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Source: *Indiana Theory Review*, Vol. 22, No. 1 (Spring 2001), pp. 37-64
Published by: Indiana University Press on behalf of the Department of Music Theory, Jacobs School of Music, Indiana University
Stable URL: https://www.jstor.org/stable/24054247
Accessed: 02-12-2018 21:28 UTC

"Composing the Sound Itself": Secondary Parameters and Structure in the Music of Ligeti

Amy Bauer

FOR OVER FIVE DECADES, the contemporary Hungarian composer György Ligeti has fashioned a highly intelligent, idiosyncratic music inspired by everything from the analog electronic studio to fractal geometry and graphic art.[1] Ligeti remains an exception to the rule among eminent composers of his generation in his search for a "music that isn't a regurgitation [Wiederkauen] of the past, that also doesn't signify the avant-garde past."[2] His music resists all categorization by school; to quote Alastair Williams, it has "the alleviating feature of being fairly accessible whilst at the same time responding to exacting listening."[3] That is, it sidesteps a tacit premise of the academy: that the value of new music demands a measure of the inscrutable.

Ligeti's works break decisively with both traditional and stereotypically modern notions of form, harmonic function, and rhythmic structure. Yet the intense materiality of this music conceals a rigorous compositional technique, one that owes as much to tradition as it does to contemporary electronic and serial procedures and thought. Compositions from *Atmosphères*, *Lontano*, and *Melodien* to the more recent Violin Concerto unite forms and methods borrowed from the distant past—canons, modality, non-tempered tuning—with an aesthetic

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[1]Ligeti discusses his relationship to visual art and artists at length in the following sources: Wolfgang Burde, *György Ligeti: Eine Monographie* (Zürich: Atlantis, 1993), passim; Ligeti, *György Ligeti in Conversation with Peter Varnai, Josef Hausler, Claude Samuel and Himself* (London: Eulenburg Books, 1983), passim; Ligeti, "On my *Etudes* for Piano," trans. Sid McLauchlan, *Sonus* 9, no. 1 (1988): 3–4; Ligeti, "Rhapsodische, unausgewogene Gedanken über Musik, besonders über meine eigenen Kompositionen," *Neue Zeitschrift für Musik* 154, no. 1 (1993): 20–29; Pierre Michel, *György Ligeti: Compositeur d'aujourd'hui* (Paris: Minerve, 1985), 139–81; Ligeti, "György Ligeti: Distinguished and Unpredictable," interview by Dorle J. Soria, *Musical America* 107, no. 4 (1987): 12–27; Ligeti, interview by Ursula Sturzbecher, in *Werkstattgespräche mit Komponisten* (Cologne: Gerig, 1971), 32–45; and Ligeti, "A Conversation with György Ligeti," interview by Tünde Szitha, *Hungarian Music Quarterly* 3, no. 1 (1992): 13–17.

[2]György Ligeti, "Musik mit schlecht gebundener Krawatte," interview by Monika Lichtenfeld, *Neue Zeitschrift für Musik* 142, no. 5 (1981): 471 (my translation).

[3]Alastair Williams, "Music as Immanent Critique: Stasis and Development in the Music of Ligeti," in *Music and the Politics of Culture*, ed. Christopher Norris (New York: St. Martin's, 1989), 203.

stance of the utmost modernity. The genre conventions of these works are familiar, but their syntax has changed radically. As Ligeti explains:

> The intervals as such are the same as in earlier music, but they are handled in a fundamentally different way: with the sounds of a dead language a new language is being evolved.[4]

That "new language" has much to do with an ironic reversal of the traditional relationship between primary and secondary parameters: the elevation of timbre, articulation and dynamics over pitch and rhythm as determinants of musical structure. A brief discussion of Ligeti's *Lontano* (1967) will illustrate this reversal and present *Lontano* as a critique of the structural hierarchy characteristic of Western art music. I then situate this reversal historically by reviewing the changing relations between primary and secondary parameters in late-nineteenth- and early-twentieth-century music as described by Leonard B. Meyer, Robert P. Morgan, and Robert G. Hopkins. After this general treatment of primary and secondary parameters, I analyze the role of secondary parameters in five Ligeti works of the 1960s: *Apparitions* for orchestra (1958–59), *Volumina* for organ (1961–62; revised 1966), *Atmosphères* for orchestra (1961), the *Requiem* for soloists, choruses and orchestra (1963–65), and the first movement of the *Chamber Concerto* for thirteen instrumentalists (1969–70).[5]

These analyses reveal numerous difficulties in the study of secondary parameters, especially timbre. As a preliminary discussion of these issues, I examine the problem of isolating and perceiving timbre, looking at spectral structure, temporal envelope, and loudness. I argue that the difficulties of theorizing about timbre—or, indeed, any other "secondary parameter"—should not prevent us from analyzing its preeminent role in contemporary music, not only as a structural parameter but also as a signifier of "ironic distance" from the classical tradition.

The New Language of Lontano

Ligeti's early micropolyphonic works used orchestral sounds derived from late-nineteenth-century music; in *Lontano* canons form "an extensively branching and yet strictly refined polyphony which, however, veers suddenly into

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[4] Ligeti, *Ligeti in Conversation*, 126.

[5] A fine recording of the three orchestral works discussed has just been released on Teldec featuring performances by Jonathan Nott and the Berlin Philharmonic (Ligeti Project, II, Teldec Classics 8573-88261-2).

something else. . . . A kind of complex of tone color, movement, changing harmonic planes."[6]

Lontano's instrumentation provides a ground against which the figures of individual pitch and intervallic events travel "through a constantly changing pattern of color like a moiré fabric."[7] Micropolyphony is submerged in its orchestration, and orchestration takes on a structural role. Ligeti assigns timbre and pitch structures to different "levels" of *Lontano*, treating harmony and intervals "as though they were tone colors."[8] The rhythmic aspects of the work function as an aspect of tone color as well. The first nine notes of *Lontano*'s first canon (A♭-A♭-A♭-G-A♭-B♭-A-B♭-A♭) appear successively in four flutes and four clarinets (see figure 1, which shows the start of the canon); in these seventy-two pitch entrances, forty-three different durational intervals occur between successive pitch entrances, and twenty-six different lengths of rests occur within individual instrumental lines. In addition, each individual canon entry and instrumental group occupies a separate subdivision of the notated beat.

The arhythmic entrance of canonic strands in different instrumental bodies suggests the eponymous distance by creating a pronounced wavering in pitch (*lontano* translates "from a distance"). This shimmering, iridescent effect, added to the implied vibrato of the expressive marking (*dolcissimo, sempre expressivo*), produces a slow acoustic beating between chromatic pitches that swells the tone, causes expressive shifts in the partial structure, and implies the octave doublings and more intrusive dissonances to come. The prescription for all instruments to enter imperceptibly at quadruple *piano* again relates to timbre: along with the prescribed mutes on bassoon, violin I and II, and cello, it eliminates upper harmonics and centers each tone more clearly on its fundamental frequency. The predominance of the fundamental in the spectral structure of this passage anchors the sound firmly in the fourth register and sets up A♭4

