesis, entitled ‘META + Hodos: A Phenomenology of 20th-Century Musical Materials and an Approach to Form’ (Tenney, 1988 [1964]), applied principles of Gestalt psychology to the perception of musical forms and has proven widely influential. During this period, he also played in Harry Partch’s Gate 5 Ensemble, and Partch’s harmonic theories (Partch, 1974 [1949]) were one inspiration for Tenney’s own theory of harmonic perception (Tenney, 1993 [1983]).

From 1961–1964 Tenney was employed as a member of the technical staff at Bell Telephone Laboratories (now Bell Laboratories) in New Jersey. While there, he composed some of the earliest substantial pieces of computer music and conducted pioneering research on algorithmic composition, psychoacoustics, timbre modeling, and computer sound generation, with Max Mathews. The detailed technical experience that he acquired with acoustics, psychoacoustics, spectral analysis, signal processing and information theory during this time informed much of his subsequent compositional work, and his spectralist music in particular.4

Meanwhile, Tenney also studied composition privately with Chou Wen-chung (1955–1956) and informally with Carl Ruggles (1956–1958), Edgard Varèse (1956–1965) and John Cage (1961–1969). Exposure to Cage’s Zen-related phenomenological attitude towards ‘letting sounds be themselves’ (Cage, 1961) had already made a strong impression on the young composer. Tenney later said that ‘people having difficulty with 20th-century music are not hearing sound because they’re not in a frame of mind to simply listen to sound for itself. That’s why Cage is indispensable’ (Tenney, 1984b, p. 4). An attraction, both intellectual and sensuous, to sound as a phenomenon—to differentiating, experiencing and appreciating its facets, and to becoming more fully aware personally of how the perceiving self is constituted—would bring him to employ spectralist means in the exploration of timbral and harmonic perception.

During the 1960s, Tenney was peripherally involved in the Fluxus art movement and was also an original performing member in both the Steve Reich Ensemble (1967–1970) and the Philip Glass Ensemble (1969–1970). While his interest in gradual formal processes precedes his involvement with these so-called ‘minimalist’ composers (appearing earlier in certain of his computer music compositions such as Phases of 1963), his work since 1967 frequently has embraced unidirectional processes of the sort also recognizable in, for instance, Reich’s Come Out (1966). In particular, between 1965 and 1971 Tenney composed a series of ten so-called ‘Postal Pieces’, which he printed on postcards in 1971 and sent to his friends.5 Several of
these simple, but very effective, little pieces exhibit gradual unidirectional formal processes and also bear other proto-spectral features. For instance, Swell Piece No. 2 (1971) asks performers to sound $A_4$ (440 Hz), repeatedly entering *dal niente*, increasing in intensity and then fading out again *al niente* in a manner rhythmically independent of one another. With sustained communal concentration, the intonation of the ensemble will improve progressively so that successively higher harmonics of $A_4$ will begin to ring out, encouraging listeners to ‘hear-out’ these partials within the composite harmonic spectrum.\(^6\)

### Early Spectralist Works

Although Tenney’s *Postal Pieces* share a phenomenological orientation and the use of gradual formal processes with the more paradigmatically spectralist music he soon began writing, his experiences at Bell Labs in the early 1960s were probably a more direct precedent for this compositional development. Indeed, his next work was an orchestrated variant of the Shepard-tone phenomenon. Tenney knew of the associated concept from his sojourn at Bell Labs alongside cognitive psychologist Roger Shepard when Shepard first investigated it.\(^7\) In 1969, Tenney produced an electro-acoustic piece based on the phenomenon entitled *For Ann (rising)*, and in 1971 he undertook an orchestration thereof entitled *For 12 Strings (rising)*. Representing not only an instrumental rendering of an electroacoustic source, but also an explicit orchestration of an evolving spectrum, to me *For 12 Strings (rising)* seems an indisputable—if unique—early example of spectral music (Wannamaker, in press). However, Tenney’s next work (entitled *Clang*) is immediately recognizable as paradigmatic spectralism.

**Clang (1972)**

The title of *Clang* is borrowed from Tenney’s theoretical research on temporal gestalt perception in music (Tenney, 1988 [1964]; Tenney & Polansky, 1980), but in this context it is apparently more onomatopoic than technical. The piece is roughly 15'30" in duration with a large-scale form comprising two successive gradual processes—the first accumulative and the second dissolutive—as shown in Figure 1. These are initiated, separated and concluded by three *fortissimo* percussive ‘clangs’.

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**Figure 1** Formal scheme showing reduced ‘clang’ chords.
The second clang marks the onset of the dissolutive process and occurs about two-thirds of the way through the work, dividing it roughly at its golden section.

These gradual progressions employ, for the first time in Tenney's output, what he refers to as an 'available pitch process'. The instructions in the score characterize this as follows:

[T]he notation indicates available pitches to be played by sustained-tone instruments (including rolls on the percussion instruments) in the following way: each player chooses, at random, one after another of these available pitches (when within the range of his or her instrument), and plays it beginning very softly (almost inaudibly), gradually increasing the intensity to the dynamic level indicated for that section, then gradually decreasing the intensity again to inaudibility.... After a pause at least as long as the previous tone, each player then repeats this process.

This espousal of indeterminacy in performance is a post-Cageian feature of Tenney's work that is not found in European spectral compositions. As in Cage's music, it promotes attention on the part of listeners to their perceptions of sound rather than to the interpretation of local structural decisions made by the composer.

The pitches used in the piece correspond to the first eight prime-numbered harmonics of an E and their octave equivalents (see Figure 2). These are approximated using equal-tempered quarter-tones for partials 11, 13 and 7. The resulting collection of pitch classes is a sort of just-intoned octatonic scale. This set makes available approximations to a great variety of different just-intoned intervals, which are heard in various contexts as the ensemble enacts the available pitch process. With regard to intonation, the score indicates that 'great precision is obviously not expected here—in fact, the beats resulting from slight discrepancies from the actual harmonic frequencies are welcome—but an effort should be made to improve the approximation as much as is possible or practical'.

The opening clang is a pitch-class unison comprising all Es between E₁ and E₇, inclusive. The following accumulative process represents a measured expansion of the available pitch gamut, starting from E₄ alone and gradually adding adjacent pitches from the just-octatonic set. The range of available pitches is expanded symmetrically above and below E₄ in stages, rather as though the bandwidth of an ideal bandpass filter were being gradually increased in steps so as to pass an increasing number of

![Figure 2](attachment:Figure2.png)

**Figure 2** Pitch-class set used in Clang. Quarter-tone inflections are denoted by accidentals in parentheses. Deviations of the harmonic pitches from these quarter-tone approximations are shown in cents.
frequency components. Meticulous orchestration is employed to ensure that changes in dynamic and timbre are extraordinarily smooth. For instance, after the initial ‘clang’, the various instruments enter in stages—fractions of a choir at a time—with the entrances of the various percussion instruments delayed to varying degrees, the timpani entering last. Regarding the opening, the score indicates that ‘[t]he effect intended... is a single, continuous pitch with gradually changing timbre, followed... by a gradually expanding, quasi-random texture of changing timbres and pitches.’ The result is by no means static; the available pitch procedure gives rise to a churning ocean of sound from which varied and haunting harmonic efflorescences emerge.

When all pitches in the just-octatonic set between E₁ and E₇ have become available, the accumulative process stops and the second ‘clang’ sounds; all sustaining instruments falling silent for about three seconds in response and then continuing as before. This second clang contrasts markedly with the first and last, as shown in Figure 1. Here, because fixed-pitch percussion instruments are used, equal-tempered B-flat is accepted as an approximation to the 11th partial of E. The chord thus comprises approximations to partials 1, 3, 17 and 11. Whereas the opening and concluding clangs are extreme consonances, the second clang is an extreme dissonance, consisting as it does of interlocking tempered major sevenths and minor ninths. However, it also contrasts sharply with the dense dissonant cluster that it locally interrupts, partly as a result of its relatively open voicing. This voicing consists of a symmetrical cyclical stacking of pitch intervals: 7, 6, 5, 6, 7, 6, 5, 6, 7, 6, 5, in semitones reading from the bass, or an alternation of interval classes 5 and 6.

Throughout the sequel, whenever all sounding or available pitches can be interpreted as harmonics of a common fundamental (whether the pitch associated with that fundamental is actually sounding or not), I will refer to it as the ‘conceptual fundamental’ of the pitch collection. At the time of the second clang, all available pitches can be regarded as harmonics of an infrasonic conceptual fundamental, E₋₃. The stages of the ensuing dissolutive process represent successive upward octave transpositions of this conceptual fundamental, with those tones (and only those tones) that cannot be interpreted as harmonics of each new fundamental dropping out of the available set at each stage (see Figure 3).¹⁰ Thus the first pitches to drop out are F₁ and G₁ (harmonics 17 and 19 of E₋₃), since these pitches are not harmonics of the new conceptual fundamental, E₋₂. At the next stage A₁-quarter-sharp and C₂-quarter-sharp (harmonics 11 and 13 of E₋₂) drop out together with F₂ and G₂ (harmonics 17 and 19 of E₋₂), since none of these pitches are harmonics of E₋₁. Pitches in the pitch class E are treated specially insofar as they are all retained in the available pitch set even once they lie below the ascending conceptual fundamental. All other pitches are gradually and systematically weeded out until only the Es between E₁ and E₇ are left sounding, at which point these are reinforced and released by the final ‘clang’.

