EMPTY SPACES: TEMPORAL STRUCTURES AND TIMBRAL TRANSFORMATIONS IN GÉRARD GRISEY'S *MODULATIONS* AND *RELEASE FOR 12 MUSICIANS*, AN ORIGINAL COMPOSITION

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Gérard Grisey's *Modulations* (1976-77) is the fourth installment of *Les espaces acoustiques*, a six-piece cycle inspired by the composer's analysis of brass instruments' E-based harmonic spectrum. This dissertation concentrates on Grisey's approach to the temporal evolution of *Modulations*, and how his temporal structuring affects perception of the piece's continuum.

The analysis discerns and examines eight temporal structures spread over three larger parts. A temporal structure creates and transforms synthetic timbres, from fashioning their individual transients to designing their overall dynamic evolution. In *Modulations*, Grisey uses processes of timbral transformations to essentially 'compose sound.' These transformations define each of the piece's temporal structures as well as the overarching structure of the piece.

Whereas the three major sections of the work are clearly defined (though elided) by elisions which serve as pointers between them, the eight temporal structures generally overlap, in a manner that Grisey describes as structural polyphony.

The analysis shows how this structural polyphony emulates the behavior of partials within a harmonic spectrum, each possessing its own discrete amplitude envelope. The notion of the individual amplitude envelope is then traced on every structural level, from small scale temporal structures where single partials are represented by single instruments—*Modulations*' sound objects—to the larger scale temporal structure.

Grisey's timbral transformations prompt expectations, then satisfy or defy them. Temporal structures define what Grisey calls the "skeleton of time," (objective time) aiming to affect the piece's "flesh of time"—its becoming.

The title of my original piece *Release for 12 musicians* refers to the gesture of setting free from a state of utmost constriction, be it physical or mental. At the start, this idea is conveyed at the micro level—one instrument playing one note over a very short time unit. It then expands at various levels, the largest being the entire structure of the piece, where two defined sections are noticeable. The first is a gradual buildup of tension, the second a release of that tension in multiple stages.

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PREFACE

I would like to thank the members of my dissertation committee Dr. David Pettersen, Dr. Mathew Rosenblum, Dr. Amy Williams, and especially to Dr. Eric Moe for his most valuable guidance and advice. Special thanks to my friend Douglas Levine for his time and generous help in every step of the way, and finally, a most heartfelt thanks to my wife Heidi and my kids, Amital, Naomi and Yinon, for their presence, love and endless support.

1.0 INTRODUCTION

1.1 *MODULATIONS* AND *LES ESPACES ACOUSTIQUES*

Grisey's work *Modulations* (1976-77) for 33 musicians is the fourth installment in *Les espaces acoustiques*. Chronologically, it is the third part of the cycle to be written following *Périodes* (1974) and *Partiels* (1976). The cycle evolves through an expansion of musical forces and structure.

The first part requires smaller forces: *Prologue* (1976) for solo viola, followed by *Périodes* for seven musicians and *Partiels* for eighteen musicians. The second part contains the orchestral pieces of the cycle: *Modulations* for 33 musicians, *Transitoires* (1980-81) for a large orchestra of 88 musicians, and *Epilogue* (1985) for a large orchestra of similar size.

The durations of the pieces range from 15 to 20 minutes, though the last piece—*Epilogue*—serving as a coda, lasts a mere 8 minutes. It is the only piece in the cycle that Grisey insists should not be played separately but only as an epilogue for the entire cycle. Written between 1974 and 1985, *Les espaces acoustiques* is considered to be a significant spectral musical composition, and as such has stood at the center of research.

Modulations is a pivotal piece, poised between the cycle's smaller and larger forces. Even though it is considered the cycle's first orchestral piece, *Modulations* can be regarded as a very large ensemble piece; as with the two previous ensemble pieces—*Périodes* and *Partiels*—

its 33 musicians are treated as soloists. *Modulations*, which lasts approximately 16 minutes, allows its composer to transition— to "modulate"—from chamber to orchestral forces. The next piece, *Transitoire*, almost triples in ensemble size and lasts about 20 minutes.

Hearing the cycle in its entirety one experiences a crescendo of duration, texture, timbre and dynamics. Without *Modulations* in its midst, this crescendo would be interrupted and the cycle might function more as a suite. On the one hand, it serves as a natural culmination to the solo and smaller ensemble pieces; on the other, as an introduction to more complex orchestral textures.

More importantly, *Modulations* is a pinnacle in the formative years of the composer, a full manifestation of his spectral ideas. Starting with *Périodes* in 1974, Grisey spent the next three years working on three important pieces—*Périodes*, *Partiels* and *Modulations*—which gave birth to the entire cycle, and established spectralism as a legitimate musical movement. Grisey's score is full of nuances that are not just an arbitrary result of an artist's imagination but carefully considered calculations that enable the larger form to exert itself.

Although Grisey's music is labeled as spectral—referring mainly to pitch content derived from the sound's harmonic spectrum—he insists that what we call sound unites various inseparable elements: space, time and timbre. In describing the composition of *Les espaces acoustiques*, Grisey emphasizes its "synthetic style in which various parameters contribute to the construction of a single sound."[1]

This was a revolutionary thought at the time, since logical extension of serialism—the prevalent musical school in the late 1960s—involved the stratification of musical components by organizing duration, pitch, dynamics and timbre independently from one another.

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[1] Gérard Grisey, liner notes, *Gérard Grisey: Les espaces acoustiques*, WDR Sinfonieorchester Köln, Stefan Asbury (conductor), (Kairos 0012422KAI: 2005) CD, 7.

1.2 TIMBRE AND AMPLITUDE ENVELOPE

Timbre, or tone color, is generally defined "as the attribute that enables the listener to identify the instrument producing the tone."[2] It is the single most important factor in sound recognition that allows the listener "to distinguish two sounds that have otherwise the same pitch, loudness, and duration."[3]

Timbre is affected heavily by the shape of the sound's overall 'amplitude envelope'—its amplitude evolution over time. "Even experienced musicians may have difficulty identifying the source of a sound when its envelope is manipulated."[4] The amplitude envelopes of individual frequency components are no less important. It is the envelope's transients that are most responsible for defining the character of a given timbre. The actual frequencies comprising the sound's spectrum—its partials—have been found to be less important for timbral recognition than the profile of the combined attack transients. (Dufourt, Feinberg) When the "attack is removed, it becomes very hard to identify instrumental timbres correctly."[5]

In *Microsound*, a comprehensive study of the micro-time scale of sounds, composer Curtis Roads emphasizes that transient events are "too brief to evoke a sense of pitch but [are]

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[2] Jean-Claude Risset and Max V. Mathews, "Analysis of musical-instrument tones," Physics Today 22(2), 1969): 23.
[3] Trevor R. Agus, Clara Suied, Simon J. Thorpe and Daniel Pressnitzer, "Fast recognition of musical sounds based on timbre," *The Journal of the Acoustical Society of America*, 131, 4124-4133 (2012): 4124
[4] William A. Sethares, *Tuning, Timbre, Spectrum, Scale* (London: Springer-Verlag, 2005), 29.
[5] Joshua Feinberg, "A Guide to Basic Concepts and Techniques of Spectral Music." *Contemporary Music Review* 19, no. 2 (March 2000): 90.

rich in timbral content."[6] Roads adds that "the ear is extremely sensitive to even minor alterations in transient morphology and envelope shape, such as the slope or duration of an attack…at the same time, the ear tends to ignore permutations in the phase of partials that cause dramatic changes in the shape of the waveform."[7]

The significance of the amplitude envelope's transients can be credited to the method of analysis by synthesis developed by Risset, which also "has triggered great progress in the understanding of musical timbre by including numerous details for the envelope of each component of a frequency."[8]