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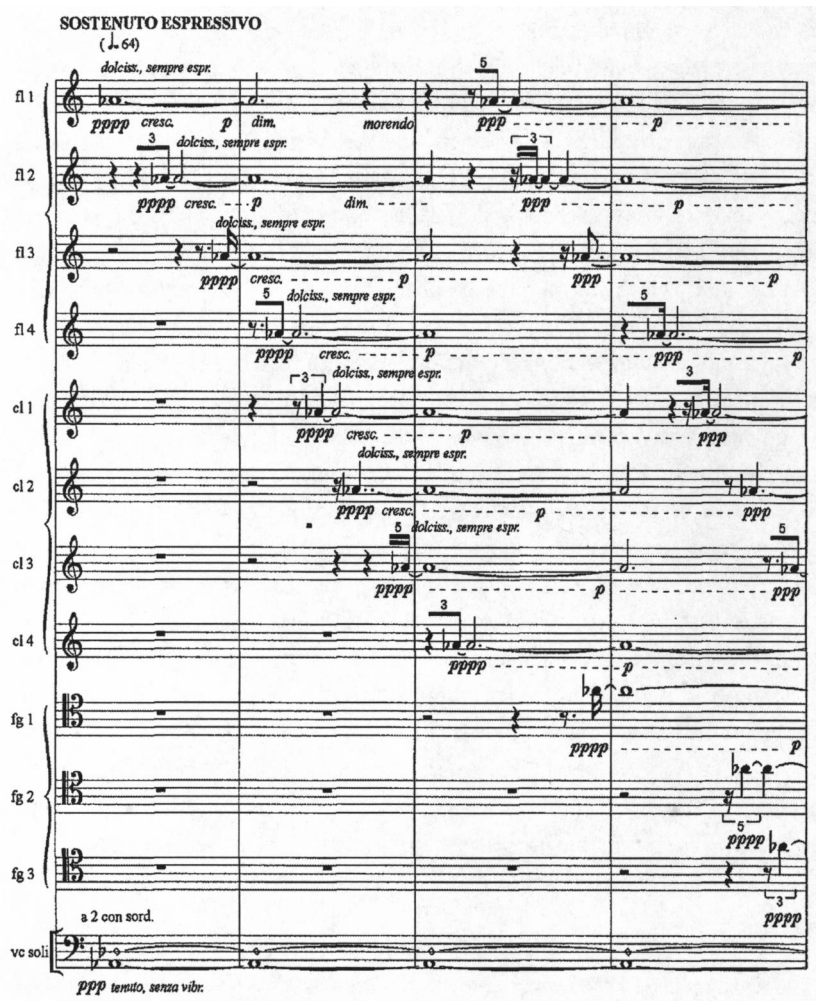
[6]Ligeti, *Ligeti in Conversation*, 95. The structure and function of these canons are discussed by Jane Piper Clendinning and Jonathan Bernard. See Jane Piper Clendinning, "Contrapuntal Techniques in the Music of György Ligeti" (Ph.D. diss., Yale University, 1989) and "Structural Factors in the Microcanonic Compositions of György Ligeti," in *Concert Music, Rock, and Jazz since 1945: Essays and Analytical Studies*, ed. Elizabeth West Marvin and Richard Hermann (Rochester: University of Rochester Press, 1995), 229–258; Jonathan W. Bernard, "Inaudible Structures, Audible Music: Ligeti's Problem, and His Solution," *Music Analysis* 6, no. 3 (1987): 207–36 and "Voice Leading as a Spatial Function in the Music of Ligeti," *Music Analysis* 13, nos. 2–3 (1994): 227–53.

[7]Ligeti, *Ligeti in Conversation*, 56.

[8]Ibid., 97.

FIGURE 1. *Lontano*, mm. 1–4



"harmonized" by the upper woodwinds as not only a central pitch but a central sonority in its own right, one whose unique instrumentation results in a critical blend of overtones (mm. 1–6).

The sweep of the initial A♭4 from flutes to clarinet and oboe, supported by bassoon and French horn, opens the work with a gradual transition from bright to dark (mm. 3–8).[9] In measures 1–13, faint and staggered entrances, the transition from upper to lower woodwinds, and the use of mutes all intensify the narrow range of the opening canon, and reinforce the close weave of the polyphonic texture as it emerges. Similar dynamic markings ensure that the overtone structure of instrumental entries merely adds resonance to the sonority already present; the introduction of bowing changes and tremolo in the strings is camouflaged by starting near the lowest point of pitch crescendos. When the fifth octave joins the fourth in measure 14, one family of instruments defines each register, forging associations between specific registers and specific instrumental timbres.

Thus the micro-rhythmic aspects of *Lontano*—canons involving subtle rhythmic subdivisions, instrumental articulations, and dynamic changes—converge as aspects of tone color, while instrumentation—the timbral qualities of shifting vertical aggregates—defines the work's harmonic flux and formal parameters, a "harmonic" progression from dark to light and near to far in an imaginary three-dimensional space. *Lontano* is thus a "double-edged" commentary,[10] one that critiques the methods and purpose of Renaissance polyphony while it questions the long-standing separation in Western art music between pitch as a dynamic, "primary" parameter and tone color as a secondary parameter dependent on pitch.

Primary and Secondary Parameters

The distinction between the primary parameters of music—usually identified as pitch and rhythm (or duration)—and the secondary parameters of timbre, dynamics, tempo, and articulation is presented most forcefully in Leonard B. Meyer's influential theory of musical style.[11] Meyer describes primary parameters

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[9]John R. Pierce, *The Science of Musical Sound* (New York: Scientific American Books, 1983), 180. Flute tones are often preceded by an instant of sounds in the lower and higher octaves, a feature of their attack that does not continue through the body of the sonority. See Pierce, 181 and Robert Cogan, *New Images of Musical Sound* (Cambridge: Harvard University Press, 1984), 145.

[10]Ligeti, *Ligeti in Conversation*, 92.

[11]Leonard B. Meyer, *Style and Music: Theory, History and Ideology* (Philadelphia: University of Pennsylvania Press, 1989), 14.

as those that can be segmented into "discrete, nonuniform relationships so that similarities and differences between them are definable, constant, and proportional."[12] Secondary parameters such as timbre and dynamics, on the other hand, form "statistical," "processive" connections dependent on the syntactical relationships of pitch. The relationships formed by primary parameters act as syntactical constraints because they establish the rules by which tonal compositions proceed and conclude.

Meyer presents pitch and duration as the only trans-cultural parameters that can serve a structural function in music, their long hegemony in the Western classical tradition documented by the history of European music theory. As Robert P. Morgan notes, this tradition delineates a set of rules that determines both the appropriate (pitch-based) structural background of acceptable works and the possible content of divergent foreground phenomena:

> Since at any given moment the background elements are not necessarily present on the surface, proper apperception of them must depend upon strong conventions concerning what is 'normal' and thus structural, as opposed to what is 'abnormal' and thus superficial and ornamental. All Western music, at least since the Renaissance, displays a more or less complex interaction between foreground and background levels of musical structure. Although the degree to which these levels can depart from one another has varied considerably from style to style, it is characteristic of the post-Renaissance period as a whole that a sufficient balance is maintained to ensure that the underlying structure is never seriously threatened.[13]

Morgan's summary agrees with Meyer's general notion of style change, in which primary parameters, and the syntactical rules they establish, are equally subject to the *laws* of perception and cognition and the *rules* of historically contingent convention. The division of labor between background and foreground—"the degree to which these levels can depart from one another"—is governed in Meyer's theory by probable strategies, compositional choices established by the rules of a particular style.[14] The dominance of particular phenomena *within* a primary parameter might shift, as occurred most notably with the growing autonomy of harmony and motive in the late-nineteenth and early-twentieth centuries.

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[12]Ibid., 14.

[13]Robert P. Morgan, "Secret Languages: The Roots of Musical Modernism," *Critical Inquiry* 10 (1984): 451.

[14]L. Meyer, *Style and Music*, 20.

In music of this period the coherence of a tonally unified "underlying structure" was threatened by the liberation of specific sonorities and motives from a functional harmonic foundation. But the primacy of pitch relations—and the distinction between primary and secondary parameters—remained secure.

By defining syntactical constraints and establishing specific criteria for "mobility" and "closure,"[15] the primary parameters described by Meyer create the background structure elaborated by Morgan. In a study on the role of secondary parameters and closure in the music of Mahler, Robert G. Hopkins confirms the syntactical function and overriding hegemony of pitch relations in music of the common-practice period, although he notes the importance of secondary parameters as organizing forces in tonal music when primary parameters are static.[16]

Secondary parameters serve such a function in Ligeti's *Requiem*. In the *Requiem*, instrumentation and articulation enhance and, at several points, provide mobility and closure in lieu of the primary parameter of pitch. Erkki Salmenhaara lists three such distinct functions served by orchestration in the *Requiem*.[17] The first is that of a "dynamic searchlight," as in measures 77 and 83 of the Kyrie. The first choir is doubled by the orchestra at *fff* up to the direction "plötzlich aufhören, wie abgerissen" ("stop suddenly, as though torn off") at the start of measures 78 and 84. Although mezzos and altos remain in measure 78, and sopranos, altos, tenors, and basses continue in measure 84, it is the abrupt end of orchestral support that marks closure in each section.

A second function of instrumentation in the Kyrie is the unique orchestration of successive canonic entries (figure 2). Each introduction of either the Kyrie or Christe canon has a unique orchestral doubling, which serves to mark and clarify the movement's form. For instance, several instrumental lines double the bass voices just prior to the second climax of the Kyrie (see bassoon, contrabassoon, trombone, tuba, cello, and contrabass in mm. 94–102). But with the entrance in measure 102, the orchestra regroups to support sopranos in the highest register of the work with flute, oboe, clarinet, trumpet, and high strings. The shifts in instrumentation are analogous to changes in organ registration: the addition of woodwinds, trumpet, and high strings acts as if 4', 2', and

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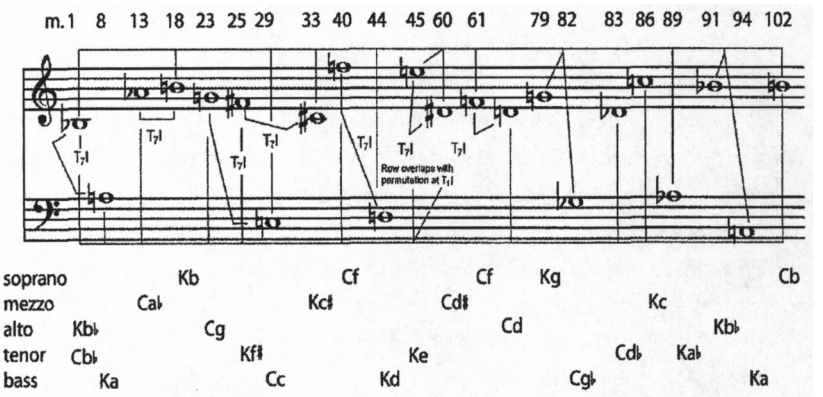
[15]Robert G. Hopkins, *Closure and Mahler's Music: The Role of Secondary Parameters* (Philadelphia: University of Pennsylvania Press, 1990), 29–55.