As the process of Clang’s second half unfolds, the texture becomes progressively less ‘noiselike’ and more ‘tonal’—not in a functional sense, of course, but in the sense
that it increasingly resembles a single complex tone whose harmonic spectrum is synthesized by the various instrumental contributions. Indeed, once the conceptual fundamental reaches E¹, all available pitches thereafter correspond to harmonics of this sounding tone. Thus the large-scale trajectory of the piece is a broad arc of tension and resolution, moving from the simplicity of a single tone towards a complex welter of different pitches and fleeting harmonic relationships, finally returning via a different process to a unitary percept. For this listener, at least, the manner in which apparent chaos gradually cedes to sublime order in many of Tenney’s works suggests a transcendentalist undertone, although the composer avoided pronouncements on such matters.

*Clang* is published but, despite its modest technical demands, the work has never had a concert premiere. It received a reading by the Los Angeles Philharmonic shortly after it was composed and a ‘bootleg quality’ cassette recording of that performance survives. Despite its poor fidelity, this recording delivers a visceral impact upon hearing. Near the end of his career, the composer—supposing that the indeterminate aspects of the score might have been a disincentive to its performance—made a new realization of aspects of *Clang* in the conventionally notated work *Panacousticon* (2005) for orchestra. To facilitate performance, the latter work uses a 12-tone equal-tempered scale in place of the just-octatonic set. Its opening cluster builds upwards from the bass rather than outward from the middle register, and it features novel sorts of ‘clang’ events, but the natures of its accumulative and dissolutive processes
are essentially those of *Clang*. In July 2007, *Panacousticon* was premiered in Munich by the Bavarian Radio Symphony Orchestra.

QUINTEXT: FIVE TEXTURES (1972)

The suite QUINTEXT: FIVE TEXTURES for string quartet and bass consists of five pieces written by Tenney in tribute to fellow composers. They represent markedly different sound worlds and methods of compositional organization. The spectralist members of the set are *I: Some Recent THOUGHTS for Morton Feldman, III: A Choir of ANGELS for Carl Ruggles* and *V: SPECTRA for Harry Partch*.\(^{11}\)

*QUINTEXT V: SPECTRA for Harry Partch* is the most unprecedented of the group. Its form comprises relatively brief opening and concluding sections bookending a longer middle portion. The total duration is nine minutes. Here Tenney achieves extremely precise intonation by means of an ingenious *scordatura*. The contrabass tunes its IV (E) string up to F\(_1\), of which it then plays select natural harmonics up to the 15th so that the other instruments can tune their open strings to these. The bass plays only its ‘F’ string throughout, but its other strings are tuned to harmonics of this pitch so that they resonate sympathetically with it. (The cello’s IV string is similarly treated as a resonator.) All pitches sounded in the piece are either open strings or natural harmonics up to the 7th, so that the highest harmonic available is number \(7 \times 15 = 105\) on the first violin’s I string. The complete set of pitches made available in this fashion is shown string-by-string in Figure 4 (notating equal-tempered pitch approximations) and by ascending pitch height in Figure 5 (indicating the precise pitches produced via cents deviations). Some pitches shown in Figure 5 may be obtainable on more than one instrument, and some appear with different enharmonic spellings in the score. Tenney notates all pitches as they sound,

![Figure 4](image-url)

*Figure 4* Scordatura and string harmonics used in *QUINTEXT V: SPECTRA for Harry Partch*. 
but where natural harmonics are to be produced the conventional notation for artificial harmonics is borrowed as well: sounding pitches are accompanied by a figure in parentheses indicating the string to be played with a filled round notehead while the location of the string node to be touched is indicated with an open diamond notehead (see Figure 6). The score uses a proportional time notation, but is fully determinate.

The opening section of SPECTRA begins with the bass’s mezzo forte F₁, which continues to be held as a drone throughout most of the piece. Over the next half-minute an additive synthesis process unfolds as successively higher harmonics of the drone (all sustained on open strings) enter with gradually increasing rapidity in the order {1, 2, 3, 4, 5, 6, 7, 9, 11, 13, 15}, although some octave equivalents are subsequently deleted so that the opening culminates with the sounding harmonic set {1, 2, 3, 5, 7, 9, 11, 13, 15}. The members of this set subsequently drop out in high-to-low order until at the 60-second mark the F₁ again sounds alone. This introductory section might be regarded as an ‘exposition’ of the open strings, with the subsequent exploration of their natural harmonics constituting ‘development’. The main (middle) section ensues, consisting of a gradual introduction of successively higher harmonics of the F₁ drone. The score indicates that instrumentalists should sustain each notated pitch continuously until a new one is indicated, and that tones other than the mezzo forte bass drone should be very soft, ‘hovering near some threshold between being heard as individual tones at all, on the one hand, and being heard simply as intensifications of some harmonic in the spectrum of the bass’s low F’.

Over the next 50 seconds all pitches obtainable using only open strings are heard, the order of their compositional selection being apparently stochastic. Thereafter the set of indicated pitches is enlarged by adding the first harmonics of open strings, with successively higher harmonics of open strings being added in stages. In this way, the total pitch set is expanded to include progressively higher harmonics of the F₁ drone, but not in any simple order. The expansion of this gamut reaches its limit (i.e., 7th natural harmonics) at roughly the golden section of the movement’s duration (5'30''). Up to this point, the sequence of attack timepoints has undergone a continuous and roughly exponential accelerando from roughly 5 seconds/attack to

![Figure 5](image_url)

**Figure 5** Complete pitch set for QUINTEXT V: SPECTRA for Harry Partch. Deviations from equal temperament (if any) are shown in cents above the staff.
Figure 6 Three systems from near the conclusion of QUINTEXT V: SPECTRA for Harry Partch. © 1972 Sonic Art Editions. Used by permission of Smith Publications, 2617 Gwynndale Avenue, Baltimore, MD 21207, USA.
0.83 seconds/attack, at which rate it then remains constant until the end of the section. Nearing the conclusion of this main section, lower harmonics of open strings begin to disappear from the texture until only open string harmonics 5, 6 and 7 remain (see Figure 6: 7’30” – 7’50”). The bass drone skips upwards to natural harmonics: first to F₂, and then to F₃ for the last 30 seconds of the section. The ‘fundamental’ thus becomes virtual since not all sounding tones are harmonics of these new bass pitches (although most are).

The conclusion unfolds as instruments begin to sustain harmonics 1, 2, 3, 5, 7, 9, 11, 13 and 15 of F₃ (i.e., the cumulative verticality of the opening section transposed up two octaves; see Figure 6: 7’50” – 8’15”). These are taken up in an irregularly descending order, some as double stops. Once the full verticality is sounding, its tones begin a sequence of downward octave transfers, now proceeding in strict sequential order from highest harmonic number (15) to lowest (1). After the first set of octave transfers, the complete verticality is heard above fundamental F₂, with a second set of octave transfers returning the piece to the verticality over F₁ that was heard in the opening section. Finally, in a retrogression of the movement’s opening process, pitches drop out starting with the highest harmonic numbers until there remains only the fading F₁ drone.

Tones in QUINTEXT V lead double lives, alternately as contributors to the timbre of a quasi-steady-state spectrum that subsumes them and as autonomous percepts available to participate in harmonic relationships. Although this duality is a characteristic preoccupation of spectralist composition (Fineberg, 2000a, p. 98), it is subjected by Tenney to an unusually sustained scrutiny, becoming a meditation on perception and its limits. When they are discernible, one might regard the role of the string quartet’s tones as illuminatory, subtly highlighting first one then another of the components and relationships latent within the bass’s tone (or, more precisely, within our perception of that tone). The representation of very high partials not otherwise discriminable, however, seems to go beyond this in a gesture towards the preternatural and the transcendence of acoustical and perceptual horizons.

**Rhythmic Analogs of Spectral Structures**

Attempts to adapt the frequency structure of the harmonic series for use in rhythmic applications have been pursued by composers as diverse as Karlheinz Stockhausen (Heikinheimo, 1972; Truelove, 1984), Conlon Nancarrow (Gann, 1995), Elliott Carter (Bernard, 1988), Ben Johnston (Von Gunden, 1986) and many younger post-minimalist American composers (Gann, 1997b). The roots of this preoccupation are traceable in large part to the early music and writings of Henry Cowell. In his seminal text *New Musical Resources* (Cowell, 1996 [1930]), Cowell constructs a just chromatic scale: a 12-note scale such that the ratio between the fundamental frequency associated with any given scale degree and that of the tonic degree equals some relatively simple numeric ratio occurring between terms in a harmonic series. He then proposes ‘scales of rhythm’ comprising durations or tempi in similar ratios...
Cowell applies these concepts in his *Quartet Romantic* (1917) and *Quartet Euphometric* (1919), wherein frequency ratios between the tones of four-part chorales are translated directly into polyrhythmic relationships between the instrumental lines (see the prefatory notes in Cowell, 1974).

One might expect that such rhythmic analogs of frequency structures would prove particularly attractive to spectralist composers, but this appears to have been the case only in North America. In a number of significant works by Tenney, both pitch and rhythmic relationships are derived from the harmonic series so that both are regulated by a common structural principle. These works include *Spectral CANON for CONLON Nancarrow* (1974) for player piano, *Three Harmonic Studies*, III (1974) for small orchestra, *Septet* (1981) for six electric guitars and electric bass guitar, *Spectral CANON for CONLON Nancarrow, Variations I-III* (1991–1998) for MIDI piano, and *Song’n’Dance for Harry Partch, II. Dance: ‘Mallets in the Air’* (1999) for Partch instruments, strings and percussion.