Recalling his "Computer Study of Trumpet Tones" presented in 1965 at the 70th annual meeting of the Acoustical Society of America,[9] Risset points out that "the time-varying analysis of trumpet sounds showed that the spectrum was variable throughout each tone. In particular, during the attack, the low-order harmonics reached their final amplitude earlier than the high-order ones."[10]

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[6] Curtis Roads, *Microsound,* (Cambridge, Massachusetts: MIT Press, Cambridge), 6.
[7] Ibid., 158.
[8] Hugues Dufourt, "The Principles of Music and the Realization of Theory" in *Contemporary Music: Theoretical and Philosophical Perspectives*, ed. Max Paddison and Irène Deliège (Urlington, VT: Ashgate, 2009), 28.
[9] Jean-Claude Risset, "Computer Study of Trumpet Tones" (paper represented at the 70th meeting of the Acoustical Society of America, Saint Louis, November, 1965).
[10] Jean-Claude Risset "Computer Music: Why?" http://www.utexas.edu/cola/france ut/_files/pdf/resources/risset_2.pdf, March 18, 2016

2.0 ORIGIN OF THE SPECTRAL "SOUND"

In 1969, following the trumpet study, Risset published his influential *Introductory Catalogue of Computer Synthesized Sounds*, detailing "the analysis, synthesis and perception of acoustic instrument tones."[11] Risset's comprehensive study was considered "the most important breakthrough in the early days of computer music,"[12] and proved to be "a rich source of information on sound synthesis for many years to come."[13]

Both the study and the catalogue greatly influenced Composer Gérard Grisey (1946-1998) and his colleagues. For the first time they could delve into the core of the sound—its spectrum—and further understand the relationship of its various components to the perception of its timbre.

Through Risset's work, Grisey was not only able to observe the frequency components of a spectrum, which had been heretofore only speculative, but to see the individual amplitude envelopes of each partial, which possess unique attack and decay transients.

A decade later, Grisey echoed Risset's "Computer Study of Trumpet Tones" with his own study of trombone sounds via the use of the sonogram (see Figure 1), which influenced the

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[11] John Chowning, "Fifty Years of Computer Music: Ideas of the Past Speak to the Future" Computer music modeling and retrieval: sense of sounds: 4th International Symposium, CMMR 2007, Copenhagen, Denmark, August 27-31, 2007: revised papers (Berlin; New York: Springer, 2008), 2.
[12] Ibid.
[13] James W. Beauchamp, "An Introductory Catalogue of Computer Synthesized Sounds by Jean Claude Risset," *Perspectives of New Music* 9, no. 2 - 10, no. 1 (Spring/Summer - Autumn/Winter, 1971), 350.

creation of *Périodes* (1974) and *Partiels* (1976), and eventually served as the basis for the large six-part cycle *Les espaces acoustiques* (acoustic spaces).

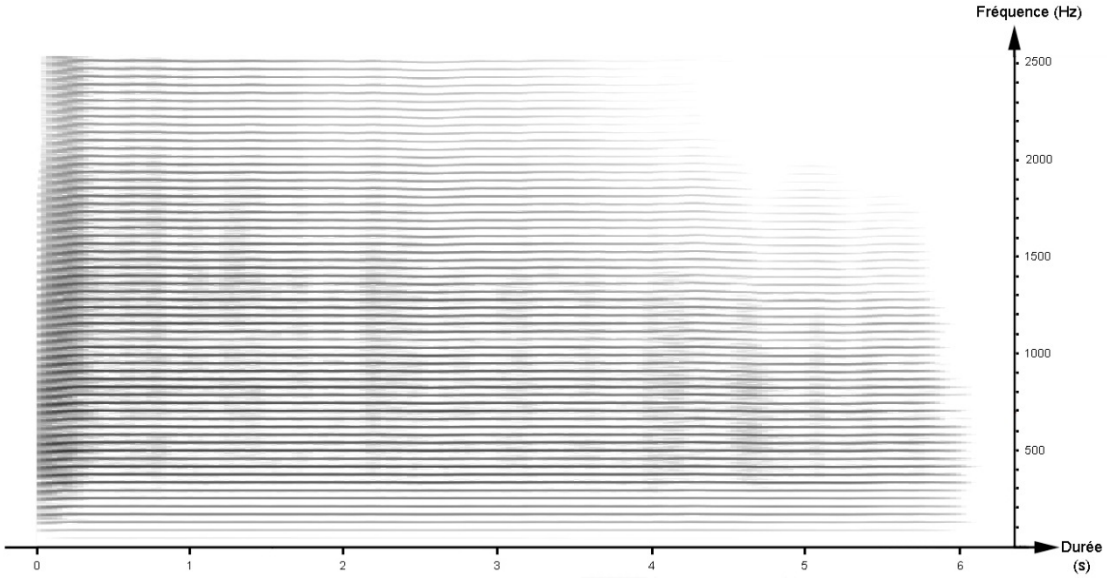

Figure 1 spectrogram of Trombone E_2

In observing the spectrum of the trombone's low E_1 (frequency of 41.2Hz), Grisey noticed similar varied amplitude envelopes throughout the harmonic structure of the sound which he then used as the basis for the beginning of *Partiels* ("partials"). In *Modulations* he expands upon this idea after observing the spectra of various brass instruments, including the use of different mutes acting as band filters.

Inspired by these findings, Grisey followed Risset's example of "resynthesize[ing] the analyzed tones"[14] in order to trace the original timbre. This layering of individual partials' amplitude envelopes in the electronic domain, described as "additive synthesis,"[15] was later adapted by Grisey and other spectral composers to the acoustic domain.

[14] Ibid., 15.
[15] Ibid.

Instrumental additive synthesis is an indispensable tool in the composition of *Les espaces acoustiques* and particularly for *Modulations*. This method allows Grisey to address "separately the evolution of the components and sum them together," specifying "different envelopes for each harmonic component, with each [envelope] corresponding to the curves extracted from the analysis."[16]

2.1 COMPOSING SOUND

As mentioned before, Grisey's own explorations in sound analysis brought forth similar conclusions to those of Risset, leading him and his colleagues to "share a central belief that music is ultimately sound evolving in time."[17] Recognizing these findings and identifying their importance to the composition of *Modulations* is crucial for conducting a comprehensive analysis of the piece.

In *Modulations*, Grisey uses processes of timbral transformation to essentially 'compose sound.' These transformations define each of the piece's temporal structures as well as the overarching structure of the piece. The structural template encompassing these processes is the amplitude envelope.

In a temporal structure, the composer creates and transforms synthetic timbres, from addressing its individual transients to designing its overall dynamic evolution—its envelope. Thinking of temporal structures instead of sections gives Grisey control of sound from the

[16] Ibid.
[17] Joshua Feinberg, "Spectral Music." *Contemporary Music Review* 19, no. 1 (March 2000): 2.

macro— "the time scale of overall musical architecture or form"[18]— to the micro, the "sound object"— "a basic unit of musical structure."[19]

Zooming in[20] on the core of the sound, the sense of time is altered by Grisey beyond its "skeleton" (chronometric time) to its "flesh" (how time is experienced). Thinking of a "scale of complexity"[21] (which will be discussed in chapter 4.4) allows Grisey to step away from the "generally dualistic categories which have been used in an attempt to classify durations: short/long, ternary/binary, rational/irrational values, symmetry/asymmetry"[22] and work on a continuum—the "becoming"[23] of sound.

As sound evolves, perception of evolving structure becomes integral to the compositional process. Grisey no longer fashions a structure one unit at a time, assembling micro units to reach a macro level, but conceives of sound as a complex phenomenon, already a structure in itself. The largest and the smallest units share a fundamental identity, though on different time scales.