[16]Hopkins cites figures from Mahler's music, Sibelius's Fourth Symphony and Tchaikovsky's Sixth Symphony.

[17]Erkki Salmenhaara, *Das musikalische Material und seine Behandlung in den Werken "Apparitions," "Atmosphères," "Aventures" und "Requiem" von György Ligeti*, translated from Finnish by Helke Sander, Acta Musicologica Fennica, 2 (Helsinki: Suomen Musiikkitieteellinen Seura, 1969), 157.

Figure 2. Serial entrances in the Kyrie of the *Requiem*



K = Kyrie canon
C = Christe canon

1' stops were suddenly substituted for 32', 16', and 8' stops. This passing reference to organ registration recalls Salmenhaara's third function of instrumentation in the Kyrie: voices of the fugue are doubled at the upper or lower octave to extend the actual range of—and add an eerie resonance to—vocal entries.

In the *Requiem* instrumentation and articulation have clearly defined functions in relation to the canons and melodic gestures that provide pitch structure and harmonic direction. But four of Ligeti's landmark compositions from the 1960s—*Volumina* for organ, *Atmosphères* and *Apparitions* for orchestra, and the first movement of the *Chamber Concerto* for thirteen instrumentalists—are composed with a static harmonic language, an immobile pitch structure animated primarily through the actions of secondary parameters. My discussion will touch on *Volumina* and *Apparitions*, but it will focus on the volte-face between secondary and primary parameters in *Atmosphères* and the first movement of the *Chamber Concerto*.

Ligeti's *Volumina* is the clearest model of a composition that is harmonically and melodically static: it begins with a stationary cluster that spans about nine octaves, and continues as a series of clusters differentiated by graphic notation; each page is to be performed within a given durational interval. *Volumina* is, as its title implies, a work about volumes: mass, texture, and density. According to the composer:

> An exact indication of pitch is of no importance, as the texture consists entirely of clusters, therefore all I needed to do was define the limits of clusters and indicate how the limits change in space and in time. . . . What matters is not the pitch of the individual notes, but the shape of the clusters, their volume and breadth.[18]

Ligeti offers conflicting interpretations of the form of *Volumina*. In the performance notes accompanying the score, he refers to "a single large arch streaming out," but in an interview he describes *Volumina* as a passacaglia.[19] In the latter interpretation, the work subjects the opening cluster to a series of variations created by alterations in articulation, dynamics, density, texture, directional contour, ambitus, and registration. The significance of these parameters is reflected in the fact that *Volumina* employs in total twelve different dynamic markings, twelve different registrations, and eleven different articulations. Although *Volumina* boasts three different pitch collections (chromatic, white-note, and pentatonic), chromatic clusters dominate the pitch content of the work, drawing attention to the stunning variety within secondary parameters. Thus, the work's formal design results from the interaction of secondary parameters rather than contrasts within the domain of pitch content.[20]

The structural use of secondary parameters, displayed so clearly in *Volumina*, forms the basis of Ligeti's contemporary orchestral works as well. *Apparitions* opens *Lento* with a series of static clusters that are outwardly immobile but not inwardly so; many clusters are composed of tremolos that oscillate analogously to the clusters with internal movement of *Volumina*. At each stage in the movement's progress, these clusters depend on the parameters of duration, instrumentation, dynamics, articulation, register, and density for motion and closure.

The premiere of *Atmosphères* shortly after *Apparitions* sealed Ligeti's public reputation as a founding father of "sound-mass" and "tone-color" composition. *Atmosphères* represented "polyphony" of tone color, severing timbre from any identifiable harmonic context and creating a laboratory in which "the tone colors were the musical elements pre-eminent in determining the form."[21] A brief review of selected sections from *Atmosphères* demonstrates the structural role of timbre.

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[18]Ligeti, *Ligeti in Conversation*, 41, quoted in Diane Luchese, "Levels of Infrastructure in Ligeti's *Volumina*," *Sonus* 9, no. 1 (1988): 39.

[19]Ligeti, *Ligeti in Conversation*, 41, quoted in Luchese, 39.

[20]Beth Loeber Williamson analyzes the creation of closure and formal design through the manipulation of contour and texture in "Performing New Music: Ligeti's *Volumina*," *The American Organist* 13, no. 10 (1979): 32–36.

[21]Ligeti, *Ligeti in Conversation*, 94.

The first of twenty-two sections in *Atmosphères* presents a chromatic cluster at *pianissimo*, constructed from layered instrumental families performing *sul tasto* (strings) and *con sordino* (strings and low winds). The shape of this eight-measure opening section is defined by a thinning texture (flutes drop out in m. 5, bassoons leave in m. 7, and clarinets, horns, and contrabasses exit in m. 8). Violas and cellos sustain a cluster spanning 1 ½ octaves through section 2 (mm. 9–13), whose shape is defined by a gradual shift from *senza colore, non vibrato* to *vibrato e sul ponticello.*[22]

In the third section, measures 14–22, certain instruments are identified with a particular pitch collection, either white-note diatonic or black-note pentatonic. Oboes, bassoons, contrabassoon, trumpets, trombones, and tuba consistently play pitches from the white-note diatonic while flutes, clarinets, and horns play pitches from the black-note pentatonic. Each of the string sections is equally divided between players with diatonic and pentatonic pitches. As in the opening two sections, however, pitch collections take on the role of supporting color to the primary, structural role of instrumentation. The skilful balancing of these instrumental groups "orchestrates" the pentatonic and diatonic by creating a chromatic blend at the beginning that alternates with patches of diatonicism (m. 18) and pentatonicism (m. 19), and ends with a return to the chromatic "color" of the opening. The crescendi and diminuendi that are distributed evenly throughout the huge, six-octave ambitus of measures 14–22 support the effect created by the use of pitch collections as orchestral color.

The fourth section of *Atmosphères* maintains a cluster of 2 ½ octaves in the strings but employs varied, submetrical divisions of the pulse to create a dense, soft, shimmering cluster animated only by changes in dynamics (*ppp* at m. 23 that diminishes in m. 27, then dies away in m. 29) and articulation (a staggered progression from *sul ponticello, molto vibrato* to *sul tasto*).

The five-octave cluster of section 1 is expanded in section 9 (mm. 44–53), where the micropolyphony found in *Lontano* first appears. A mirror canon over five octaves gradually pulls inward to a minor third. Although the canon decreases its range, it remains densely chromatic, with no recognizable melodic profile; in a sense, the opening cluster is simply compressed into a smaller registral space, with rhythmic variations in the canon harking back to the "shimmering" cluster of section 4. The oscillating pitch motion of the canon as it tightens supports the true "harmonic" progression of instrumental colors through the strings: *sul tasto*,

[22]In the performance directions accompanying the score, Ligeti instructs that the differences in string articulation "be maintained with exaggerated exactness."

pppp, to *ordinario*, *sul ponticello*, followed by a huge crescendo at *ordinario* (up to *ffff*). Thus the canon as a device develops the opening cluster by varying its density, articulation and volume, and implies that the "formless" *Atmosphères* may actually represent a series of variations on a theme, not unlike *Volumina*.

Ligeti refined and developed the use of microcanon to regulate uniform changes in ambitus and density in *Lontano* and the Kyrie of the *Requiem*. Later works incorporate rhythmic cycles in the context of smaller ensembles to allow an even greater differentiation of secondary parameters. The entire pitch collection of the *Chamber Concerto*'s first movement grows out of a chromatic canon in measures 1–7 that involves only five pitches (G♭4, G4, A♭4, A4, B♭4).[23] The beginnings of the canonic entries are permuted so that each of the first five instrumental entries begins on a different pitch (flute begins on G♭4, clarinet on B♭4, bass clarinet on A4, cello on A♭4 and contrabass on G4). The canonic theme itself contains every possible two-pitch succession available within its restricted pitch collection, creating a blurred but nearly continuous melodic motion.[24] The pitch ambitus is restricted even further in measure 11 (G4–B♭4), before a slow expansion by semitone to D5 (mm. 15–26).