Three Harmonic Studies, III (1974)

Figure 7 presents a score excerpt from near the conclusion of Tenney’s *Three Harmonic Studies*, III. Each part sounds just a single pitch. Parts that articulate the

![Figure 7](image_url)

*Figure 7* Wind and percussion parts, partially condensed, from *Three Harmonic Studies*, III, penultimate score-page. © 1974 Sonic Art Editions. Used by permission of Smith Publications, 2617 Gwynndale Avenue, Baltimore, MD 21207, USA.
same pitch have been combined on single staves, and the order of the staves has been
drawn to reflect the height of their associated pitches. Only the wind and
percussion parts are presented. The string parts, which reinforce certain of the pitches
already shown, are omitted.

Observe that by the middle of the first measure the pitches presented comprise
equal-tempered approximations to the first through eleventh partials of a harmonic
series on F2. Regarding the parts as separate voices and numbering them from 1 to 12
beginning with the uppermost, notice that Voice n attacks periodically with an inter-
attack duration of n 16th notes. There are two exceptions to this rule, however: a 3:2
polyrhythm between the flute and oboe delineates an 8th-note pulse, but with certain
attacks omitted, and—near the end of the third measure shown—some attacks in the
higher voices are omitted in order to render clearly audible a marcato ascension of the
harmonic series that sweeps through all of the parts at a steady 16th-note rate. Thus,
not only do the pitches associated with successively higher voices reside in a
harmonic pitch series (their associated fundamental frequencies being successive
multiples of the fundamental frequency associated with F2) but—apart from the
marginal exceptions just noted—the inter-attack durations of successively lower
voices form a harmonic duration series since they are all successive multiples of the
xylophone’s inter-attack duration. That is, higher durational harmonics are associated
with lower pitch harmonics. Alternatively, regarding each line as possessing a distinct
tempo associated with the reciprocal of its characteristic inter-attack duration, we
could say that the tempi of successively lower voices form a subharmonic tempo series
since they are all submultiples of the xylophone’s tempo.12

It might be argued that such structural analogies between pitch and rhythm are
purely notional since pitch and time are phenomenologically independent (‘apples
and oranges’), but in the case at hand the analogy engenders an audibly accessible
correspondence. If we accept that a ratio of, say, 11:10 is more perceptually complex
than a ratio of, say, 2:1, whether these be regarded as polyrhythmic tempo ratios or as
ratios between the fundamental frequencies of paired tones, then in Three Harmonic
Studies, III the complexity of inter-voice harmonic relationship decreases mono-
tonically with increasing complexity of inter-voice polyrhythmic relationship. For
instance, inspecting Figure 7 we see that the harmonic relationship between Voice 1
(Xylophone) and Voice 2 (Fl. 1 & Ob.) is relatively complex (involving a frequency
ratio of 12:11), whereas the rhythmic relationship between these parts is simple (1:2).
On the other hand, the harmonic relationship between Voice 10 (Tbn. 1) and Voice
11 (Tbn. 2) is relatively simple (involving a frequency ratio of 2:1), whereas their
rhythmic relationship is relatively complex (involving a 10:11 polyrhythm). These
complexity relationships are straightforwardly audible.

The global form of Three Harmonic Studies, III is a sequence of 13 subsections,
each occupying a single three-measure-long page of score in 5/4 time. Suppose we
number the pages 0 – 12. (With this page numbering scheme, Figure 7 shows Page 11
and the first attack on Page 12.) Then Figure 8 provides a complete graphic score for
Pages 1 through the beginning of Page 12 with attacks represented by dots. First let us
consider the pitch structure shown. After a preparatory ‘zeroth’ page (not shown) introducing the pitch B₅, Voice 1 (the xylophone) commences steady 16th notes on that pitch. These are not typographically resolved in Figure 8 and thus appear as a solid line across the top of the figure. One further voice is added with each successive page until, on Page 11, the eleven voices of Figure 7 have accumulated. The pitches assigned to all voices except Voice 1 change from one page to the next, however. The sequence of ‘lowest pitches’ descends a subharmonic series below that of the xylophone so that the \( l \)-th subharmonic of the xylophone’s B₅ appears in the lowest voice on Page \( l \). This permits the lowest pitch on Page \( l \) to serve as the fundamental of a harmonic pitch series of which B₅ is the \( l \)-th harmonic, the other harmonics being supplied by the other instrumental parts.

Now consider the rhythmic structure. Numbering voices as before from the xylophone’s Voice 1, let us denote the tempo of Voice \( n \) as \( T_n \) so that, in particular, the xylophone’s 16th-note tempo (240 attacks per minute) is \( T_1 \). As on Page 11, on each page the tempi of successive voices below that of the xylophone fall in a subharmonic tempo series (i.e., on Page \( l \), the tempo of Voice \( n \) is \( T_n = T_1/n \) for \( 1 \leq n \leq l \)). Taking the special case of \( n = l \), we observe that the tempo of Voice \( l \) on Page \( l \) is \( T_l = T_1/l \). This means (and Figure 8 shows) that not only does the sequence of lowest pitches descend a subharmonic pitch series below B₅ (as mentioned above), but that the sequence of tempi at which these lowest pitches appear is a subharmonic tempo series. Each page introduces one new tempo that is always the lowest heard thus far, and the ‘tempo intervals’ within this succession of lowest tempi narrow just as the pitch intervals between their associated pitches narrow.

On Page 12 the expected harmonic pitch series on E₂ (the twelfth subharmonic of B₅) appears but—with the exception of its fundamental, which moves down to B₁—it

**Figure 8** Graphical pitch-time score for the body of *Three Harmonic Studies*, III.
is then briefly displaced by an unexpected revisitation of the harmonic series on F₂ before definitively returning in the final measure. This departure momentarily generates a (tongue-in-cheek?) functional altered dominant of E major (B₇[59913]), which is cadentially resolved by the concluding return of the harmonic series on E.

As is usually the case in Tenney’s music, listeners directing their attention differently will find different interesting aural paths through the work. One possibility involves focusing on various pairs or small groups of instruments and picking out their polyrhythmic or harmonic relationships, as well as the aforementioned anti-correlation between these relationships. Observing the shifting harmonic role (i.e., location within the harmonic series) of each instrument/tempo as the movement progresses is interesting too. Also, the combination of many differently pitched polyrhythmic layers generates varied resultant melodic and rhythmic figures whose constitution depends in part on the set of instruments to which the listener directs his or her ear.

The reader has no doubt already noticed the striking appearance of the formal structure illustrated in Figure 8. If rotated 90-degrees counterclockwise, the figure resembles an ensemble of divisive polyrhythms undergoing a general ritardando. Inspecting the individual voices participating in this ‘polyrhythm’, it becomes apparent that their ‘tempi’ comprise the first twelve terms of a harmonic tempo series (1:2:3:4:5:6:7:8:9:10:11:12). Regarded as a polyrhythm this structure embeds characteristic patterns of coincidences between attacks; regarded as the formal scheme that it actually is, these patterns of coincidence become patterns of pitch recurrences (e.g., the recurrence of B₅ on each score page, the recurrence of B₄ on every even-numbered page, the recurrence of E₄ and E₅ on every third page, etc.).

Clearly harmonic and subharmonic series are palimpsestically inscribed in the music: as local pitch structure, as local rhythmic structure, as global pitch structure and as global rhythmic structure. The resulting form is both organic and crystalline, gradually and inexorably unfolding a web of shifting relationships between pitches, tempi, intervals and polyrhythms whose aspects are rigorously integrated both conceptually and phenomenally. Nonetheless, this remains one of the simpler expressions of Tenney’s interest in pitch-rhythm analogs (!). The most sophisticated is surely his Spectral CANON for CONLON Nancarrow.

Spectral CANON for CONLON Nancarrow (1974)

The Spectral CANON was composed between 1972 and 1974. A teletype machine was used to produce trial scores, with the final version taking the form of a player-piano roll hand-punched by the work’s dedicatee as a favor to Tenney.¹⁴ The first realizations were made by Tenney together with composer Gordon Mumma in Santa Cruz, California, in 1974.¹⁵ The piano is retuned to sound the first 24 harmonics of A₁. The canon of the title unfolds in 24 voices, with each restricted to just one of these harmonic pitches. The opening 80 seconds of the piece are illustrated graphically in Figure 9. Each voice repeats its assigned pitch while slowly accelerating through 185
attacks, following which this sequence of inter-attack durations begins to retrograde. The durational sequence is identical in each voice, but voices enter canonically in the order of their pitch height so that the lowest voice (sounding $A_1$) enters first and the highest voice enters last. In fact, the lowest voice commences retrogression at the instant when the highest voice enters, and the piece concludes when this lowest voice finishes its retrograde. Thus higher voices do not finish retrogression and the highest voice is only just about to begin its retrograde when the piece ends $3'36''$ after it begins. This conclusion coincides via subtle construction with the first simultaneous attack of all 24 voices.

The relationship of the harmonic series to the pitch structure of the opening is explicit, but turning Figure 9 counterclockwise through 90 degrees reveals its additional relationship to the rhythmic structure. The sequence of attack times in each voice comprises a harmonic duration series, albeit one which starts from its eighth partial rather than from its fundamental:

$$\left\{c \log_2 8, c \log_2 9, c \log_2 10, \ldots \right\} \text{ seconds},$$

where $c$ represents the value of a temporal octave as specified by the composer and where the time origin precedes the first attack by three temporal octaves. The entrances of successive voices are separated by time intervals corresponding to eight attacks of the lowest voice (see Figure 9). In fact, these voice entrances themselves fall in a harmonic duration series. Thus the entire rhythmic structure of the opening might be regarded as a collection of individual intra-voice harmonic duration series (governing attack times) constructed upon a master inter-voice harmonic duration series (governing voice-entrance times).