This approach led Grisey to use gradual transformation of timbre as a compositional technique, allowing him to come a "bit closer to [working with] real time,"[24] time as it is perceived. Grisey composes with a heightened awareness of the listener "who selects, who creates the changing angle of perception which will endlessly remodel, perfect, sometimes destroy musical form as the composer dreamed it."[25]

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[18] Microsound, 3.
[19] Ibid.
[20] the term is adopted from Grisey's use in Tempus, p.259: "Everything happens as if the effect of a zoom lens, which brings us closer to the internal structure of sounds, was only able to function by way of an opposite effect in relation to time."
[21] Grisey, Gérard. "Tempus ex Machina: A Composer's Reflection On Musical Time." *Contemporary Music Review* 2, no. 1(1987):244.
[22] Ibid.
[23] *Les espaces acoustique*, 9
[24] Ibid.
[25] Tempus, 273.

2.2 STATE OF RESEARCH

Previous analytical essays on spectral music concentrate primarily on pitch content. References to Modulations itself can be found in research concerning the derivation of pitch sets and the construction of harmonic textures based on individual sound spectra (Anderson, 2010, Rose, Hasegawa).

The preeminent spectralist technique of instrumental additive synthesis—in which acoustic instruments are given the role of harmonic and inharmonic partials of an individual spectrum in order to reconstruct (resynthesize) the original spectrum and its derivatives—has been detailed in a number of informative papers (Rose, Feinberg, Hasegawa).

Spectral composers themselves have explicated their respective approaches to composition, or, as Tritan Murail described it, their "attitude towards music and composition,"[26] in numerous lectures and articles. Again, pitch content (i.e. spectrum-based pitch sets and their treatment) is the primary focus, which, as Hasegawa comments, tends to emphasize the natural origins of their material "even while acknowledging the artificiality of some of the procedures used to transform and develop spectral pitch sets."[27]

Although many papers have been written on spectral composition techniques by both scholars and composers, there are very few in-depth analyses of individual pieces. *Modulations*, however, has generated a few detailed investigations. In addition, examples from the score are

[26] Roland Bruce Smith, "An Interview with Tristan Murail," *Computer Music Journal*, 24 No. 1 (Spring, 2000): 11.
[27] Robert Hasegawa. "Gérard Grisey and the 'Nature' of Harmony" *Music Analysis* 28, no. 2/3 (July 2009): 349.

often used to illustrate various spectral compositional techniques such as filtering, subharmonicity—the result of "inverting the order of [the spectrum] intervals [resulting in] an artificial construct with a very chromatic low register"[28] and combination tones—"the acoustical counterpart to ring modulation"[29]—among others.

An analysis of *Modulations* can be found in Jérôme Baillet's *Gérard Grisey: Fondements d'une écriture,*[30]where a dedicated chapter on the piece focuses on Grisey's pre-compositional work. Baillet traces the methods by which Grisey generates his pitch material and provides insight into *Modulations'* harmonic structure. His main contribution is to place *Modulations* within the context of *Les espaces acoustiques*, showing how pitch and harmonic texture connect the six pieces of the cycle. However, the scope of Baillet's book does not allow for exhaustive treatment of any of the cycle's individual piece.

Sascha Lino Lemke, who builds on Baillet's research, offers the most extensive insight into *Modulations*' pitch structure to date, including brief observations of other aspects of the score. In his *"...sublimiert zu einem ständigen klanglichen Werden…"* ("sublimated to a permanent aural becoming")[31], Lemke provides a global overview of *Modulations'* pitch structure. Discussion of combination tones is prominent in this analysis.

Neither Lemke nor Baillet examines *Modulations*' structure through the prism of time—"the very object of form,"[32] as described by Grisey—which consequently prompts a more

[28] François Rose, "Introduction to the Pitch Organization of French Spectral Music," in *Perspectives of New Music* 34, 2 (Summer, 1996): 15.
[29] Ibid., 20.
[30] Jérôme Baillet. *Gérard Grisey: Fondements d'une écriture*. Paris: L'Harmattan, 2000.
[31]Sascha Lino Lemke, " '...sublimiert zu einem ständigen klanglichen Werden:' Gérard Griseys *Modulations* pour 33 musiciens," in *1001 Mikrotöne*, (Neumünster, Germany: Bockel Verlag, 2014): 235-310
[32] Gérard Grisey. "Did you say spectral?" Contemporary Music Review 19, no. 3 (2000): 2.

"attentive attitude towards the phenomenology of perception."[33] Instead, they base their structural map on the frequency domain, by reflecting the proportions created by the intervals between partials into the time domain, as Grisey laid out in *Périodes.*

Rhythmic organization is the subject of a short article by Xavier Ferron, where he discusses its structural significance in the first part of *Modulations.*[34] Ferron discusses temporal structuring, in a brief section titled … *à la structuration temporelle*, where he also references Baillet's analysis. Both Ferron and Baillet rely heavily on Grisey's own sketches (from the archive at the Paul Sacher Foundation). The extensive detail of these sketches emphasizes the composer's fascination with time, and the extent to which he explored temporal structural possibilties prior to the composition of the score.

Huey Meei Chen discusses time and process in Grisey's work in a dissertation[35], which also includes extensive analyses of two of Grisey's works (*Périodes* and *Tempus ex Machina*).

Although Chen does not refer to temporal structures, she does reference amplitude envelopes—which are the very definition of temporal structures—when discussing the dynamic evolution of individual instruments. However, Chen neglects to relate those to larger structures within pieces and, most importantly, doesn't mention their innate affinity to the overall structure.

Amplitude envelopes, as the dynamic evolution of sound, define not only the boundaries within which sound operates—its temporal structure—but, as this analysis argues, are directly responsible for the very perception of it, which in turn is the major defining element of its timbre.

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[33] Ibid., 3.
[34] François-Xavier Féron "L'organisation rythmique dans la première section de *Modulations* (1976–77) de Gérard Grisey," in *Mitteilungen der Paul Sacher Stiftung*, Nr. 25 (April 2012): 41-48.
[35] Huey-Meei Chen. "Temporality and Process in the Compositions of Gérard Grisey." PhD diss., Columbia University, 2010.

Temporal structures, prominent in Grisey's own discussions about time, are shown in this analysis to be the building blocks of *Modulations*. The absence of a discussion of temporal structures in previous investigations is surprising, as they lie at the heart of what Murail considers the basic tenet of spectral music: "think[ing] of the continuum before thinking of the discrete."[36]

Each of *Modulations'* temporal structures is defined by the onset and ending of the process of timbral transformation they contain. These processes contribute to the piece's continuum and, as a result, our perception of its larger form.

Continuous change (what Murail calls "continuum") is Grisey's objective throughout *Les espaces acoustiques* and particularly *Modulations.* He states that "in *Modulations,* the substance does not exist in and of itself. Rather, it dissolves into a process of musical flow and becoming that constantly changes and cannot be captured at any one moment; everything is in flux."[37]

Timbral transformations occurring within *Modulations*' temporal structures provide the space for that constant change. The interaction between those structures, as will be shown by this analysis, helps bridge momentary disruptive points, allowing for continuity to emerge.

[36] Moscovich, Viviana "French Spectral Music: an Introduction," *Tempo,* New Series, no. 200 (April 1997): 21-27.
[37] Les espaces, 9.

2.3 TEMPORAL STRUCTURES

Grisey was keenly interested in the temporality of music and sound. His treatise "Tempus ex Machina: A Composer's Reflections on Musical Time"[38] describes the potential impact that working with temporality and its perception can have on musical compositions.