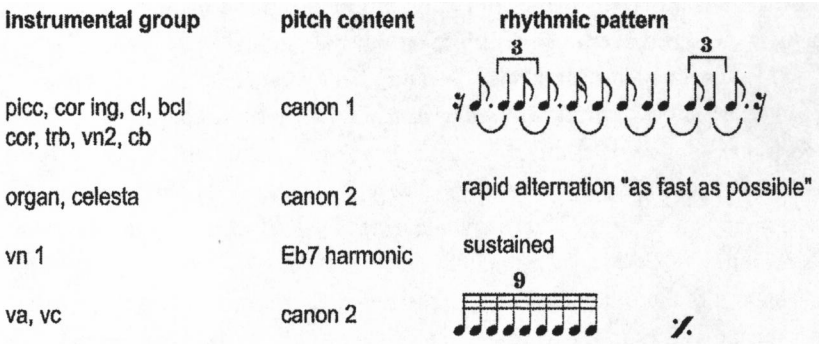
The implied congruence of vertical and horizontal pitch space focuses the listener's attention on the procession of tone colors, dynamic shades, changing articulation and varying densities of texture, as in *Atmosphères*. The opening strains of the *Chamber Concerto* establish pitch content as the structural background to a foreground progression of tone colors determined by dynamics, articulation, density and the rhythm of canon-tone pacing. This functional series of "timbres" is colored—but not principally structured—by the density of intervals in succeeding passages. When the strings die away to close out the first of two sections (on a C♯5/D5 trill in mm. 34–37), the first violin remains as a tenuous filament that ignites an E♭ sounded in five octaves (mm. 38ff). This sustained E♭ is a striking event because it is the first introduction of pitch as a salient parameter.

In the second section of the first movement of the *Chamber Concerto*, individual instruments, durational patterns and dynamics are no longer blurred, as they were in the first section. Instead, instrumental lines articulate a rhythmic polyphony of simultaneous cycles at different rates of speed. Figure 3 lists the pitch and rhythmic patterns found in measures 49–50: woodwinds and brass play strongly accented lines, in a series of asymmetrical rhythms that crosses the barline (reduced to their common denominator of 1=1/12th of one beat,

[23]Jane Piper Clendinning analyzes this movement in "Contrapuntal Techniques."

[24]Noted by Michel, *Ligeti: Compositeur d'aujourd'hui*, 211–12.

Figure 3. *Chamber Concerto*, pitch and rhythmic patterns in mm. 49–50



canon 1: D-E-G-F-F#-D#, ordered series in 5 octaves

"canon" 2: D, Eb, E, F, Gb, G in various permutations

their line forms the durational series 17-13-9-18-16-17). Beneath the winds and brass, the organ and celesta play a registrally compact and unmeasured ostinato, *prestissimo possible* and *pianissimo*. Viola and cello have their own pattern, articulating nine divisions of the beat while violins and contrabass sustain harmonics before joining the canon of the winds and brass in measure 50.

As in *Lontano*, the movement of one texture to another distinguishes form: changes in ambitus, the individualization of instrumental lines, or the fusion of motive and instrumentation into a vertical sonority (clusters or "Ligeti signals"[25] containing intervals of a major second or minor third). But unlike *Lontano*, the first movement of the *Chamber Concerto* juxtaposes passages of precisely notated rhythmic writing with sections that are rhythmically free, in which players simply perform their parts "as fast as possible."

"Harmonic" progression in the first movement of the *Chamber Concerto* is thus marked by the transition of one instrumental group—and its associated intensity/articulation/range—to another. The "melody" is the common, invariant element between successive blocks, adding an iridescent hue here, an opaque gloss there, in the same way a change in orchestration might color the tonal progression in an eighteenth- or early-nineteenth-century work. But the "tim-

[25] As described by the composer in *Ligeti in Conversation*, 28–29.

bral melody" of the movement moves in a regular, "harmonic" rhythm: a small, clearly identified number of instrumental groups form identifiable units within a functional progression of sonorities.

Problems of Isolating and Defining Timbre

Hopkins's previously cited study of secondary parameters in the music of Mahler would seem to point the way towards a full consideration of secondary parameters in works like *Apparitions* and *Volumina*. In those works melody and harmony are no longer active forces moving towards a perceptible goal, and qualities such as register, concordance,[26] dynamics, and duration take over the work of delineating form. Hopkins, however, will not make an exception for timbre:

> Indeed, it is impossible to build [hierarchical] structures without defining timbral closure, and since timbres cannot be ordered along a single dimension and there is no kind of timbral 'tonic' to which other timbres are related, there is little we can say about closure.[27]

It is possible—as the above analyses indicate—to mark difference clearly enough within a work that hierarchies of register, texture, intensity and duration can be identified from context. Hopkins excepts timbre from this company because of its multi-dimensional nature. As Dahlhaus notes, timbre is a "sound quality, not a parameter, since it does not fulfill the condition of being variable independently of the other parameters."[28] But if we accept Schoenberg's famous dictum that "Tone color is, thus, the main topic, pitch a subdivision," then timbre can be ordered by its interdependence on pitch.[29]

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[26]Concordance is defined in Hopkins as "the compound parameter whose elements are combinations of pitches that define harmonic progressions without regard to tonality but rather with respect to the agreement between adjacent partials in the combined harmonic spectrum." See Hopkins, *Closure and Mahler's Music*, 40.

[27]Ibid., 57.

[28]Carl Dahlhaus, *Schoenberg and the New Music: Essays*, trans. Derrick Puffett and Alfred Clayton (Cambridge: Cambridge University Press, 1987), 252. Carol L. Krumhansl states, "Understanding the multi-dimensional nature of timbre is the most challenging problem facing the musical community at the present time." See Carol L. Krumhansl, "Why is Musical Timbre so Hard to Understand?" in *Structure and Perception of Electroacoustic Sound and Music* (New York: Excerpta Medica, 1989), 43.

[29]Arnold Schoenberg, *Theory of Harmony*, trans. Roy Carter (Berkeley: University of California Press, 1978), 421–22.

The pitch we ascribe to a complex sound is the pitch of that component to which attention is most strongly drawn. Pitch demands that, first, we attend to a sound and, second, we are able to "hear out" the sound (pitch may be related to periodicity up to about 4000 Hz; above this boundary our sense of interval declines). The American National Standards Institute defines timbre as "that attribute of auditory sensation in terms of which a listener can judge two sounds, similarly presented and having the same loudness and *pitch*, as dissimilar" [emphasis added].[30] Thus the official definition of timbre depends on *difference*; it says nothing about what attribute of auditory sensation *relates* any two sounds.

Spectral Structure

Most of what may differ between any two musical sounds is assumed to relate to one of the three primary components: spectral structure, temporal envelope, and sound pressure level. Of the many dimensions that compose a distinct timbre, the strongest component is usually its spectrum. A Fourier spectrum analysis reveals the number and shape of a complex periodic waveform's component frequencies,[31] revealing a musical sound as a sum of sinusoidal components or frequency partials. These partials include characteristics of both temporal structure and loudness: each frequency component has a particular amplitude and phase. Our auditory sense marks only the relative phases of those components within the range of a critical bandwidth, roughly the space of a minor third (distinctions of phase seem to affect our perception of timbre only in the frequency range from approximately 200–400 Hz).[32]

Almost all unique sounds include peaks in the spectral envelope at certain frequencies and effects peculiar to the region of the fundamental frequency. These peaks, or formants, affect the tone quality of a particular sound, and are tied to the body resonance and excitation mechanisms of an instrument or vocal cavity.[33]

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[30]American National Standards Institute, *American National Psychoacoustical Terminology* (New York: American Standards Association, 1973), S.3.20. Researchers on timbre and psychoacoustics have long debated the meaning and apparent inadequacy of this definition; see especially A.J.M. Houtsma, "Pitch and Timbre: Definition, Meaning and Use," *Journal of New Music Research* 26, no. 2 (1997): 104–15.

[31]Fourier's Theorem states that any periodic wave may be represented as the sum of a number of simple harmonic waves with frequencies that are integral multiples of one fundamental frequency.

[32]Pierce, *Science of Musical Sound*, 185–87.

[33]Ibid., 206.

Most orchestral instruments have one or two rather broad formant areas, which can be averaged as fixed-frequency bands of emphasis across the entire range, or within low, middle and high registers of an instrument. The change of either a tone's fundamental frequency or its intensity will emphasize different partials within these peak regions. What this means for timbral analysis is that a fixed formant structure may vary less with frequency than a description of comparative harmonic amplitudes.[34] Thus a spectral peak description is an elegant shorthand description of an instrument's spectrum at different fundamental frequencies and intensities.