A thorough elucidation of the complex structural and phenomenological consequences entailed by this rigorous construction are beyond the scope of the present treatment. It must suffice to note with reference to Figure 9 that increasingly complex polyrhythms arise as successive voices enter and that—in contrast with Three Harmonic Studies, III—the complexity of the polyrhythmic relationship between any set of voices increases monotonically with the complexity of the harmonic relationship between them. For instance, Voices 1 and 2 (here numbering from bass to treble) exhibit a relatively simple harmonic relationship.

![Figure 9](https://via.placeholder.com/150)

**Figure 9** Graphical pitch-time score for Spectral CANON for CONLON Nancarrow (opening).
(frequency ratio 1:2) and articulate a relatively simple polyrhythm (also 1:2), whereas Voices 3 and 4 exhibit both a relatively more complex harmonic relationship (frequency ratio 3:4) and polyrhythm (also 3:4).

The intricacy of the accumulating and accelerating polyrhythms eventually defeats the perception of relationships between individual voices, producing an audibly chaotic maelstrom of rhythmic and melodic fragments that obscures the commencement of rhythmic retrogressions in the lower voices. As these retrogressions gradually invade higher voices, an unexpected textural transformation unfolds. Harmonic glissandi begin to sweep progressively higher in pitch, ultimately supplanting the preceding disarray with a new, multifaceted rhythmic and melodic order. As this happens, the instrument seems to begin to ‘ring’ as though it were sustaining a single shimmering complex tone. The structural consequences are illustrated in Figure 10, which shows the penultimate page of the score. Vertical lines indicate attack-time coincidences. Note the increasing pitch compass of both the coincidences between lower voices and the harmonic glissandi that flank them.

To my ears, the concluding tutti attack (not shown) is remarkable in part because it does not seem like 24 individual voices, but rather like a single fused tone. This is a consequence of the precise harmonic intonation of the various voices, which promotes their perceptual fusion into a unitary ‘hyper-piano’ tone in the same way that the partials of any harmonic complex tone tend to perceptually fuse. It is as though the spectral components of this final tone, having been separately accumulated throughout the opening of the piece and subjected to great rhythmic pressures in its interior, and are ultimately forged into a unified percept at its conclusion.

Speech-Modeling Pieces

Three Indigenous Songs (1979)

*Three Indigenous Songs* (1979), for two piccolos, alto flute, bassoon or tuba, and two percussionists, addresses the instrumental synthesis of American English speech. Its three movements are based upon three different vocal models: Tenney’s transcription of the song ‘No More Good Water’ by the early blues singer Jaybird Coleman; a transcription of Tenney’s own voice as he reads the poem ‘Kosmos’ by Walt Whitman; and a prior setting by the composer of an Iroquois chant ‘Hey when I sing these 4 songs Hey look what happens’ as translated by Jerome Rothenberg. The preface to the score contains the following passage:

> The perceptual space induced by THREE INDIGENOUS SONGS is meant to be somewhere near the threshold between music and speech. Occasionally, perhaps, some semblance of the underlying texts may actually be heard.

The prospects for actually evoking intelligible utterances by means of instrumental synthesis will not seem entirely implausible to those who have heard examples of
so-called ‘sine wave speech’, in which comprehensible speech is produced using as few as three sine waves whose frequencies track those of the lowest-frequency formant peaks of the utterance to be evoked (Remez et al., 1981).
The first two stanzas of the text to the source recording for Movement I are:

Well there’s no more good water
because the pond is dry.

I walked down to the river
then turned around and ’round.

In the music, these stanzas are each preceded by freely composed equivalents of the recording’s harmonica choruses. My reconstruction of the composer’s working method from his notes is illustrated in Figure 11. Part (a) of the figure shows measure 7 of the first movement. The text ‘wa- - -ter’ is provided in the score only as a reference, being neither spoken nor sung in performance. Rather it (or, more precisely, its u, a, t and e sounds) are musically transcribed. The sounds subjected to transcription are represented on the text staves using symbols of the International Phonetic Alphabet. Consonants are rendered by the percussionists using woodblocks (for k, t and p), tom-toms with sticks (for g, d and b), tom-toms with brushes (for th, f and h) and suspended cymbals (for s and sh). The pitch of vowels is transcribed from the source recording and appears throughout as the bassoon/tuba part. The flute and piccolos play harmonics of this fundamental that are near the centers of the first three vocal formants associated with that sound. Flutes are an apposite instrumental choice for these upper parts because the relatively simple sound spectra they produce suit their roles as suppliers of particular harmonics.

Figure 11(b) is adapted from Tenney’s composition notes and specifies the locations of the first three formants (labeled \(F_1\), \(F_2\) and \(F_3\)) for the vowel sounds \(\alpha\) (\(a\)) and \(\Lambda\) (\(e\)) that appear in ‘water’.\(^{19}\) These locations are indicated in the figure both as frequencies taken from the acoustical literature and as the nearest corresponding equal-tempered pitches.\(^{20}\) Each formant location falls within a range whose lower and upper limits are indicated with filled noteheads and whose midpoint is indicated using an open notehead. Figure 11(c) (also excerpted from Tenney’s notes) shows equal-tempered approximations to the harmonic series above the fundamentals associated with the bassoon/tuba pitches C\(\#\)\(_3\) and G\(_2\). With this information at hand, it is a simple matter to select harmonics of the appropriate fundamental that fall within the formant regions associated with a given vowel and assign the pitches of those harmonics to the alto flute and piccolos. For instance, vowel \(\alpha\) begins on fundamental C\(\#\)\(_3\) so that its 6th and 8th harmonics (G\#\(_5\) and C\#\(_6\)) fall in the first and second formant regions, respectively, and are assigned to the Alto Flute and Piccolo 2. The 20th harmonic (\(F_7\)) appearing in Piccolo 1 lies very close to the third formant region.\(^{21}\) When the fundamental changes to G\(_2\), harmonics of that pitch must be selected instead: harmonics 8, 10 and 24 (G\(_5\), B\(_5\) and D\(_7\)) fall within the appropriate formant regions. After the tam-tam renders the D (\(t\)) consonant, the \(\Lambda\) (\(e\)) sound appears, the formant regions shifting to those associated with this new vowel so that now the 6th, 12th and 24th harmonics of G\(_2\) (i.e., D\(_5\), D\(_6\) and D\(_7\)) appear in the flutes. The fleeting G\(_6\) in Piccolo 2 probably emulates a formant transition, a rapid
movement of a formant peak that immediately follows or precedes certain consonants and is important for their correct identification (Parsons, 1986, pp. 121–123).
Tenney revisited the project of speech synthesis by instrumental means in two subsequent works. *Ain’t I a Woman?* (1992) for 2 violins, 2 violas, 3 cellos and celesta is based on a text by Sojourner Truth. *Song ’n’ Dance for Harry Partch, I. Song: ’My technique’* (1999) for Adapted Viola, Diamond Marimba, strings and percussion is based on a recording of the composer’s voice reading from the writings of Harry Partch. In the last of these, Tenney’s progressive refinement of the transcription process embraced the modeling of voiced consonants, sixths-of-a-semitone intonational accuracy in the harmonics, *portamenti* replicating vocal inflections, and direct spectral analysis of the source recording using custom software.

Like much of Tenney’s work, these pieces decisively stake out for music a perceptually and conceptually engaging domain of sonic organization not previously regarded as proper to it—in this case, a hybrid of concert music with speech and physical acoustics. While none of these works evokes genuinely intelligible speech (a fact that their composer readily pointed out), I personally hear their rhythmic and inflectional patterns as decidedly speech-like. This is especially the case with *Song ’n’ Dance*. The daunting technical difficulty of the latter work in particular has so far prevented performances from achieving the marked tempo, so the possibility exists that more-accurate renditions may yield stronger evocations of the music’s spoken model.

In any event, the considered choice of sources with strong sonic characters, coupled with a faithfully pursued process of acoustically-informed transcription, has clearly projected those particularities onto the resulting music. For instance, the transcribed blues song, the Whitman poem and the Iroquois chant of *Three Indigenous Songs* all exhibit markedly different characters immediately relatable to their sources. Note, however, that these sources are themselves complex artifacts. Each incorporates aspects inherited from: the physics of speech production; general rhythmic, inflectional and grammatical patterns of the English language; qualities related to the source’s cultural origins; the unselfconscious vocal idiosyncrasies of its original author; features intentionally imbued therein by that author; and, in some cases, corresponding attributes from the contemporary speaker whose voice was recorded for transcription purposes. The list of contributions runs a gamut from the purely impersonal to the most intimately personal, although even the latter is ultimately perceived through the alienating lens of spectrographic transcription.

Where much instrumental music depends for its impact on the metaphorical evocation of vocal expressivity, here the evocation is boldly literal. My experience of these works is reminiscent of viewing an X-ray: they confront me with the strange and variegated materiality underlying even the most intimate aspects of subjectivity. This music presents the almost surreal spectacle of an ensemble seated upon a stage attempting to re-enact before an audience the assembly of these material aspects into a coherent, expressive self. Measures of success and shortfall both contribute to the poetry of the work.
Pieces Employing Tape Delay

Several Tenney works incorporate tape-delay systems in order to generate dense quasi-orchestral textures using a soloist or a relatively small number of instrumentalists. In particular, the works *Symphony* (1975) for woodwind quintet, *Saxony* (1978) for one or more saxophone players and *Voice(s)* (1983–1984) for variable ensemble, voice(s) and multiple tape-delay systems use this approach to accumulate complex textures based on one or more harmonic series.

*Voice(s)* (1983–1984)

As I read it, the title of *Voice(s)* has at least four different senses. An early version of the work was composed for vocalist Joan LaBarbara and the title presumably refers, in one of these senses, to the original dedicatee. After hearing the original, the composer decided to make a second version with expanded instrumentation in order to achieve increased textural density. This later rendering is the published version and my discussion here will address it specifically. The score calls for at least one violin, one cello and one soprano voice, plus three or more of the following: flute, alto flute, oboe, English horn, clarinet, bass clarinet, bassoon, saxophone (soprano, alto, tenor, baritone), viola and trombone. Other voices in any register may be used, but all must sing without vibrato and all pitches must be sung in their written octaves. A second sense of the title refers to this instrumentation.