Grisey differentiates between the "skeleton of time" (chronometric time) and the "flesh of time" (perceptual time). He explains that it is the "flesh of time," rather than the "skeleton of time," that allows the listener to be "attentive to the relativity of any temporal structure from the moment a sound materializes it."[39]

He admits that "what continues to attract me is the possibility in the future of imagining structures which are no longer fixed to a single type of perception."[40] And he further recognizes that "temporal structures themselves acquire a plasticity relative to the change in scale."[41]

This conclusion is rather crucial to *Modulations* since at the heart of its compositional process lies the composer's acknowledgment of its temporal structures and their various perceptions. Through these temporal structures Grisey aims to tap into what he calls "the flesh of time." As he explains:

> ....it is here a question of approaching the immediate perception of time in its relationships with the sound material. The same temporal skeleton [chronometric time] may be enveloped and therefore perceived differently according to the way in which the volumes and weights of the musical flesh are distributed. To a greater extent than for the skeleton of time, we will be attentive here to the relativity of any temporal structure from the moment a sound materializes it.[42]

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[38] Grisey, Gérard. "Tempus ex Machina: A Composer's Reflection On Musical Time." *Contemporary Music Review* 2, no. 1(1987): 239-275.
[39] Ibid., 258.
[40] Ibid., 268.
[41] Ibid.
[42] Ibi., 258.

Therefore, the correlation for Grisey between timbral perception and temporal structure is clear, as well as his intention to mutually define and manipulate timbral and temporal perception. Grisey modifies this idea to realize its acoustic execution on every level of the piece's structure.

Grisey's temporal structures are in fact structural envelopes within which sound evolves. Near one end of the scale, temporal structures behave as overall amplitude envelopes. Their acoustic characteristics "govern[s] changes in our perception not only of a sound's loudness over time, but also of its timbre."[43] At the macro level, where this idea is magnified, Grisey's large temporal structures (TS) embody timbral transformation.

This analysis postulates that the core material of *Modulations* is timbre, and that the piece's eight temporal structures (TS) each embody a process of timbral transformation.

As the discrete amplitude envelope of an individual sound is largely responsible for determining its timbral character through the evolution of its attack, sustain and decay transients, larger temporal structures set up processes of timbral transformation through analogous transitory portions along their continuum.

In the score of *Modulations*, temporal structures are used as "time-varying envelopes" on multiple levels from the macro— "the time scale of overall musical architecture or form"[44] — down to the micro—the sound object, which can be defined as the "basic unit of a musical structure," where the "traditional concept of the note" can be expanded to include "complex and mutating sound events on a time scale ranging from a fraction of a second to several seconds."[45]

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[43] Guillaume T. Vallet, David I. Shore, Michael Schutz, "Exploring the role of the amplitude envelope in duration estimation" in *Perception* 43, 7 (2014): 616.
[44] Ibid., 11.
[45] Ibid., 3.

In granular synthesis, a technique well-known to Grisey, "time-varying envelopes are used on a microscopic time scale" extending down "to the threshold of auditory perception," and can be measured "in thousandths of a second or milliseconds."[46]

[46] Microsound, 4.

3.0 ANALYSIS

3.1 MACRO-STRUCTURE

Modulations is structured in three large parts, comprised of eight smaller temporal structures (TS): five in Part I, two in Part II and one in Part III (Figure 2). The analysis follows the timbral transformation processes occurring within the boundaries of each of these temporal structures, and their effect on *Modulation*'s entire structure.

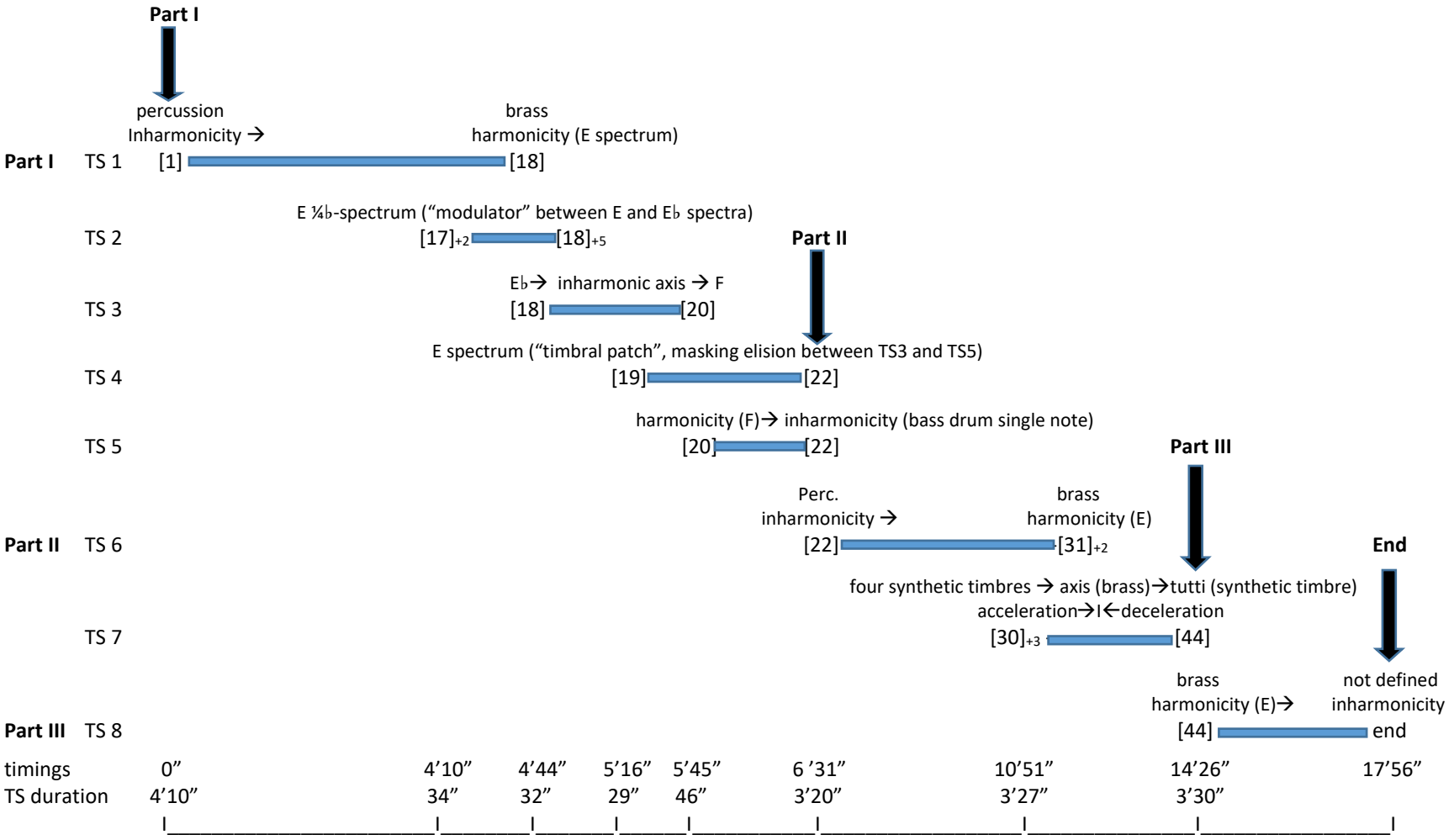


Figure 2 macro-structure of *Modulations*[47]

[47] bracketed numbers throughout are rehearsal numbers taken from *Modulations*’ score

The three parts are defined by distinctive pointers marking their ends and beginnings. However, temporal structures usually overlap, behaving within each part in what can be defined as a structural polyphony. This structural counterpoint emulates the relationship between partials and their individual envelopes within the spectrum of a single sound. Each larger section (Parts I, II & III), and ultimately the entire piece, as a single large-scale (non-overlapping) temporal structure.

Modulation's structural polyphony can be described as the acoustic compositional equivalent of the time-varied sound spectra of brass instruments[48] where partials are not synchronized in their onset (although there is a consistent feature of higher partials coming in later), and each possesses its own discrete amplitude envelope.