Temporal Envelope

Despite timbre's dependence on pitch, a spectral peak description still neglects much of the complete audio sensation we actually consider timbre, or tone color. The temporal characteristics of most musical sounds strongly affect our perception of their source and tone quality.[35] Features of a sound over time can usually be assigned to one of the three general sections that comprise the sound's temporal envelope: attack, steady state, and decay. The rise time and shape of the tone's spectral envelope, noise or inharmonic partials, and the continuous or unequal rise of partials all belong to the attack, or onset effect of a note. The steady-state portion of the sound may include vibrato, amplitude modulation, or pitch instability. Characteristics of the tone's decay will depend on how quickly or slowly each resonance dies according to the damping quality of the instrument.[36]

There are several definitions of the attack and decay portions of the note's signal, and qualities associated with the on- or offset of a tone obviously depend on both articulation and playing style. Nonetheless, instrumental families—and

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[34]Jean-Claude Risset and David L. Wessel, "Exploration of Timbre by Analysis and Synthesis," in *Psychology of Music*, ed. Diana Deutsch (New York: Academic Press, 1982), 25–58.

[35]Jean-Claude Risset discovered that some complex features of trumpet sounds are important to our ear and some are not. The short-term amplitude fluctuations of various partials, and the short burst of noise that accompanied an attack seemed to play no role in the recognition of a timbre as trumpet-like. On the other hand, the late rise and early fall of higher partials compared to lower partials proved crucial to the proper synthesis of an artificial trumpet sound, with special attention to the rise and fall of partial intensities, and the addition of random frequency change or vibrato applied to partials. Cited in Pierce, *Science of Musical Sound*, 197.

[36]Jürgen Meyer, *Acoustics and the Performance of Music* (Frankfurt/Main: Verlag das Musikinstrument, 1978), 32.

individual instruments within those families—display typical and consistent attack and decay characteristics. The attack time of an instrument is a function of its size and the frequency of the tone produced. And a low-loss energy system such as the clarinet maintains a longer attack time than a high-loss system like the bassoon. Percussive sounds may be distinguished solely by the noise produced at their attack, while a long, gradually decaying resonance dominates the overall sound of struck or plucked strings. The versatility of orchestral strings is largely due to an extremely wide range in decay times created through changes in bowing pressure and fingering.

Sound Pressure Level and Loudness

The advent of computer-automated spectrum analysis made it much easier to isolate those characteristics unique to the tone quality of individual sounds over time. Yet other attributes of auditory sensation—such as spectral shape and energy distribution (the intensity of specific partials), sound pressure, and the frequency location of the spectrum—contain subjective components that frustrate objective analysis and comprehension. But a sound's *subjective* intensity or sound pressure level does have an *objective*, physical correlate—loudness—that can be expressed in decibels.[37] Dynamic range varies enormously from one instrumental family to another, but non-percussive instruments average approximately 11 dB between *pianissimo* and *fortissimo*.[38] A sound produced at different energy levels varies in both intensity and tone color. An instrument weakly—as opposed to strongly—excited emits intermittent high-frequency partials and smoother, more continuous low-frequency partials. All vibrating systems convert extra energy or abrupt changes in motion into high-frequency rather than low-frequency partials. In addition, the loudness of a sound's harmonics increases rapidly as frequency increases, so that an instrument's dynamic range and level are tied to a particular frequency region (the largest variations between register are found in the double bass, flute, and French horn).

Loudness modifies spectral structure (and thus timbre) directly, but the exact intensity of a sound is impossible to specify. A composer's dynamic markings must take not only playing style and context into account but also the

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[37]R. A. Rasch and R. Plomp, "The Perception of Musical Tones," in *The Psychology of Music*, 2d ed., ed. Diana Deutsch (San Diego: Academic, 1999), 10.

[38]William J. Strong and George R. Plitnik, *Music, Speech, Audio* (Provo, Utah: Soundprint, 1992), 208.

combined effect of two or more instruments sounding together.[39] As a result of this principle, the intensity of *one* sound can be raised if the power of upper partials separated by *more than a critical bandwidth* is increased.

The notion of timbre includes not only aspects of waveform, but also the directionality of the sound source, the behavior of compound tones, and the function of a sound's source or meaning.[40] The phenomenon of tone color is thus many phenomena; in that sense alone it is quite remarkable that we are able to group all of its separate dimensions into one "unified perceptual object" we call a sound.[41] As a multidimensional stimulus, therefore, timbre defies subjective measurement in the manner of loudness (measured in sones) and pitch (measured in mels). Timbre cannot be anchored to functional structures that transcend an individual context, such as octave equivalence and the gravity of the fifth in the tonal pitch system. John Chowning and others have recently discovered that our auditory system relies on a narrow set of properties to identify tone quality. Only a few components of any individual sound seem to have perceptual effects, yet researchers have yet to grasp how these attributes combine in perception.[42]

A comprehensive theory of tone color would have to surmount these difficulties, and reconcile empirical data with the intricate and often paradoxical responses of our auditory system. But that should not stop us from critical analysis of timbre's function within a particular work, or with discussion of the fact that, as Risset elegantly phrased it, so much of Ligeti's music is about "composing the sound itself, not merely composing with sounds."[43]

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[39]J. Meyer, *Acoustics*, 34. For instance, loudness will be doubled by *two* sounds of equal loudness when they are separated by *more* than a critical bandwidth, but to double the loudness of sounds *within* the same critical bandwidth requires a combination of *eight* equally intense sounds very close together in pitch (Pierce, *Science of Musical Sound*, 127).

[40]Krumhansl, "Musical Timbre," 43. It must be added that complex timbres resist perceptual fusion.

[41]Robert Erickson, *Sound Structure in Music* (Berkeley: University of California Press, 1975), 9. Three major acoustic parameters not yet addressed in this essay include 1) the range between tonal and noiselike characters of the sound; 2) changes of spectral envelope (formant-glide) and fundamental frequency (micro-intonation); and 3) the prefix, or that portion of a sound's onset dissimilar to the ensuing steady-state portion of the tone (Erikson, 5).

[42]Krumhansl, "Musical Timbre," 44.

[43]Jean-Claude Risset, "Computer, Synthesis, Perception, Paradoxes," in *Für György Ligeti: Die Referate des Ligeti-Kongresses Hamburg 1988*, ed. Constantin Floros, Hans Joachim Marx, Peter Petersen (Laaber: Laaber-Verlag, 1991), 257.

"Composing the Sound Itself"

A prime illustration of Risset's comment is found in *Lontano*'s opening sonority (shown in figure 1): a single flute playing near the bottom of its range at a dynamic level two levels below the softest standard marking (*pppp*). The flute has the strongest fundamental of any instrument over E4 but takes the longest time to reach its full tonal development. An ordinary legato onset is accompanied by a burst of noise and preliminary tones formed by higher resonances followed soon after by a smooth and continuous growth in the instrument's overtone spectrum. But at such a low dynamic level, under the instruction to "enter with an imperceptible attack," the sound's intensity oscillates and the tone has few, if any, harmonics. In essence Ligeti's directions elicit a tone that comes close to that of a pure sine wave.

The single flute is followed at irregular intervals by three more flutes before the clarinet enters with the same prescriptions on attack, volume, and manner (*pppp*, *dolcissimo*, *sempre espressivo*). The clarinet maintains a leisurely but uninterrupted increase in partials at this frequency, and shows off its ability to produce the softest tone of all wind instruments. At higher intensities the clarinet spectrum differs greatly from that of the flute in emphasizing odd-numbered harmonics over even (especially those of the first and third in this register). At this dynamic level, however, the instrument produces a dull tone similar to that of its neighbor because of the even intensities of the few partials sounding.

The bassoon comes in next, again at *pppp* with the same imperceptible attack. A cloth placed in the bell thwarts the continuous development of the partials of the bassoon's A♭4 and dampens the strong second harmonic normally heard in this octave. The oboe does not enter until measure seven, growing quickly from *pppp* to *mp* and subsiding again. Ordinarily rich in overtones, the oboe's tone at this energy level includes only the first and second partials, with the octave stronger than the fundamental.

A stopped horn and muted trumpet join the woodwinds in a layered support of the third A♭4 in *Lontano*'s opening canon. Brass instruments all display a strong fundamental in the higher parts of their compass but reveal individual formant areas in lower registers. The horn and trumpet are unique among the brass in that the fundamental predominates at lower registers. The tone color of both instruments is dependent on dynamics; at higher levels the upper harmonics increase dramatically in amplitude, but at low intensities few harmonics are audible. Muting further restricts the upper reach of the tone and produces a soft, round timbre.

An almost inaudible A♭4 harmonic on two celli at *pppp* accompanies the opening "theme" of the first canon, the first example of an atypical background role played by solo strings throughout *Lontano*. A solo viola with a harmonic on G4, two celli with harmonics on B♭4, and two violins with harmonics on G4 follow rapidly in succession. All of these instruments are muted, to quiet their otherwise abundant growth of partials, reduce higher frequencies, and produce a flute-like sound with a similar noise-to-frequency ratio. The intended effect can be judged by the fact that, compared to bowed tones on stopped or open strings, string harmonics resound for a much longer time, and both muted and harmonic tones maintain a softer dynamic level.