*Voice(s)* requires the use of four tape-machines, and calls for tape-changes and volume manipulations whose timings must be accurately observed if the formal design is to unfold as intended. The tape-machines perform the following functions:

**Machine 1:** records both the instrumental sounds and re-played sounds coming from the other tape-machines.

**Machine 2:** after a delay of six seconds, plays back the tape from Machine 1 slightly attenuated so that a total acoustical fade-out time of about 60 seconds results. With one brief exception (see below), this ‘echo effect’ remains in use throughout the entire performance, thickening the sonic texture.

**Machine 3:** records roughly the first third of the performance using a tape-speed of 15 inches-per-second (ips), then plays that recording backwards at a halved tape-speed of 7.5 ips during roughly the last two-thirds of the performance duration.

**Machine 4:** records roughly the first two-thirds of the performance at a tape-speed of 7.5 ips, then plays that recording forwards at a doubled tape-speed of 15 ips during roughly the last third of the performance duration.
A twofold increase in tape-speed causes the replayed signal to sound one octave higher than the signal that was recorded and to last half as long. Conversely, a decrease in tape-speed by a factor of two causes the replayed signal to sound one octave lower than that recorded and to last twice as long. Thus, evoking a third sense of the title, we can see that *Voice(s)* takes the form of a three-voice canon at the octave, although each voice is (usually) a composite of multiple simultaneous melodies rather than a single one. One voice (henceforth ‘Voice 1’) comprises the sum of all live instrumental sounds while the other two voices are created by the operation of the tape machines. The output of Machine 3 (‘Voice 2’) is material from Voice 1 heard retrograded, in rhythmic augmentation and one octave lower, while the output of Machine 4 (‘Voice 3’) is material from Voice 1 and Voice 2 heard forwards, but in rhythmic diminution and an octave higher. Note that nothing is recorded prior to the performance.

The instrumentalists of Voice 1 follow an available pitch procedure similar to that employed in *Clang*. The score indicates that the pitches notated for each section ‘are to be used by all performers in an improvisatory way to create melodic sequences of varying shape and duration’. This instruction allows considerable melodic and even stylistic freedom on the part of the instrumentalists, while rigorously fixing the harmonic structure. Although my ensuing analysis necessarily concentrates upon the work’s determinate harmonic plan, it should be kept in mind that realizations display a prominent polyphonic melodic component. The effect of Machine 2’s tape echo and the accumulation of instrumental lines (some live and some on tape) is to provide a rich harmonic cloud of sound on which melodies float and into which they submerge.

Figure 12 shows the opening system of the score to *Voice(s)*. Conventional pitch notation is extended in order to provide accurate specification of pitches in the harmonic series above B-flat, using pitch gradations of one-sixth of a semitone (i.e., 72-tone equal temperament). To this end, arrows bearing one to three arrowheads are positioned above noteheads in order to indicate changes in the intonation (sharp or flat) with respect to 12-tone equal temperament: one arrowhead per sixth-of-a-semitone deflection. This system correctly specifies all target pitches used in the piece.

Figure 12 *Voice(s)*, opening system of the score. © 1984 Sonic Art Editions. Used by permission of Smith Publications, 2617 Gwynndale Avenue, Baltimore, MD 21207, USA.
to within 7.7 cents, and all except the 13th partial and its octave equivalents to within 5 cents. In performance, reference pitches are provided by the cello and violin, which employ scordatura such that the open strings of the cello are tuned to harmonics 2, 3, 5 and 7 of B-flat while those of the violin are tuned to harmonics 6, 10, 14 and 22. These two instruments are instructed to play only open strings and natural harmonics, thus making available to the other instrumentalists reliably accurate intonational references for many of the pitches indicated in the score.

Figure 13 provides a formal schematic for Voice(s), with sections labeled by letters corresponding to markings found in the score. The upper part of the figure shows the timings of sectional changes (i.e., changes of available pitch set), the time intervals during which Machines 3 and 4 are in record and playback modes, and indicates for Voice 1 the ranges of harmonics of B-flat that correspond to available pitches in each section. Regarding labeling, the first re-played materials in Voice 2, for instance, are labeled ‘b2/2’ indicating that they are a recorded version of Voice 1’s b2 materials replayed at half speed and thus sounding one octave lower (a frequency ratio of 1/2). Similarly, the first replayed materials in Voice 3 are labeled ‘2a2’ indicating that they include a recorded version of Voice 1’s a2 materials replayed at double speed and thus sounding one octave higher (a frequency ratio of 2/1). The lower part of the figure shows the evolving pitch compass of each voice. In Section e, where this compass is not delimited, bounding lines have been omitted. Sustained single pitches are indicated with solid black horizontal lines and the conceptual fundamental of the available pitch collection is indicated with a thick broken line.

Voice 1 opens with a single available pitch, B-flat (see Figure 12 and Figure 13), gradually increasing in dynamic from pianissimo to fortissimo. If the instrumentalists exercise good intonation, their massed unison will yield a timbrally modulated complex tone with many ringing harmonics clearly audible above its fundamental. At the end of Section a1, B-flat is supplanted by B-flat, which fades to pianissimo over the course of a 30-second time interval that is not marked in the score, but which I will denote as Section a′. This time interval, spanning 1’30″–2’00″, calls for a strategic sequence of volume adjustments to Machine 2: at 1’30″ its playback level is abruptly reduced to nil, remains thus until 1’37″, and then is increased gradually to normal level at 1′45″ (see Figure 12). The effect is that the B-flat is cleanly released with no echo, this being the only such release in the piece. This unique early event will engender a significant quasi-cadential figure heard in Voice 2 at the work’s conclusion and discussed further below.

As illustrated by Figure 12 and Figure 13, in Section a2 harmonics 8 through 16 of B-flat become available pitches. Over the next two sections (b1 and b2) the available pitch set rises in register, admitting progressively more complex harmonic relationships as it moves higher in the harmonic series and correspondingly contracts in registral compass. The effect of the tape echo associated with Machine 2 is to blur in performance the abrupt temporal boundaries between the successive pitch sets indicated in the score and in Figure 13. At Section c the available set is extended both upward to the 32nd harmonic of B-flat and downward to the 8th, re-embracing all
Figure 13 Formal schematic for Voice(s).
of the pitches heard since the beginning of Section $a_{2}$ (see Figure 13).\footnote{26} Twenty seconds later, Voice 2 enters with the retrograded materials of Section $b_{2}$ transposed down an octave (designated ‘$b_{2}/2$’ in the figure), thus effectively dropping the conceptual fundamental of the collection from B-flat$_{0}$ to B-flat$_{-1}$. The density of the texture increases as the complex harmonies heard in Voice 1 just 20 seconds earlier reappear an octave lower in Voice 2. The pitches appearing in Voice 2 are harmonic numbers 16–24 of B-flat$_{-1}$ while those in Voice 1 are now harmonics 8–32 of B-flat$_{0}$, so that Voice 2 fills in the ‘low end’ of Voice 1, doubling the number of distinct sounding pitches between B-flat$_{3}$ and F$_{4}$.

Sections d and e extend Voice 1’s available pitch gamut still further, ultimately down to the B-flat$_{2}$ of the opening and upwards without bound into high natural string harmonics. Voice 2 persists in the role of filling in Voice 1’s lower pitch extremity over Sections d and e, its registral descents synchronized with those of Voice 1, but also, of course, retrograding at the octave and in rhythmic augmentation both the outline and details of Voice 1’s earlier ascent between the 2- and 8-minute marks. The measured increase in the range, number of sounding voices and harmonic complexity accumulates a texture of almost oceanic depth by 17’.

Voice 3 enters at 16’50” with harmonics 8–16 of B-flat$_{1}$ (or, equivalently, even-numbered harmonics of B-flat$_{0}$ between numbers 16 and 32), serving over the next few minutes to emphasize harmonics in progressively higher registers and eventually extending its range above that of Voice 1. Of course, it presents in rhythmic diminution at the octave not only all materials that previously appeared in Voice 1, but also (starting at 20’00”) materials previously heard in Voice 2 during the time interval 8’20”–16’20”, which now appear in a fourth ‘voice’ presenting an incomplete retrograde of Voice 1 (3’50”–7’50”) at pitch and in tempo (marked ‘Voice 4’ in Figure 13). This section marks the zenith of the work’s textural and harmonic complexity. Amid the vast number of simultaneously sounding tones, individual instruments lose their identities as partials dissociate from their particular instrumental sources, undergoing kaleidoscopic harmonic fission and fusion. The resulting texture evokes not instrumental sources, but rather a gigantic choir whose range extends both above and below that of normal human voices. The progression from the individual voice (or voices) heard at the opening to this immense and seething choral texture at the work’s culmination reveals a fourth sense of the title.