3.2 THE THREE PARTS

On the largest scale, *Modulations* starts with an extremely high amplitude, and ends with that same amplitude. In between there are two clear structural interruptions at [22] and [44], very different from each other, but serving the same purpose: to signal the end of one process and the start of a new one. Nowhere else in the piece does Grisey clearly articulate sections. Smaller scale sections comprising these, which will be called temporal structures (TS), are generally overlapping, while the three larger sections (Part I, II & III) are clearly separated by two pivotal points. The first, a single bass drum note at [22], which marks the ending of Part I, is followed by the first "empty space" of the piece marking the beginning of Part II. The second, an abrupt

[48] Jean-Claude Risset, "Timbre Analysis by Synthesis: Representations, Imitations, and Variants for Musical Composition" in *Representations of Musical Signals*, edited by Giovanni De Poli, Aldo Piccialli, Curtis Roads, (Cambridge, Mass.: MIT Press,1991), 15-16.

change in dynamic from a climactic *fff* to a static *ppp* at [44], marks the end of Part II and the beginning of Part III.

3.3 BETWEEN PART I AND PART II

The first silence of the piece at [22] right after the aforementioned single bass drum note, is preceded by a deceleration of subdivision accompanying a registral descent in the harp and the lower string instruments. A dense chromatic texture at [21] gradually thins as the music slows, ending on a single low bass drum note of indefinite pitch at [22], which is followed by the first rest of the piece. The larger process of Part I is thus concluded.

Though the next measure, with its tempo change to ♩ =78, might mark the beginning of Part II, as others have concluded (Baillet, Lemke), this analysis takes a more nuanced view. The bass drum stroke is followed by a whole note rest with a fermata—the first "empty space" of the piece. The following passage, until [23], accumulates "empty spaces" of various lengths, destroying any sense of meter, and robbing the tempo change of meaning. No clear pulse can be detected; expectation is thus tampered with. The process will be described in detail later (chapter 6.1).

Grisey was interested in working with "empty spaces—the distance—that separates one tone from another," and "not merely…the material."[49] The empty space, one measure before [22], is the first in a row of five empty spaces occurring between sounding measures ("the material") in the section ending at [23].

[49] Gérard Grisey, "Die Entstehung des Klangs," in *Katalog Wien Modern 2000*, edited by Berno Odo Polzer and Thomas Schäfer, (Saarbrücken: Pfau 2002):121.

Thus, the bass drum note ending Part I and preceding that first empty space can be perceived as an elision between Parts I and II. Striking a bass drum not only produces a low note of indefinite pitch with an inharmonic spectrum, but depending on the drum size and the acoustics of the venue, it will also produce subtle reverberations.[50]

3.4 BETWEEN PART II AND PART III

The second clear division between larger parts occurs at [44]. Near the end of Part II (beginning on beat two of the fourth measure before [44]), the entire orchestra arrives at a rhythmic unison. An acceleration via a decreasing scale of durations, accompanied by steadily increasing dynamics, leads to the culmination of Part II on the downbeat of [44].

The acceleration and gradual crescendo stop abruptly on a short dissonant sixteenth-note attack on a very loud dynamic (*fff*). With a dramatic dynamic shift from *fff* to *ppp*, an additive harmonic spectrum emerges immediately, marking the beginning of Part III. The concluding gesture of Part II with its short and loud wide range inharmonic spectrum triggers the start of a new process which will define the final large section of *Modulations*—Part III.

The three parts of the piece are defined by the larger process they contain: Part I begins with a broad frequency band inharmonic spectrum, advancing with an uneven and erratic rhythmic movement. It concludes via deceleration to a single indefinite-pitch. Attacks and dynamics are tailored to serve each of those ends and to emphasize their extremes. Part I starts

[50] Even a short staccato bass drum note with Grisey's instruction to muffle with a mute (*avec une sourdine*) will produce very brief secondary reverberations. Thus, the bass drum strike signals the first gesture in a string of recurring, periodic rhythms whose speed increases in the measures after [22].

with short, very loud (*ffff*) unpredictable attacks and concludes with a short, very soft and quite predictable (*ppp*) attack.

Part II commences with that same very soft attack on a single note and concludes with a very short and loud (*ffff*) attack on a wide inharmonic texture. Thus, its overarching structure mirrors that of Part I. The structural amplitude envelope of Parts I and II can be described as one large quasi-symmetrical structure (Figure 3) Both parts together form the substantial, main part of *Modulations*.

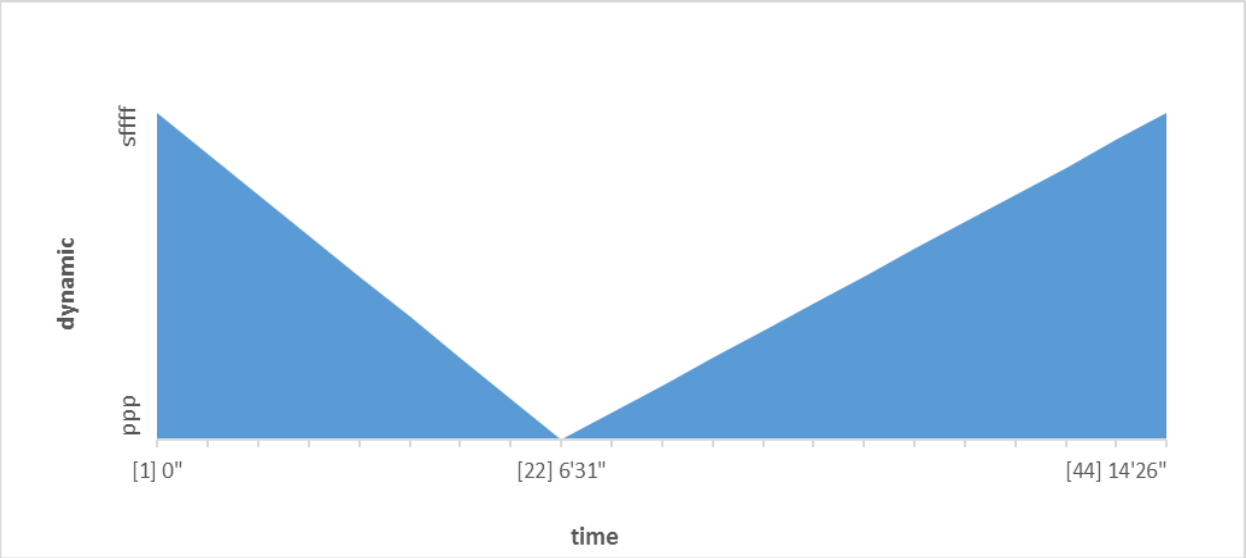


Figure 3 structural envelope of Part I+II, ([1]-[44])

Part III acts as a coda, and begins with a short, sharp attack with a dense inharmonic spectrum, immediately followed by a soft E-based harmonic spectrum. Throughout Part III this harmonic spectrum gradually transforms, ending *Modulations* with a loud inharmonic spectrum which is rudely interrupted. Part III's envelope condenses the preceding larger processes into an effective finale (Figure 4).