The contrabass and the oboe are the only instruments that play the F♯-B motive that ends the first canonic segment. Through the agent of harmonics, Ligeti pushes the bass to the limit of its full range on the first two strings. At this frequency the tones start quickly but decay slowly, while exciting harmonics on neighboring strings. The oboe follows the bass to close out the first subsection of *Lontano* in measures 12–14. The even-numbered harmonics that predominate in this register complement the sound of the bass, while producing a darker sound as the pitch rises from F♯4 to B4 and grows perceptibly louder.

The aperiodic sequence of durations between successive pitch entrances in measures 1–14 of *Lontano* alludes to Ligeti's formative experience in the Studio for Electronic Music of the West German Radio in Cologne.[44] The slightly wavering but simple frequency spectra of each tone mimic those produced by analog electronic synthesis, and the regular but staggered appearance of rests in each line creates a gentle pulsation like that of an electronically generated sound. According to Ligeti, the sound of micropolyphony

> is often an artificial timbre created by the great density of successions and by the blurring of this succession. This combination produces a new timbre that didn't exist with separate instruments; it comes from my experience in the electronic music studio, although I don't employ any electronic sounds. I use very few special instrumental effects; a few in *Apparitions*, but more in the suite. In *Lontano*, one plays normally, but the totality, the combination, the manner of combining the instrumental voices gives new timbres.[45]

[44]Ligeti worked at the Studio from February 1957 through 1958; see Paul Griffiths, *György Ligeti*, 2d ed. (London: Robson, 1997), 25–26.

[45]Michel, *Ligeti: Compositeur d'aujourd'hui*, 169 (my translation).

A particularly striking instance of the creation of new timbres through micropolyphony occurs in the final passage of what I have labeled section 2 (mm. 92–122).[46] This passage is characterized by what I call timbral "variation" and "attenuation": sixty-three individual voices whither to three after ten instrumental groups have cycled through the final five canon tones (G-B♭-A♭-G♭-F♭). Each instrument peaks in turn and then exits; the arrangement of these peaks allows the darker and less distinctive tones of muted brass (mm. 97–100) and low strings (mm. 99–112) to emerge. A new, transitional section begins at measure 113 and reverses the attenuation of measures 93–112 through a process of textural thickening, which features the chromatic trichord {E3, F3, F♯3} before contracting to F3 in measure 118.

Figure 4 graphs changes in canon-tone pacing and linear density through measures 60–105, and indicates the dominant dynamic level and associated instrumental group that accompany a change in each parameter. At the outset of section 2 (m. 60), the rapid introduction of new canon tones contrasts with a spare orchestration. The rate of change and number of individual lines increases from measure 65 to 75. The pace of canon-tone entrances climbs with the canon through the sixth octave, but slows to one pitch per measure when the canon reaches C7 (m. 83). As the final five canon tones (G-B♭-A♭-G♭-F♭) begin to cycle through instrumental groups, canon-tone speed and density increase.

While the pace of canon tones increases from one (mm. 93–99) to two (mm. 100–105) or more (mm. 106–111) per measure, the aural effect is remarkably static. The close relation between "notes in a tune" that proceed so rapidly the "tune [is] transformed into a chord" is an acoustic phenomenon that has fascinated Ligeti for many years (see the graph of canon tone pacing in figure 4).[47]

At first hearing, this phenomenon would appear to bear no relation to Ligeti's use of canon. But his mentor, the electronic composer Gottfried Koenig, discovered that when pitches are presented at a rate faster than twenty per second, a listener cannot distinguish each note separately. If the *tune* itself is longer than 1/20 of a second, a "strangely blurred" melody results, one that creates an *Ersatz* polyphony. Ligeti achieves this effect, again, through subversive means:

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[46]I discuss *Lontano*'s three-part form in further detail in "Compositional Process and Parody in the Music of György Ligeti" (Ph.D. dissertation, Yale University, 1997).

[47]Ligeti, *Ligeti in Conversation*, 39–40.

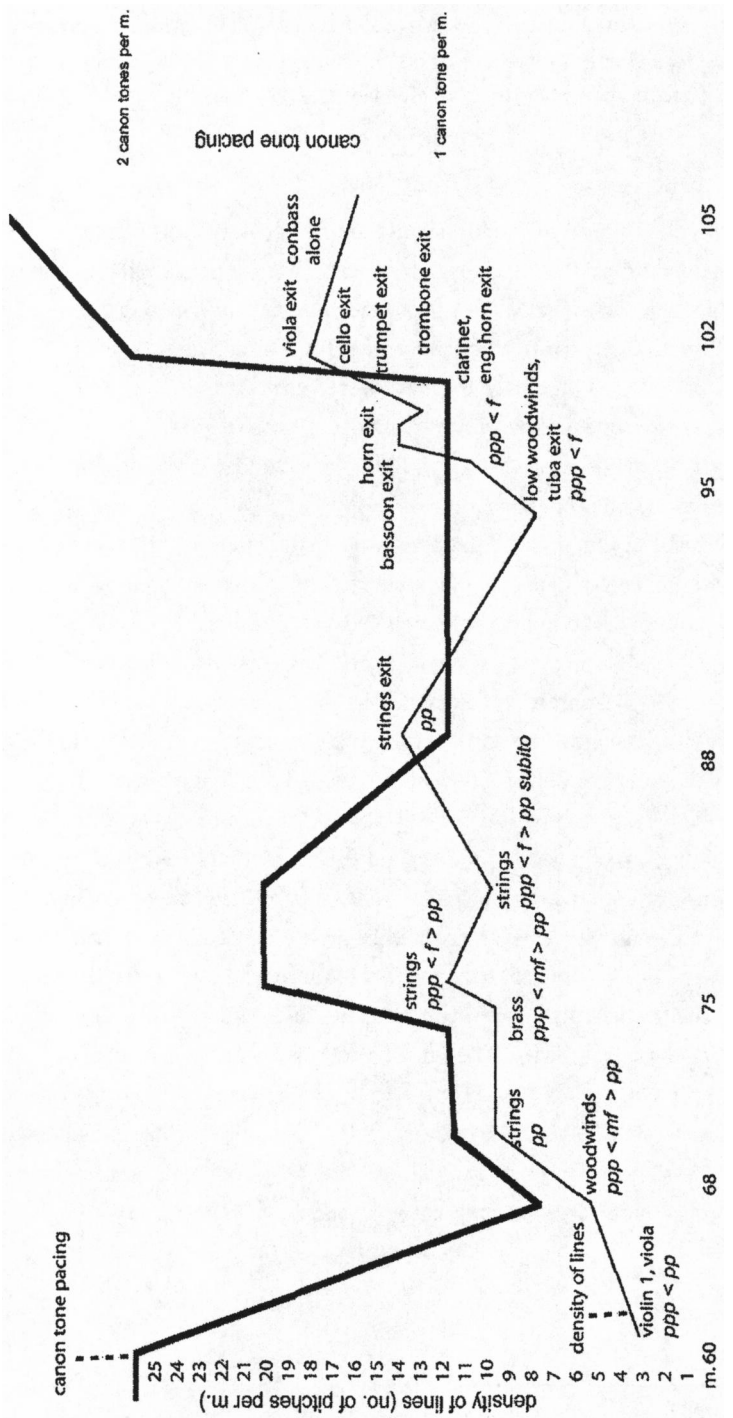


FIGURE 4. *Lontano*, graph of canon tone pacing, linear density, dynamic variations and instrumental grouping in mm. 60–105

> Since you cannot play an instrument fast enough to produce a succession of notes at a rate of 20 per second, I built the rhythmic shifts into the music. For instance, 24 violins would play the same tune but with a slight time-lag between them. The figurations are almost identical but not quite.[48]