Several aspects of the formal design strategically collude to produce a dramatic conclusion. First, the harmonic complexity of Voice 2 has been decreasing gradually as it descends lower in the harmonic series of B-flat$_{-1}$, finally giving way to a single B-flat$_{2}$ pitch at 20’00” (although the emergence of this harmonically simpler texture is rendered gradual by the operation of the tape echo). This amounts to a progressive harmonic clarification of the texture following the welter of the preceding minutes. Second, at 21’00” the upward range of Voice 1 is strategically reined in, in preparation for Voice 3’s subsequent ascent. Third, and most importantly, at 20’00”, Section $a_{1}/2$ commences in Voice 2, providing a crescendo on B-flat$_{2}$ lasting just long
enough (60 seconds) for the tape-echoes of the various other Voice-2 pitches sounded in Section a₂/2 to completely fade. This is significant because among them are the only pitches in the total texture necessarily associated with the conceptual fundamental B-flat₇₁ rather than any higher fundamental. Of course, the conclusion of the crescendo on B-flat₂ corresponds to the aforementioned clean (i.e., un-echoed) release of B-flat₂ in Voice 1 at 1'30", which is now heard in retrograde and transposed down an octave, becoming a clean attack of B-flat₁ in Voice 2. This is the lowest pitch heard in the piece and it has not sounded previously. It appears just as Section f commences at 21'00", at which time the same B-flat₁ is made available to the instrumentalists of Voice 1 and all odd-numbered harmonics of B-flat₀ are deleted from Voice 1’s available pitch set (which thus becomes a harmonic series on B-flat₁). All pitches in Voice 3 can also be regarded as harmonics of B-flat₁, so as the echoes of Section e fade the conceptual fundamental of the total sounding pitch collection is effectively raised from a non-sounding B-flat₇₁ to this sounding B-flat₁. For the first time in the piece since the opening unisons, the conceptual fundamental corresponds with an actually sounding pitch, aurally rationalizing all tones as harmonics within the spectrum of this fundamental. Section f is marked with a diminuendo to pianissimo, and Voice 2 executes a similar fade as it retrogrades Section a₁, so that in the end we are left with the high fleeting tones of Voice 3, still intelligible as upper harmonics of the fading fundamental. The piece closes with just a hint (10 seconds worth) of Section 2e replaying in Voice 3 as that voice is finally faded out as well. Thus Voice 3 finishes with a pitch set whose lowest member is a B-flat.

As in Clang, we observe in Voice(s) a global trajectory of gradual, systematic harmonic complexification and subsequent clarification that assumes a motivating and unifying role somewhat reminiscent of that played by background harmonic prolongation and resolution in tonal music, but without resort to traditional harmonic formulæ.

Other Works

Tenney’s compositional œuvre is more varied in its techniques and concerns than that of most composers. Apart from the groundbreaking computer music already mentioned, it includes influential examples of tape collage,²⁷ Fluxus-related performance pieces, works predicated on his theories of formal perception, percussion music, pieces inspired by the music and theories of Ruth Crawford and Charles Seeger, inventive arrangements of music by other composers such as Cage and Nancarrow, and even striking examples of original ragtime music. Nonetheless, what I have been calling Tenney’s spectral music comprises the single largest component of his output since 1971. Other significant early compositions in this vein not discussed above include Chorales for Orchestra (1974) and Orchestral Study (1974).²⁸ Tenney’s later spectralism-related works are numerous, but include Glissade (1982) for viola, cello, contrabass and tape-delay system, Critical Band (1988) for any ten or more sustaining instruments,²⁹ Diapason (1996) for string orchestra (which

In the Three Harmonic Studies (1974) for small orchestra and the sequence of compositions entitled Harmonium #1–#7 (1976–2000) Tenney began to explore the harmonic series as a source of specifically harmonic relationships. In Harmonium #1 (1976) for variable ensemble, which presents the conception behind the Harmonia series in its plainest form, a chordal texture undergoes a gradual transition (one tone at a time) between subsets of harmonic series with different fundamentals. In the first half of the piece, the fundamental of the new subset is always the last tone to be supplied by this gradual ‘modulation’. Its arrival is marked each time by a sudden strong perceptual fusion between all of the sounding tones together with a concomitant increase in sensory consonance. The composer described this phenomenon as ‘a sudden making of sense’ of the harmonic relationships between pitches.

Tenney spent much of the next thirty years exploring such harmonic relationships both theoretically and compositionally. Only a small fraction of his theoretical writings on the subject have appeared in print, but among those that have one finds a semantic history of the terms ‘consonance’ and ‘dissonance’ (Tenney, 1988), a call for a descriptive harmonic theory consistent with a post-Cagean empiricism together with the quantitative foundations for such a theory (Tenney, 1993 [1983]), proposed neurophysiological mechanisms underlying harmonic perception (Tenney, 1992), and an algorithm for accumulating referential pitch-class sets based on a quantitative measure of harmonic distance between pitches (Tenney, 2007). Also, in addition to the Harmonia series, this line of exploration has yielded a body of other major compositions including Bridge (1984) for two pianos/eight hands in a microtonal tuning system, Koan (1984) for string quartet, ‘Water on the Mountain . . . Fire in Heaven’ (1985) for six electric guitars, the monumental Changes: 64 Studies for 6 Harps (1985), and the series of works Forms 1–4 (1993) for variable ensemble, to name only a few.\(^{31}\) Detailed discussion of these works and their theoretical underpinnings is beyond the scope of the present treatment. In any event, a specific interest in harmonic perception arguably diverges from the paradigmatic spectralist concern with the duality of harmony and timbre. Indeed it is significant, in part, precisely because it opens a progressive and fruitful compositional avenue that leads beyond classic spectralism while retaining unalloyed its radical phenomenological orientation.

Spectrum 6 (2001)

The Spectrum series represents a convergence of Tenney’s compositional and theoretical interests in spectrum as timbre, harmonic perception and temporal gestalt perception in music. Tenney’s gestalt theory is sophisticated and cannot be treated in detail here (see Tenney, 1988 [1964]; Tenney & Polansky, 1980). In outline, he
theorized the hierarchical perceptual grouping of musical components, proposing that grouping is promoted by *proximity* in time and/or *similarity* in other musical parameters (pitch, timbre, dynamic, etc.). In Tenney’s parlance, indivisible musical *elements* (typically individual notes or chords) group into *clangs* (collections often with the cardinality, if not necessarily the function, of ‘motives’), which in turn group into *sequences* (collections of length often similar to ‘phrases’) and so forth through higher hierarchical levels such as subsections, sections and so on. The largest grouping is the piece as a whole. In the pieces of the *Spectrum* series, such musical components were generated algorithmically using software written by the composer that was customized as needed for individual works.

Consider *Spectrum 6* (2001) for six instruments. In this work, the instrumentation is divided into two Groups. Group 1 comprises flute, bass clarinet and piano while Group 2 comprises violin, cello and percussion. The piano is microtonally retuned. The percussionist plays a standard equal-tempered vibraphone with motor off, plus seven freely chosen unpitched percussion instruments. All instruments except percussion share throughout a common pitch reservoir, shown in Figure 14. The pitches to the right of the barline comprise a 12-note ‘just chromatic’ scale that divides the octave fairly uniformly. This 12-note scale is repeated in higher octaves (not shown) up to the top of the ensemble’s range. All pitches correspond to harmonics of F₀, so some pitches of the ‘chromatic scale’ do not appear in the lower registers. Note that the conceptual fundamental F₀ is not itself in the set.

Each instrumental part is generated in a separate software run. The inputs to the routine include the duration of the work, the name and range of the instrument, the maximum number of tones per chord for polyphonic instruments and any required transposition for the part. Various composer-defined time-dependent mathematical functions control the selection of clang durations, the number of elements per clang, the probability that a clang will be replaced by a rest and the dynamic of each clang. The algorithm itself only generates elements and clangs—larger-scale formal organization is compositionally imposed by prescribing these functions. The particular functions used in *Spectrum 6* are shown in Figure 15, as specified in the code to Tenney’s software. Note that different curves are stipulated for each of the two instrumental Groups. 32

Consider the generation of clangs and elements in Group 1. (Everything proceeds similarly for Group 2.) The length of each clang is selected at random without bias

![Figure 14](image-url) Pitch set used in *Spectrum 6* (2001). The pitches after the barline are repeated in higher octaves (not shown).
between the limits provided by the upper and lower solid curves in Figure 15(a), reading the figure at the time value that corresponds to the beginning of the clang in question. With the probability indicated in Figure 15(b), the clang is randomly replaced with an equivalent period of rest. If it is not so replaced, then the number of elements within the clang is randomly selected without bias from the range between the solid lines in Figure 15(c), and their associated attacks are distributed evenly throughout the duration of the clang. A dynamic is assigned to the clang as deterministically specified by Figure 15(d). If the clang was not replaced by rest, then a padding rest of 0.5 seconds is appended to it in order to ensure its perceptual segregation with respect to neighboring clangs.

Figure 16 shows the first and last systems of the concert-pitch score. Time is proportionally notated. Individual clangs are beamed together wherever this is typographically convenient, in which case the beamed group is to be played legato. Breath marks (’) signal the beginning of rests. Numbers above noteheads indicate deviations in cents from 12-tone equal-temperament, and noteheads replaced by numbers identify non-pitched percussion instruments.

![Figure 15](image-url) Parametric curves used in the algorithmic composition *Spectrum 6.*
Figure 16 The (a) first and (b) last systems from the concert score to *Spectrum 6*. © 2001 James Tenney. Used by permission. Published by Frog Peak Music (http://www.frogpeak.org).
Compare Figure 15 with Figure 16. The variations and counterpoint of the parameters illustrated in Figure 15 are easily observable by ear and in the score, resulting in a unique variety of contrapuntal spectral music. For a given instrumental Group, clang duration and rest probability decrease (on average) over the course of the work, while the number of elements per clang and the dynamic increase (on average). Furthermore, variations in all parameters are initially out-of-phase between the instrumental Groups, but over the course of the work they gradually come into phase, exhibiting an interesting ‘parametric counterpoint’ along the way. Thus Group 1 begins with (on average) relatively brief clangs, low probability of rest, high numbers of elements per clang, and loud dynamic, whereas Group 2 begins with just the opposite attributes. At the conclusion of the work, on the other hand, both Groups exhibit the same highly energetic temporal and dynamic attributes. Finally, note how local maxima of the elements-per-clang and dynamic curves (and local minima of the clang duration and rest probability curves) flank the golden ratio conjugate, \( \Phi \approx 0.618 \), of the work’s duration. This general variety of parametric counterpoint has often featured in Tenney’s algorithmic compositions beginning with his computer music of the 1960s (see Tenney, 1969; Polansky, 1983, pp. 159–171).