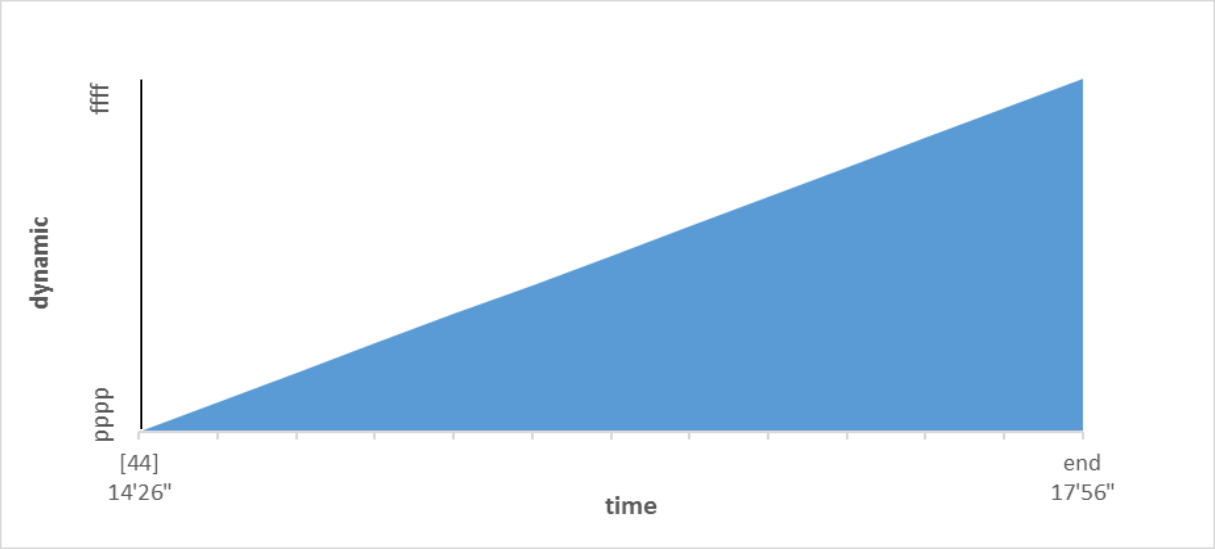


Figure 4 structural envelope of Part III ([44]-end)

4.0 OVERVIEW OF THE EIGHT TEMPORAL STRUCTURES (TS1-TS8)

After defining *Modulations* three larger parts (Part I, II and III), a detailed investigation of the eight overlapping temporal structures will follow. As shown in Figure 2, Part I is comprised of five temporal structures (TS1-TS5), Part II contains two (TS6 and TS7), and Part III is a temporal structure of its own (TS8).

As the opening temporal structure of Part I, and of the entire piece, TS1 introduces the first timbral transformation of *Modulations*, occurring over 11 segments. That process begins with an inharmonic synthetic percussive timbre played over erratic and unpredictable rhythmic patterns, gradually becoming more predictable as the inharmonic content clears. The transformation concludes with a synthetic harmonic brass timbre. The following four structures (TS2-TS5) act as one unit:

TS2 consists of a harmonic set one quarter tone lower than the E harmonic spectrum which ended TS1. Its harmonic content serves as a pitch-bend mechanism, modulating the E-based harmonic spectrum at the end of TS1 to the E♭-based harmonic set which defines the beginning of TS3. The third temporal structure gradually transforms its initial E♭-based harmonic spectrum to one based on a harmonic set from an F spectrum via an inharmonic climax serving as its axis ([19]). TS4 begins at the point of TS3's climax. Its fully manifested E spectra at [20] masks the enharmonic elision (celesta's A_4), between TS3 and TS5.

TS6, the opening temporal structure of Part II, introduces the first unmeasured silences of the piece. In between these empty spaces a percussion trio plays periodic rhythmic patterns that accelerate with each successive iteration. At the trio's rhythmic climax [23] Grisey introduces a dense inharmonic orchestral tutti that undergoes a 13 segment timbral transformation, ending on a sparse E-based harmonic spectrum that reflects yet another synthetic Brass timbre.

TS7 consist of four mixed instrumental groups, each projecting synthetic timbres that are transformed through an acceleration/deceleration to and from a climatic axis at [37]. As TS7 progresses, a process of compound phase shifting takes place between the four groups until they arrive at a rhythmic unison (zero phase shifting) at TS7's coda (four measure before [44]). TS8 encompasses the entire Part III and progress in 11 stages, transforming its initial soft E harmonic spectrum to its very loud and dense inharmonic ending.

4.1 TEMPORAL STRUCTURE 1 (TS1)

The first temporal structure defines the character of the whole piece. Its process is that of a slow transformation of timbre through fourteen stages—Segments I-XIV—as shown in Table 1. Timbre is defined by the sound's harmonic spectrum, independent of pitch, loudness, and duration, and most importantly by transients of attack and decay manifested in its overall amplitude envelope, defined by the amplitude envelopes of its spectral components.

Specifically, the sounds of brass instruments, on which *Modulations* is based,[51] do not have a fixed spectrum; their "wave shape varies throughout the course of a note."[52] Further,

[51] Les espaces, 9.

"most of the energy is concentrated in the [sound's] harmonic lines," with "a burst of inharmonicity…often visible at the onset of the sound."[53]

In TS1 Grisey is working on slow transformations of various parameters such as attack (short to long), rhythmic patterns (aperiodic to periodic) and dynamics (extremely loud to very soft). The spectral transformation proceeds overall from a dense inharmonic texture to a sparse texture based on the E harmonic spectrum.

The process within TS1 starts with short, jerky, percussive attacks which eventually become long, sustained, and essentially unarticulated at [7] with the complete abandonment of the percussion. Harmonicity finally emerges three measures before [14], where another process of rhythmic transformation from rhythmic aperiodicity to periodicity (which will be discussed later) is in its final stages.

[52] Timbre Analysis, 13.
[53] Ibid., 14.

Table 1 process of temporal transformation along TS1 (segment I-IX, [1]-[18])

segment	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
rehearsal numbers	[1]			[2]	[3]	[4]	[5]	[6]	[7]	[9]	[11]	[13]	[15]	[17]
phrase length [in 2/4]	1	2	3	5	7	9	11	13	15	17	19	21	23	21
Percussion														
Group I	low bongos		tom toms		cowbells		tubular bells		(x) off					
mallets	sticks				very hard sticks			medium mallets						
Group II	woodblock	high bongos		temple blocks		cowbells		vibraphone	(x) off					
mallets	sticks			very hard sticks			medium sticks	medium mallets						
pitch	no pitch			minimal			Harmonic + many non-harmonic frequency components	Harmonic	none					
attack	very short		short accent	accent	accent	full duration	tenuto		none					
decay	none		none	Short (l.v.)	longer	full duration	longer		none					
dynamic	*ffff*	*fff*	*ff*	*f*					none					
Hammond Organ														
Percussion knob	on					(x) off								
Percusion decay	off	slow												
General														
Spectrum	inharmonicity →											harmonicity		
texture	very dense →											sparse	sparser	
Spatial range	very wide →													narrow
Dynamic	*ffff*	*sffffppp*	*sfffppp*	*sfff>ppp*	*ff>pp*		*f>p*	*f>mp*	*mf—*	*mp<mf>*	*p<mf>*	*pp<mp>*	*0<mp>*	*0<p>*

Since defining *Modulations'* temporal structures is at the center of this analysis, the acoustic implementation of the sound's spectral and amplitude envelopes (i.e. its timbral transformation) must be clarified. Essentially, the onset and decay of the dynamic evolution of processes (their "from" and "to") and their supporting harmonic-textural transformation, define the two ends of a given temporal structure.

In TS1 Grisey concentrates on transforming a synthetic percussive timbre to a synthetic brass timbre. The two timbre types are defined by different if not entirely contradictory amplitude envelopes. The percussive one has a very fast attack, minimal if any sustain and a fast decay (Figure 5a). The brass envelope has a relatively quick attack, a clear sustain and a gradual decay over a longer period of time (Figure 5b).