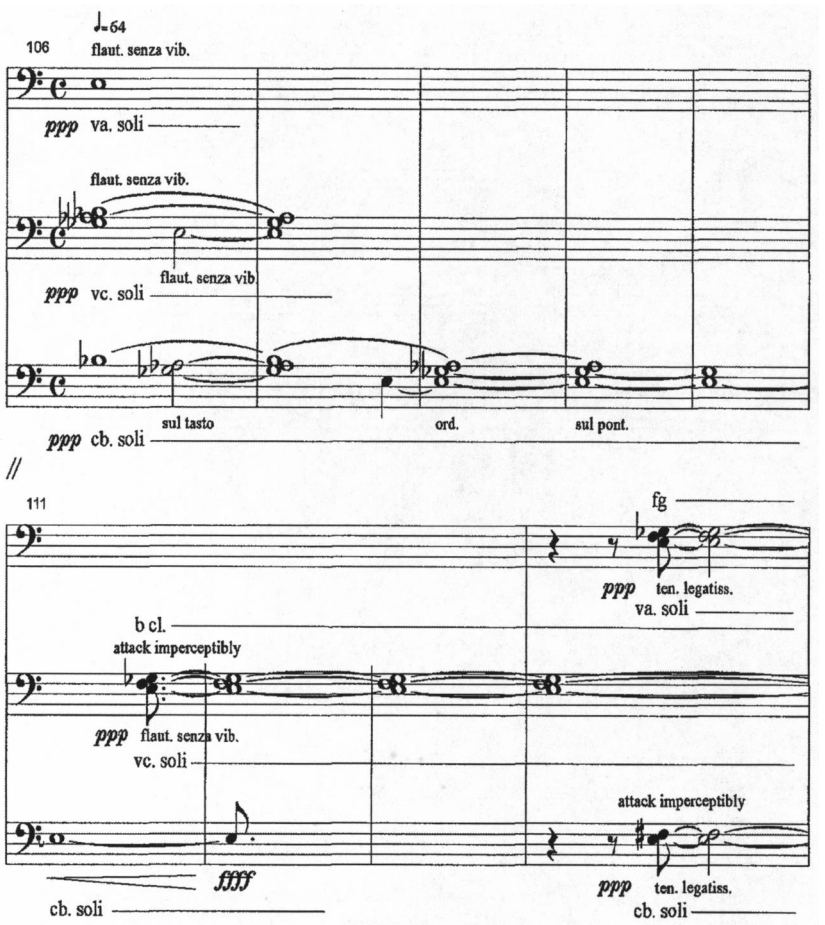
Ligeti's typical micropolyphonic method achieves this effect through the heterophonic juxtaposition of canons at the unison and octave. But in the dénouement of section 2 of *Lontano*, the composer pushes this technique to its limit; in order to create a polyphony that turns in on itself, Ligeti cycles a very brief melody very quickly through every instrument in the orchestra. Each group swells to a louder peak just before it ends: *ff* in the violas (mm. 102–103), *fff* in the cellos (m. 104), and *fffff* "like a sudden eruption," in the contrabasses (mm. 111–112).

This slows the pace of the revolving pitch figure until the point of greatest activity in *Lontano* becomes the point of ultimate stasis—melody becomes not only harmony, but an immobile, whole-tone tetrachord in measures 106–111, fixed in the third octave, like a crystal held fast while light glances off its opposing facets—an impression heightened by the contrast with the high C7 and C8 of the previous measures and the immediate resumption of motion in the opposite direction (see reduced score of mm. 106–122 in figure 5a and 5b).

The obsessive repetition of four tones, the measured succession of instrumental groups, the lack of meter, and the narrow range all work to focus the listener's attention almost solely on tone color at the close of section 2. Again, a narrow, static harmonic complex is defined by tone color: simultaneous attacks in bassoon, viola and contrabass (m. 114) followed by staggered entrances in English horn, clarinet, horn, trombone and tuba, and further cellos and contrabasses (mm. 115–119). The glacial progress of *Lontano* reaches a complete standstill in measures 116–118: two cellos on E3 and G♭3 move to F3, bringing all the sounding instruments to the pitch F3. The entire texture is condensed into a dense singularity set in low and mid-range woodwinds, muted brass, and strings *senza vibrato*, all at *ppp*, *tenuto*, *sehr gleichmäßig* ("very even").

[48] Ibid., 40.

FIGURE 5a. *Lontano*, a reduced score of mm. 106–114

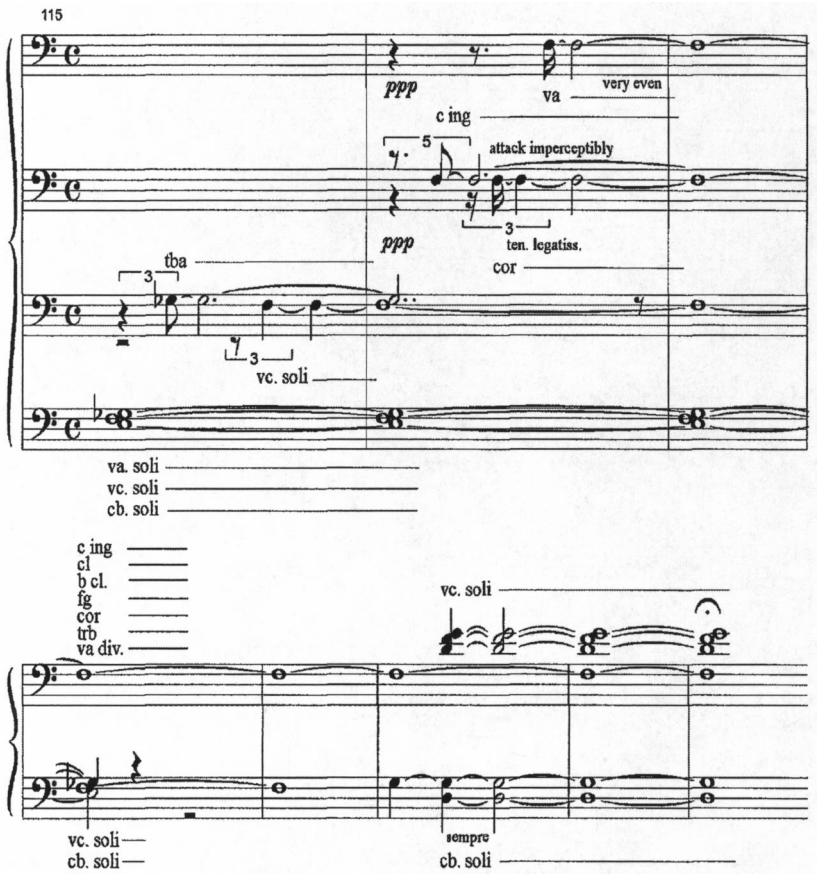


The composer explains this aesthetic in *Lontano*:

> The music has something artificial about it: it is an illusion. There are many elements in it that don't manifest themselves, but remain subliminal. . . . So I am of the opinion that this is not a return to traditional intervallic and harmonic music, but rather that harmony and intervals are treated as though they were tone colors.[49]

[49] Ibid., 96–97.

FIGURE 5b. *Lontano*, a reduced score of mm. 115–122



In this way *Lontano* passes from one static prolongation to another in an intervallic or harmonic space animated by the play of colors, a critique of the traditional relation between a musical "foreground" of timbral and textural variation and its harmonic "background." *Lontano*, in this sense, is written in a musical metalanguage that embodies the eponymous distance of its title, a "complex of tone color, movement, changing harmonic planes" that confuses structural hierarchies in force throughout the common-practice period.[50]

[50]Jane Piper Clendinning notes that the inaudibility of note-to-note detail against an audible background is in contrast to most tonal works. See Clendinning, "Contrapuntal Techniques," 34.

The Individual Sound as a "Kernel of Musical Form"

As Dahlhaus notes, the notion of pitch and timbre as separate entities—and the dominance accorded pitch in the history of Western music—has little to do with how music was actually perceived.[51] The notion of a primary, pitch-based (usually harmonic) structure was enshrined in notation, a structural background to be interpreted by an elaborative, primarily expressive foreground of variable orchestration, texture, and articulation. Tristan Murail goes even further than Dahlhaus, calling the accepted distinction between harmony and timbre a result of our "cultural conditioning . . . all a question of perception, of habits of perception."[52]

The idea of pitch as central, and of timbre, dynamics, and articulation as peripheral, is a historically based construction, in the same sense that viewing music in terms of discrete and analyzable "parameters" is a legacy of the 1950s. The era in which a crusading Pierre Boulez could assert, "[I wanted to] bring everything into question again, to make a clean sweep of [my] musical heritage and start all over again from scratch,"[53] adopted an apparently objective, ahistorical and relentlessly analytical view towards the composition of new music. As Dahlhaus reminds us, "Thinking in parameters was also a way of thinking about possible relations, whether they had been realized or not."[54]

The many unexplored facets of timbre—as well as the advent of analog electronic sound synthesis—excited the imaginations of mid-twentieth-century composers as diverse as Ligeti, Mauricio Kagel, Karlheinz Stockhausen, John Cage, and Morton Feldman. The use of extended instrumental techniques, along with rapid advances in artificial synthesis and recording, expanded the scope and variety of compositional sound sources. It followed naturally that composers attempted to employ timbre and dynamics "syntactically for the articulation of form and the shaping of process,"[55] in Meyer's view, crossing the perceptual and historically formed boundaries that perforce separated primary and secondary parameters.

As the composer remarks, *Lontano* is founded on a contradiction: "The quality of tone color reverts to the quality of harmony and harmonic-polyphonic trans-

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[51]Dahlhaus, *Schoenberg and the New Music*, 63.

[52]Tristan Murail, "Spectra and Pixies," trans. Tod Machover, *Contemporary Music Review* 1, no. 1 (1984): 158.