The pitch content of the work is also determined algorithmically. For each element within a clang, a pitch is drawn from the pitch reservoir at random within the range of the respective instrument. If the instrument is classified as polyphonic (in this work, only the piano is thus regarded), then the number of tones in the given element is determined at random in such a fashion that the probability of a large number is a decreasing function of the attack rate within the clang (so that fast clangs are primarily monophonic). When determining the multiple tones within a single chord, the pitch probabilities are adjusted after each individual pitch choice so that pitches near the previous one are favored for the next choice of chord tone. This deters the formation of chords exhibiting extreme registral dispersion. On the other hand, whenever a given pitch class is selected, the probability of its being selected again is strongly suppressed, gradually returning to normal over the course of the next six attacks. This serves to promote the regular circulation of all pitch classes within each instrumental part. In the percussion part it is assumed that only standard tempered pitches are available from the vibraphone, so if a selected pitch differs by more than five cents from the nearest tempered pitch then an unpitched percussion sound is assigned to the corresponding element. After all elements in a given clang have been specified, the algorithm advances the time value by the duration of the clang (plus any padding rest) and the process is repeated for the next clang.

The absent fundamental \( F_0 \) of the pitch collection serves ‘behind the scenes’ as a unifying force for the entire work in a manner somewhat reminiscent of the background tonic harmony in tonal music. In passages where the number of elements per clang is low, I tend to become preoccupied with hearing the various local harmonic relationships between tones, some of which are simple and some of which are complex. As the event density increases, the texture becomes increasingly...
polyphonic as melodies emerge due to the grouping of tones by both proximity in time and similarity in timbre (i.e., instrument), although harmonic relationships remain salient. During passages of high event density (and especially at the work’s conclusion), I begin to perceive the ensemble of pitches as elements of a harmonic spectrum above the missing F₀, especially when other members of this pitch class prominently sound. Spectrum 6 thus illuminates the composer’s longstanding interests in harmonic perception, on the one hand, and spectrum as timbre, on the other, as two sides of a coin.

Conclusions

Tenney’s work is a seminal representative of a broader current of spectral music composition that arose in North America independently of spectralist developments in Europe. It has significant roots, on the one hand, in encounters by artists with a scientific culture whose influence and pervasiveness expanded enormously during the postwar era and, on the other hand, in a quasi-empiricist musical aesthetic inherited principally from John Cage. Tenney’s work is not the only expression of these influences, of course; one finds related manifestations in the music of Alvin Lucier (b. 1931), La Monte Young (b. 1935), Terry Riley (b. 1935), Maryanne Amacher (b. 1943), Phill Niblock (b. 1944), Glenn Branca (b. 1948), and many younger composers (see Hasegawa, 2006; Gann, 1997a, 2004). Nonetheless, Tenney’s Clang and Quintext seem to be the earliest examples of ‘paradigmatic’ spectral music arising in North America, clearly displaying the ensemble of characteristics outlined in the introduction.

Tenney’s work exhibits certain characteristics, however, that distinguish it from most European spectral music. These derive in large part from his focused concern with phenomenology and the nature of perception, and include:

- His relatively strict intonational stipulations, which promote strong harmonic fusion and allow discrimination of many distinct harmonic-series intervals, in contrast with the common acceptance of quarter-tone pitch approximations in European spectralism.
- An apparent disinterest in inharmonic spectra due to their lack of referential perceptual status, compared with the frequent appearance of such spectra in European works (Anderson, 2000).
- The relative exclusion from his music of concerns for textural variety and formal elaboration of the sort that became increasingly prominent in continental spectralism after 1980 (Anderson, 2000, pp. 15–16).
- Tenney’s increasing interest in harmonic perception, a productive route away from classic spectralism that retained its radical phenomenological orientation.
- The element of post-Cageian indeterminacy manifested in Tenney’s available pitch procedures, which serves in part to direct the listener’s attention to perception rather than to local semantic considerations.
Another conspicuous distinction is the appearance in Tenney's work of rhythmic analogs to frequency spectral structures, although this may be motivated less by phenomenological considerations than by structuralist curiosity and an identification with the tradition of American experimental music in which such analogs have played a significant role since Cowell.

Compositions in a spectralist vein appear among the works of a number of Tenney's students. Among their ranks are such important composers such as Larry Polansky (b. 1954) and John Luther Adams (b. 1953). Polansky's contrabass quartet of 1975–1977 entitled Movement for Lou Harrison uses natural harmonics on just-tuned strings to achieve an evolving variety of pitch constellations within a given harmonic series, a technique that the composer indicates was first suggested to him by Tenney's QUINTEXT V: SPECTRA for Harry Partch (Polansky, 1994). Later Polansky compositions such as Psaltery (1979) for tape, and Horn (1989) for horn and tape, employ gradual systematic modulations between different harmonic spectra. John Luther Adams' large-scale musical theatre work Earth and the Great Weather (1990–1993) includes a collection of pieces for strings and digital delay. Several of these employ textures, techniques and tuning systems related to those found in such Tenney compositions as QUINTEXT V and Glissade. Indeed, Adams explicitly describes one of them as 'an homage to Tenney' (Adams, 1994). Earth and the Great Weather departs from strict phenomenological concerns in its attention to the evocation of place. Here spectralist techniques function in part to suggest the austerity and rarefied temporal sense associated with the Alaskan wilderness where the composer resides. 34

From 1976 to 2000 Tenney lived and taught in Toronto, Canada, where his influence was felt by a number of Canadian composers including Marc Sabat (b. 1965), Paul Swoger-Ruston (b. 1968), Josh Thorpe (b. 1975) and the author (b. 1967).

I would like to conclude with some remarks of a more personal sort. It seems to me that certain artists bequeath to future generations a legacy that is not limited to a distinctive body of accomplished works, nor even to an expansion of expressive means, but which also includes new aesthetics that enlarge our conception of the art form itself. The work of such composers as Varèse, Cage, Feldman, Lucier and La Monte Young, for instance, impart viable new senses for the phrase 'listening to music'. This is the case with Tenney's music as well, particularly in its affirmation that the exploration of perception and a self-reflective experience of its operation are subjects proper to the domain of music. In this way For Ann (rising), Clang, Three Indigenous Songs and Changes broke ground for new wings on the idea of music. These are now open, and subsequent generations of artists are busy occupying and expanding them.

Tenney's works refuse adulteration by concerns for impressiveness or approachability, but ultimately attain both through their insistence that the modes of perception and comprehension they engage are wondrous and rewarding in themselves. This variety of artistic integrity is part of what I find inspiring in his work. Tenney once indicated to me that he believed in the possibility of an art motivated not by desire for posterity and the concomitant cult of the masterpiece,
but instead by curiosity regarding ourselves and our world. For me, this idea is an
important part of his legacy. It does not prevent me from finding masterful his deft
unlocking of spaces where listeners encounter anew the audible universe and their
perceiving selves.

Acknowledgements

I would like to thank Lauren Pratt for answering my numerous questions and
allowing me access to James Tenney’s notes and library of recordings. My thanks are
also due to Robert Hasegawa for reading drafts of this article and offering helpful
suggestions.

Notes

[1] ‘Harmonic fusion’ refers to the perceptual synthesis of a tone’s multiple partials into a
unitary percept, as commonly happens when we hear instrumental tones in traditional
musical contexts. Partials arrayed in a harmonic series undergo such fusion much more
readily than partials exhibiting other intervallic relationships, a fact that lends the harmonic
series a special perceptual status. Where other terms in the above list arise below, they will be
explained in context. For the remainder, and for further information regarding these
topics, interested readers should consult a general reference on acoustics or psychoacoustics
(e.g., Moore, 1997).

[2] I would like to thank the editors of the published proceedings in which Wannamaker (in
press) appears for allowing me to reprint here the introductory biographical text and two
figures from that paper. Readers interested in Tenney’s work should be aware that analyses of
For 12 Strings Rising (1971) and Saxony (1978) can be found in the earlier paper, as well as
discussions of Clang (1972), QUINTXT (1972) and Three Indigenous Songs (1979) that are
briefer than those herein.

examination in Larry Polansky’s book-length analytical study of his music (Polansky, 1983),
which remains an indispensable scholarly resource for anyone interested in Tenney’s work.
It is published in Soundings 13 (Garland, 1984). Hardcopies are available from Frog Peak
Music (http://www.frogpeak.org), and the entire text is freely available online from

World Records CD 80570. An analytical survey of these works is available in (Polansky, 1983,
pp. 151 – 171), a version of which constitutes Polansky (2003). In Tenney (1969), the
composer himself published analyses of these works and an account of his time at Bell Labs.
Technical aspects of the research that Tenney conducted while there on sound synthesis and
the modeling of instrumental timbres appears in Tenney (1963), which is one of the very first
publications regarding computerized sound synthesis directed towards musicians, while
some of his conclusions regarding the physical correlates of timbre are collected in Tenney
(1965).

and expanded in Polansky (2004).