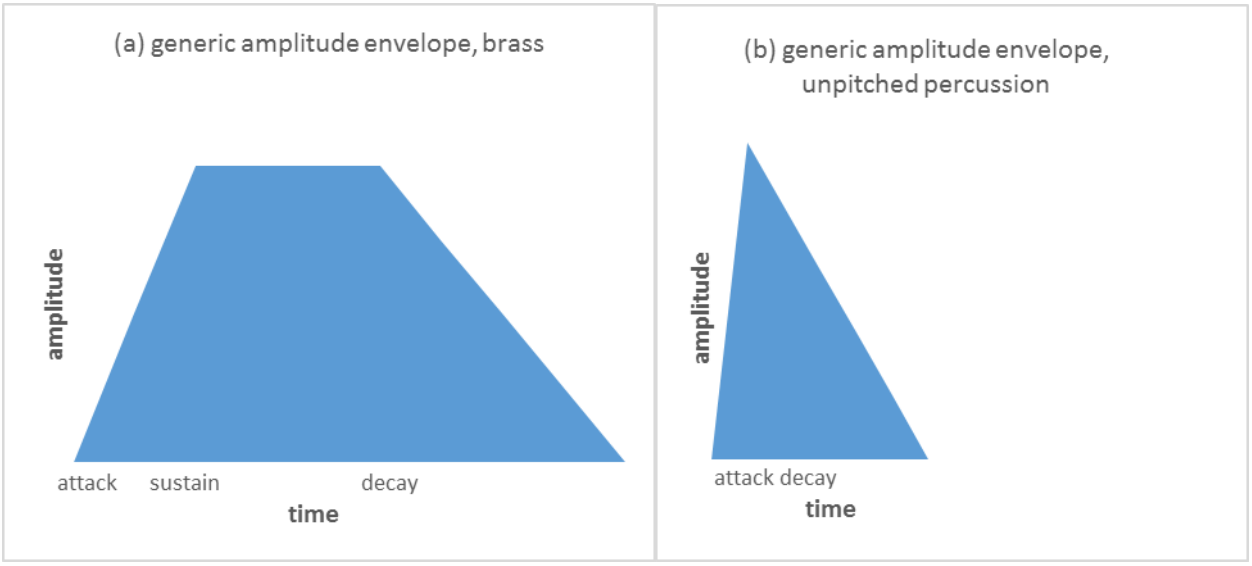


Figure 5 generic amplitude envelopes of brass and unpitched percussion

4.2 INSTRUMENTAL GROUPS: THE VARIOUS "VOICES" OF TS1

On the surface, as others have observed (Baillet, Lemke), the progression through TS1 is triggered by a rhythmic dichotomy between two "voices" or instrumental groups.[54] The first group is formed around the timbre of the entire wind and brass sections. The second group involves the entire string section consisting of five violins, three violas, two cellos and two basses.

Each of these groups is aided by various percussion instruments to complement or intensify a certain sound quality in a given moment throughout the transformation process. Grisey's desire to achieve various degrees of percussive timbre lead him to simulate a succession of envelopes via their attack transient, resulting in his choice of very specific percussion instruments and mallets. For example, timbre characterized by a short attack with a short decay time is typically enforced by unpitched percussion, which at times includes instruction to the performer to muffle the sound to shorten the decay time.

As attack and decay times of envelopes become longer throughout TS1, the dense texture of the initial inharmonic spectra in segment I ([1]-[2]) steadily thins. By segment VII ([5]), pitched percussion with relatively harmonic spectra and longer decay times are introduced. Finally, at [7], where the "sustain" portion of the envelope dominates, percussion is no longer used.

For the fifteen measures of the sustain portion, between [7] and [9]—segment IX—sustained dynamics of *mp* for the winds and *mf* for the strings define a transitional mid-section,

[54] Throughout the piece Grisey explores the relationship between timbre and temporal structures via division of the larger 33-piece ensemble into various smaller instrumental groups usually organized by timbral affinity. This technique is primarily used to clarify a given sound transformation and enhance perception of its process.

emphasized by the explicit instruction *senza diminuendo*. The result is analogous to the sustain portion of the brass amplitude envelope. Eliminating the attack and decay transients of amplitude envelopes of various instrumental combinations in that portion of TS1 aims to blur the distinction between their timbres.

Furthermore, starting at segment VI ([4]) exactly where the Hammond organ percussive attacks are left out, low strings from Group II gradually join the woodwinds and brass of Group I. And, at segment VII ([5]), woodwinds from Group I gradually join the strings of Group II.

Arriving at segment IX ([7]-[9])—the sustain passage—both groups are already immersed in a noticeable timbral exchange, which further blurs the distinction between the two original timbres. By now the winds and brass of Group I are engaged with a trio of strings (two violas and bass) from Group II, and the strings of Group II are engaged with a trio of woodwinds (oboe, clarinet and bassoon,) from Group I.

4.3 THE EMERGENCE OF A THIRD TIMBRE—GROUP III

This timbral exchange is a precursor to the introduction of a third timbral group. In the following measures ([9]-[11]) whenever the strings are left alone (i.e. without the winds doubling) they are exclusively occupied with two bowing techniques, tremolo and ricochet, with the added instruction *le plus rapide possible* (as fast as possible). The added instruction to "not synchronize but stay exactly within the duration boundaries indicated," enhances the perception of a newly emerged unique timbre by differentiating it from the synchronized string strokes in both Group I and II.

Ricochet and especially tremolo act as an amplitude modulator to the carrier frequency of the note. The ear does not perceive a variation in pitch but a pulsation in loudness. This transformation of the string sound is significant. While Group II establishes a string timbre separate from the wind timbre of Group I over the next few measures, another group with its own unique timbre emerges, differentiating itself from the two original groups.

At the end of the sixth measure after [5] and following six gestures in its newly established timbre, Group II's sound unexpectedly shifts as both ricochet and tremolo disappear. Added to that texture (of ordinary arco) is the English horn, which is assigned to the lowest note of the chord (G ¼#). A distinct new timbre is then formed—Group III. In later occurrences of Group III, various wind instruments join in.

As the music progresses, the strings alternate between rapid tremolo/ricochet and normal bowing, to produce one distinct timbre or the other. The new Group III timbre becomes more prominent while the timbre of Group II gradually disappears. Gaps between Group II's strokes are prolonged, causing its rhythmic deceleration and eventual elimination.

The final tremolo occurs three measures after [12]. The following chord in that group is played without tremolo, three measure after [14], but with *molto vibrato*. The next gradation appears a measure before [16], where the vibrato is reduced to *poco vibrato*. Whereas tremolo and ricochet can be considered a form of low frequency amplitude modulation, vibrato is a form of low frequency modulation.

It has been found that "between the sensation of a continuous tone and the sensation of metered rhythm stands a zone of ambiguity."[55] Grisey touches upon "infrasonic frequency

[55] Microsound, 17.

domain, [which] is too slow to form a continuous tone but too fast for rhythmic definition,"[56] to affect the timbre of orchestral groups during the process of timbral transformation in *Modulations'* TS1.

Both amplitude and frequency modulations are sensed near the threshold of "regular pulse and meter…occur[ring] from approximately 8 Hz down to 0.12 Hz and below."[57] This frequency range is where "the most salient and expressive vibrato, tremolo, and spatial panning effects occur."[58]

Group III goes through its own timbral and harmonic transformation. The ratio between the wind and string instruments in the group is continuously shifting, gradually giving more weight to the winds, and affecting its overall timbre as a consequence. Simultaneously, an ascending microtonal scale, applied to its lower "partials," defines the harmonic progression of the group and help distinguish it from the already established timbre of Groups I and II (Figure 6).

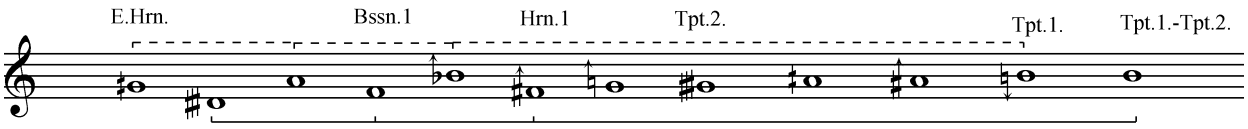


Figure 6 ascending microtonal scale in the lower register of Group III

At the end of the process, all three groups project the harmonic series of the E_1 spectrum (Figure 7).