[53]Pierre Boulez, *Pierre Boulez: Conversations with Célestin Deliège*, foreword by Robert Wangermée (London: Eulenburg, 1976), 56.

[54]Dahlhaus, *Schoenberg and the New Music*, 71.

[55]L. Meyer, *Style and Music*, 21.

formations have the appearance of tone-color transformations."[56] *Lontano* and Ligeti's other works from the 1960s invert the relationship between "foreground" and "background" parameters while retaining the mutual dependence of the two to signal an *ironic* distance from tonal tradition.

This critical distance is especially pronounced in the first movement of *Apparitions*. In his seminal article "Metamorphoses of Musical Form," Ligeti described the individual sonic event as a "kernel of musical form" whose attack and decay processes qualify it for replication on larger structural levels.[57] Ligeti did just that in the approximately thirty-five seconds that elapse between measures 29 and 39 of *Apparitions* where forty-nine instruments model the envelope of a single sound: a sudden burst of energy at measures 29–30 is succeeded by several moments of silence and a 'tone' that begins quietly in the middle registers and expands outward, with high and low register 'transient' harmonics as the envelope peaks (see the registral graph of *Apparitions* mm. 29–39 in figure 6).

A closer look at the succession of tone colors in this passage reveals a pattern created by timbre in measures 29–39. This pattern is articulated by the spectral centroid of successive cluster formations in measures 29–39. The spectral centroid reflects the bright-dark dimension of tone and is often used by acousticians as an index of the difference between two related timbres.[58] The graph shown in figure 6 orders time along the horizontal axis and pitch along the vertical axis. Orchestration and articulation link different patterns within each cluster; the strings are divided by instrument and playing style into various combinations of *ordinario* (*arco*, *vibrato*), *pizzicato*, *sul tasto*, *sul ponticello*, *con sordino*, and *tremolo*. The lowest block of each cluster as it proceeds along the temporal axis from left to right indicates the actual pitches produced by an ideal performance of this passage. Above each cluster hovers another—the area of its spectral centroid, or in other words the central portion of those upper partials that compose the full acoustic spectrum of each cluster.

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[56]György Ligeti, program notes to *Lontano* (Wergo, 60163-50, 1993), 14.

[57]György Ligeti, "Metamorphoses of Musical Form," in *Die Reihe* 7: *Form-Space* (Bryn Mawr, Pa.: T. Presser, 1965), 18; originally published as "Wandlungen der musikalischen Form," *Die Reihe* 7 (1960): 5–19.

[58]My choice of spectral centroid as a central analytic parameter was prompted by Gregory Sandell's arguments in "Perception of Concurrent Timbres and Implications for Orchestration," in *Proceedings of the 1989 International Computer Music Conference* (San Francisco, Calif.: International Computer Music Association, 1989), 268–70. Figure 6 displays my calculated approximation of the spectral centroid for each sounding pitch, based on ideal performing conditions and a tuning model where A4=440 Hz.

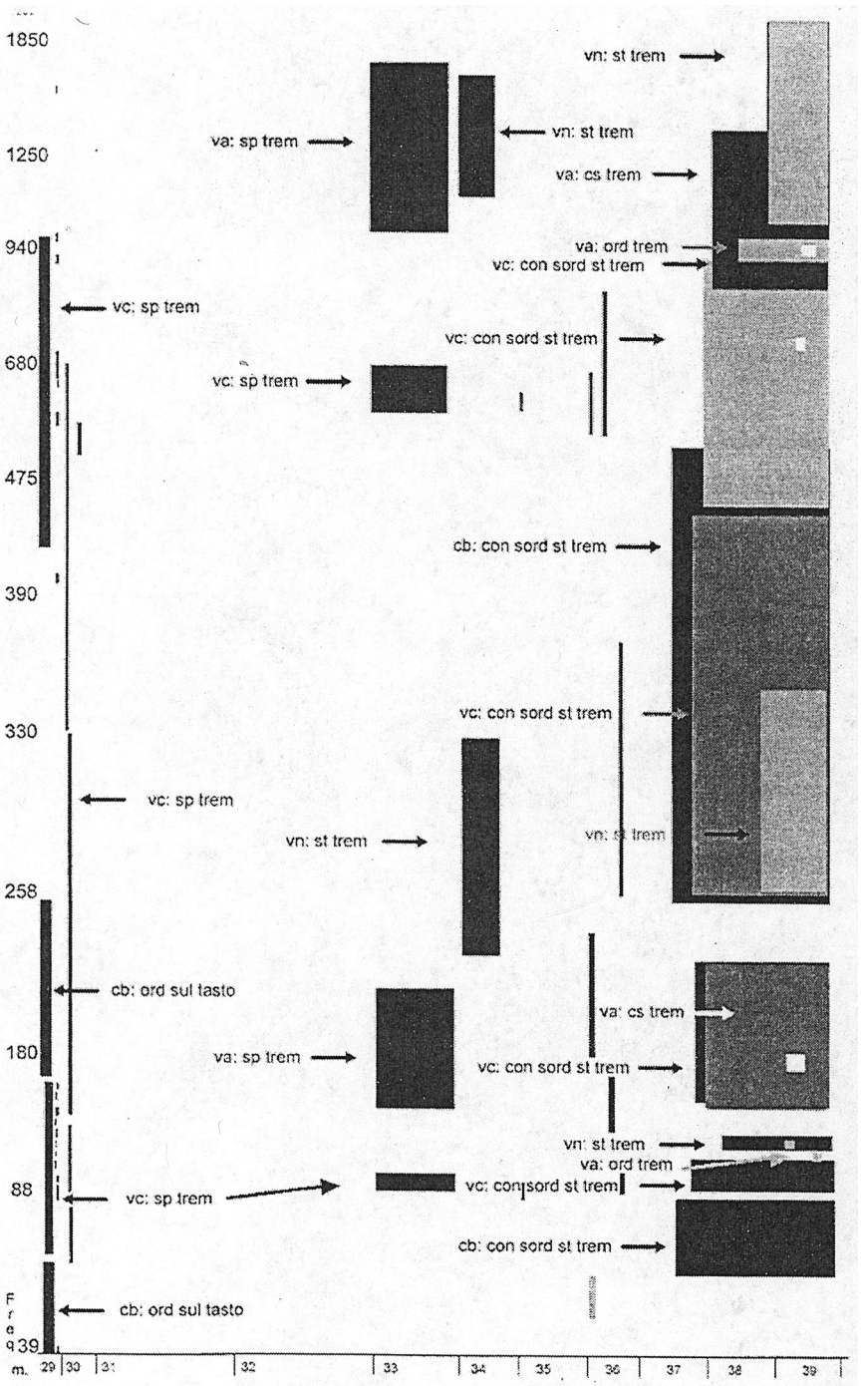

FIGURE 6. *Apparitions* 1, registral graph of mm. 29–39 showing spectral centroid as registral space above the fundamental of each vertical cluster

In general, as the pitch of an instrument is raised, the spectral centroid shifts towards the fundamental, indicating a decrease in the number of partials in a spectrum, and thus a corresponding change in the shape of the spectral envelope. But as the dynamics, or the intensity of striking, blowing, bowing or plucking increases, the centroid shifts away from the fundamental, favoring higher component frequencies in the tone's spectrum.[59] The graph indicates an expansion of spectral energy that sketches in the "outlines" provided by the written score and represents more clearly the irony inherent in measures 29–39: the gross distortion involved in modeling an orchestral phrase on the attack envelope of a single sound.

Secondary Parameters and Ironic Distance

By glorifying tone color and articulation at the expense of audible pitch relations, taking a microscopic "natural form" as a macroscopic formal model (and poking fun at the manipulations of the studio composer) and ignoring classical models of formal shape and development, the first movement of *Apparitions* maintains a playfully ironic distance from both traditional norms and its modernist forebears. As with *Lontano*, *Apparitions* no longer subordinates the surface gloss of timbral or textural variation to a deeper, form-defining harmonic foundation. It confuses the established hierarchy of post-Renaissance music, challenging not only the normative *relations* between surface and substructure, but the notion of what *constitutes*—a priori—a musical foreground and background. In this sense it returns to a pre-Classical state in which texture was a more important parameter than harmony. Yet both *Apparitions* and *Lontano* exemplify Pierre Boulez's prescription for the use of timbre in instrumental music: a coordination of articulation and fusion that describes the "outside vs. inside of the sound-object." "Without musical discourse," Boulez reminds us, "[timbre] is nothing, but it can also form the entire discourse on its own."[60]

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[59]John M. Chowning, "Music from Machines: Peceptual Fusion and Auditory Perspective—for Ligeti," in *Für György Ligeti: Die Referate des Ligeti-Kongresses Hamburg 1988*, 239.

[60]Pierre Boulez, "Timbre and Composition—Timbre and Language," *Contemporary Music Review* 2, no. 1 (1987): 169–70.