[6] The reason that successively higher partials become salient is that if the fundamental
frequencies of two complex tones in a unison dyad are mistuned by a frequency difference
$f_2 - f_1$, (which will be the frequency of beating between them) then the $n$-th harmonics above
these fundamentals will be mistuned by a frequency difference $nf_2 - nf_1 = n(f_2 - f_1)$. Thus, once the intonation has improved sufficiently so that the rate of beating between lower harmonics is no longer noticeable, then the beating between relatively higher harmonics becomes evident due to its greater rapidity.

[7] A ‘Shepard tone’ is a collection of sine tones, separated in pitch by octave intervals, all of which are glissading or stepping upwards together at a common rate in semitones per second. Each tone is individually subjected to an identical amplitude envelope such that it gradually ‘fades in’ at some given bass pitch, attains a dynamic plateau and then ‘fades out’ as it approaches a given treble pitch. The impression imparted to a listener is that of a tone rising continuously in pitch without getting higher (see Shepard, 1964).

[8] ‘Just intonation’ refers to any of a variety of intonational systems based solely on intervals occurring in the harmonic series. Quarter-tones are indicated in this score using accidentals in parentheses, denoting pitch alterations by half—rather than by full—semitone.

[9] Over the next decade, Tenney would become increasingly strict regarding the need for intonational accuracy, settling in the 1980s on stipulations of pitches to within $\pm 5$ cents. This $\pm 5$ cent guideline applies, of course, to the intonation of intervals derived from the harmonic series. As such, it receives some support within the psychoacoustical literature. Studies of thresholds for hearing mistuned lower partials in harmonic complexes as separate tones set such thresholds as low as 8 cents for some subjects with stimulus durations of 1610 msec (Moore & Glasberg, 1986). Furthermore, these thresholds fall with increasing stimulus duration (1610 msec was the longest reported). Tenney’s progressive strictness regarding intonational accuracy sharply distinguishes his thinking from that of European spectralist composers, who even to the present day have commonly accepted the quarter-tone as an approximation.

Tenney appreciated the potential performance difficulties engendered by his intonational demands, and developed means of making them feasible that were appropriate for each piece. These included the provision of intonational references (in the form, e.g., of tunable electronic keyboards or scordatura strings playing natural harmonics), textures that permit tuning via monitoring the tempo of beating, the use of multiple instruments tuned sixths-of-a-semitone apart in order to realize 72-tone equal-temperament (which includes excellent approximations to many just intervals), the monitoring by instrumentalists of electronic tuners in live performance, and the re-tuning of tunable instruments such as pianos. He always believed, however, that performance practice would evolve such that one day non-specialized players would commonly be able to accurately tune the intervals of such music by ear alone just as he could, and in my experience an increasing number of instrumentalists seem to be doing just that.

[10] Tenney’s structural use of this process in Clang predates its appearance in the work of composers such as Gérard Grisey, in whose music ascents or descents of the conceptual fundamental by octaves are associated by Rose (1996, pp. 9–10) with motion towards ‘harmonicity’ or ‘inharmonicity’, respectively.


[12] A subharmonic series of frequencies comprises a fundamental frequency $f_0$ together with its submultiples (i.e., $f_0/1$, $f_0/2$, $f_0/3$, $f_0/4$, etc.) The corresponding pitch sequence is an intervallically inverted harmonic series. The subharmonic series does not possess the unique acoustical and psychoacoustical properties of the harmonic series: it is not naturally produced by common physical oscillatory systems and its components have no strong tendency to perceptually fuse. It does have an intelligible interpretation, however, as the collection of fundamental frequencies of which $f_0$ is a harmonic. The definition of a subharmonic series of durations or tempi can be accomplished by analogy with the definition of a subharmonic series of frequencies.
The ‘ritardando’ disappears if fundamental frequencies are plotted instead of pitches.

See also the discussion of Spectral CANON in Brian Belet’s article in this special issue.

A recording of this realization is available on Cold Blue, Cold Blue Music CB0008, compact disc; also on Donauescoging Musiktage, 1994, col legno WHE 3CD 31882, compact disc; also on the cassette accompanying Musicworks 27 (Pearson & Monahan, 1984). A reference score is available in (Tenney, 1976) and the player-piano roll itself appears in Musicworks 27 magazine (Pearson & Monahan, 1984). There also exists an interesting unreleased extended (5'25") version of the Spectral CANON dating from 1991 (realized by composer Clarence Barlow on a Yamaha Disklavier) in which all voices are allowed to completely finish their retrogrades. Finally, there exist Spectral CANON for CONLON Nancarrow, Variations #1-3 (1991/1998) for harmonic player piano realized by composer Ciara ´n Maher to Tenney’s specifications in 2006/2007 using MIDI (available online with documentation at: http://www.rhizomecowboy.com/spectral_variations; accessed 25 March 2007). These utilize the same inter-attack duration sequence as the original, but specify different temporal patterns for the voice entrances.

The author is preparing a separate report addressing the topic (see also Polansky, 1983, pp. 223 – 227).

The earlier setting is Hey When I Sing These 4 Songs Hey Look What Happens (1971) for soprano, alto, tenor and bass voice(s). Tenney also provided the Coleman transcription with a more direct musical rendering in Blues for Annie (1975) for viola. The original Coleman recording can be heard online at: http://www.juneberry78s.com/sounds/ListenToCountryBlues.htm (accessed 19 June 2007) or on Jaybird Coleman & The Birmingham Jug Band 1927 – 1930, Document Records DOCD-5140, compact disc. See also the discussion of Three Indigenous Songs in Brian Belet’s article in this special issue. A recording of Three Indigenous Songs is available on the audio cassette accompanying Musicworks, 27 (Pearson & Monahan, 1984).

Examples of sine wave speech can be heard online at: http://www.haskins.yale.edu/research/sws.html (accessed 1 August 2007). A ‘formant’ is a peak in the power spectrum of an acoustical signal occurring at a resonant frequency of the originating acoustical system. Vocal formant frequencies vary independently of the vocal pitch as the shape of the vocal tract changes during speech or singing, permitting the production of different vowels or voiced consonants with the same pitch (see Parsons, 1986, pp. 104 – 106).

The initial u sound in ‘water’ is transcribed in the previous measure.

Tenney’s notes indicate that he began work on Three Indigenous Songs as early as 1975, and he apparently updated his working formant data during the course of composition. An early source was Peterson and Barney (1952), but it seems that in the late 1970s he preferred data from Fairbanks and Grubb (1961). Thus the frequency data in Figure 11(b) correspond with Fairbanks and Grubb (1961) except for the entries in parentheses, which derive from Peterson and Barney (1952). The latter may have been invoked because they entailed a broader formant region within which harmonics might fall. Perhaps for a similar reason, the pitch associated with the asterisked 640 Hz figure is rounded up to E5 when it is actually slightly closer to D#. 

It is unclear to me why the 18th harmonic (D#7), which falls squarely within the third formant’s bandwidth, was not selected. It may be because this pitch was present in the immediately preceding sound and a new pitch was considered appropriate for a new articulation.

A detailed analysis of Saxony can be found in Wannamaker (in press). Alternate versions of the work exist for the following instrumentation, all with tape delay: (1) brass quintet, (2) three saxophones, (3) string trio or string quartet. Also, the composer indicates that the work may be realized as a ‘stochastic canon’ using any instrumentation.

A recording of Voice(s) is available on the audio cassette accompanying Musicworks, 27 (Pearson & Monahan, 1984), although it suffers from poor production quality. The work’s score is reproduced in the issue.
Of course, today all of this hardware and associated manipulations can be replaced with a rudimentary Max or Pd patch.

I have made a few finer sectional discriminations through the introduction of primes on some labels.

Above the 24th harmonic, only even-numbered harmonics are employed, these being octave equivalents of more familiar partials residing lower in the series.

Tenney’s Collage #1 (‘Blue Suede’) (1961) is the earliest example of so-called ‘plunderphonic’ music of which I am aware (see Polansky, 1983, pp. 144 – 146; Davies, 1996, p. 10).

The interested reader is referred to the analysis of Chorales for Orchestra in Polansky (1983, pp. 219 – 222) and brief remarks on both works in Wannamaker (in press).

An analysis of Critical Band can be found in Gilmore (1995). Glissade is discussed in Brian Belet’s article in this special issue.

See the article by Michael Winter in this special issue.

Bridge is recorded on James Tenney: Bridge & Flocking, hat ART CD 6193. Koan can be heard on Musicworks 64 CD. ‘Water on the Mountain . . . Fire in Heaven’ is recorded on Seth Josel: Long Distance CRI CD 697. Forms 1–4 are collected on hat[now]ART 2–127 CD. For further information on these compositions, the reader is referred to Von Schweinitz (2007). Analyses of all of these works except the Forms can be found in Belet (1990); Koan for string quartet is discussed in Belet’s article in this special issue. The composer published his own detailed analysis of Changes in Tenney (1987). Regarding Bridge, also see Tenney (1984a, 1984b). Analytical remarks on the Forms series can be found in Mörchen (2000).

For readers who are interested, all of the illustrated functions have a common mathematical form. They are cosines with decreasing frequencies plus linear ramps: \( at + b + c \cos(2\pi r t^p) \), where \( a, b, c, r \) and \( p \) are constants specified for each individual curve and \( t \) is the time variable. Additionally, ordinates of the clang duration and number-of-elements-per-clang curves are subjected to an exponential transformation of the form \( x \rightarrow 2^x \). The constants \( r \) are chosen such that the curves for instrumental Groups 1 and 2 begin in anti-phase and end in phase. The value of the exponent \( p < 1 \) is the same for all curves and was specified such that the vertical line shown in the figures occurs at the golden ratio conjugate, \( \Phi \approx 0.618 \), of the work’s duration.

Tenney himself makes this connection with Cage in Tenney (1993 [1983]).

Score excerpts and further information regarding Adams’s work can be found in Feisst (2001).

References