[56] Ibid.
[57] Ibid.
[58] Ibid.

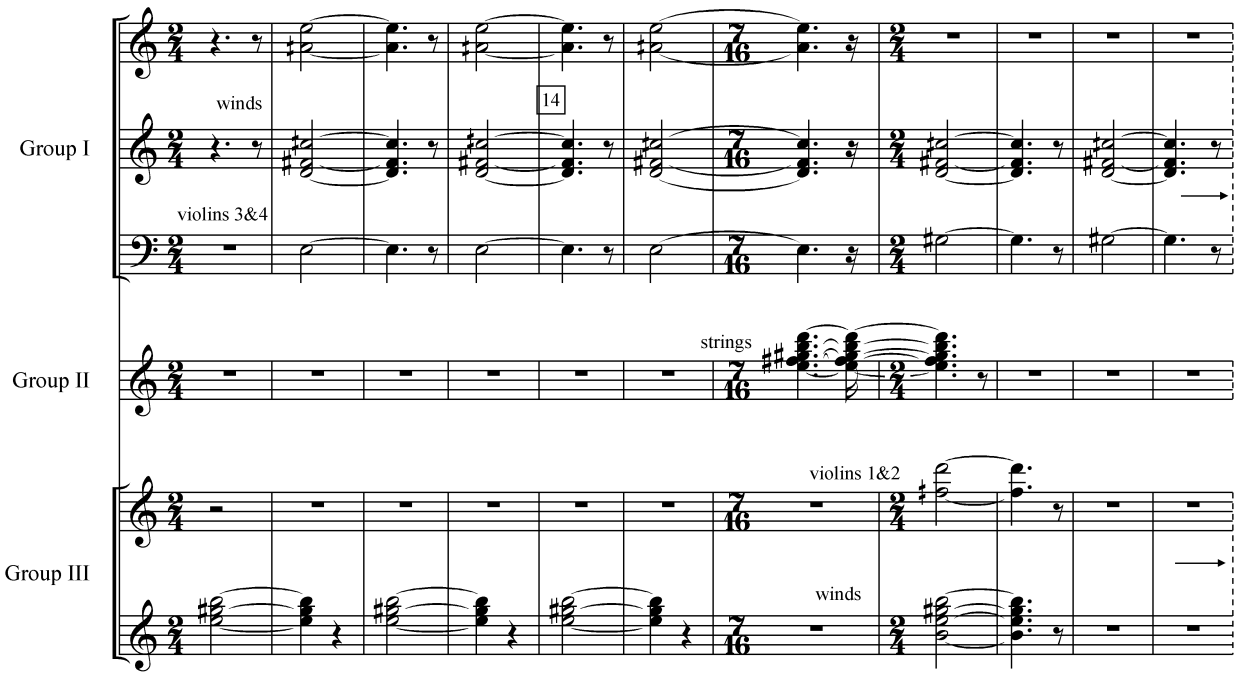


Figure 7 E spectrum at the end of TS I, at [14]

4.4 PERIODICITY, PREDICTABILITY AND THE SCALE OF COMPLEXITY

The "scale of complexity"[59] is a way of addressing structure within the "skeleton of time" and how structural complexity affects its perception, the "flesh of time." In *Time in Music*[60] Jonathan Kramer differentiates between "music in time," i.e. objective, chronometric time (Grisey's "skeleton of time," and "time in music," subjective, perceptual time (Grisey's "flesh of time"). Kramer suggests that, "if we believe in the time that exists uniquely in music, then we begin to

[59] Tempus, 244.
[60] Jonathan D. Kramer, *The Time of Music: New Meanings, New Temporalities, New Listening Strategies* (New York: Schirmer, 1988)

glimpse the power of music to create, alter, distort, or even destroy time itself, not simply our experience of it."[61]

Grisey agrees, insisting that it is "virtually impossible to reflect on structures of musical time without immediately touching on phenomenological and psychological aspects."[62] And indeed, he does make an effort to work with the "flesh of time" when composing the opening temporal structure, TS1.

One example of movement along the scale of complexity can be heard towards the end of TS1. A sound quality is transformed via very soft attacks and longer envelopes, the music shifts from the aperiodic, unpredictable sharp attacks of the beginning to smooth, periodic reoccurrences at predictable time intervals. TS1 progresses from "disorder" to "order" and reflects various stages along the scale (Table 2).

[61] Ibid., 5.
[62] Tempus, 257.

Table 2 Grisey's "Scale of Complexity"

Chronometric Time ("skeleton of time")	Perceptual Time ("flesh of time")	Result
Periodic	maximum predictability	**Order**
Continuous-Dynamic 1. continuous acceleration 2. continuous deceleration	average predictability	
Discontinuous-Dynamic 1. acceleration or deceleration by stages or by elision 2. statistical acceleration or deceleration	slight predictability	
Statistical complete redivision unpredictability of durations maximum discontinuity	zero predictability	**Disorder**
Smooth rhythmic silence		

The scale is an expansion and more musically detailed version of electrical engineer and information theorist Abraham Moles' scale of predictability (Table 3). For Moles "the isochronism of the period between events is the essential factor in the perception of periodicity. Every rupture of isochronism weakens this perception…variations in period by a factor of much more than one to two end up destroying it."[63]

[63] Abraham A. Moles, *Information Theory and Esthetic Perception,* (Urbana: University of Illinois Press, 1966), 71.

Table 3 Moles' "Scale of Predictability"

Unicity →	Repetition →	Isochronism →	Periodicity
unforeseeable	possible but unforeseeable	statistically foreseeable	foreseeable

TS1 of *Modulations* reverses this order, starting from the lower "statistical" stage and moving up to the "periodic" stage. Here, the periodicity is of four quarter-note pulse movement for each period, with a single hiccup—an added sixteenth note—one measure before [16]. This moment is marked by a timbral shift and, thirteen measures later, is compensated for (one measure before [17]). From [17] forward, a strict periodicity is sustained until the end of TS1 (two measures after [18]). The hiccup seems to challenge the rhythmic periodicity. However, periodicity can suffer minor mutations without effecting our perception of it and the predictability of consecutive periodic events.

Moles concludes that "without being absolute, its [periodicity's] precision must be such that the fluctuations of period remain below difference threshold for perception of durations, on the order of 10 percent."[64] The fluctuation in TS1's periodicity (at one measure before [16] and at one measure before [17]) is below the threshold suggested by Moles. "Order"—apropos Grisey's scale of complexity—is maintained.

[64] Ibid., 75

5.0 TEMPORAL STRUCTURES 2, 3, 4 AND 5

5.1 DEFINING THE END OF TS1

Previous analyses of *Modulations'* larger form (Baillet, Lemke) identify the start of a new section at [17]. Even though score numbers generally correlate with musical segmentation, this analysis questions that assumption, particularly in regards to [17] being a new section. TS2 starts two measures after [17] and it overlaps with TS1's ending (segment XI, [17]-[18]).

Following the overall process of timbral transformation occurring over TS1's 11 segments, the final segment (segment XIV) starting at [17] has no special significance as the second element in a larger transformational process. Further, the change of time signature at [17] (predominantly 2/4 to 4/4) has no effect on the periodicity progression. The periodic duration still maintains a four quarter-note duration as well as a symmetrical fade in/out.

There is a slight change in orchestration at [17] with the elimination of the woodwinds, thereby omitting the 10^{th} and 11^{th} harmonic partials of the fundamental E_1, played by the flutes. However, while the partials played by the flutes are dropped, those played by the clarinets are transferred to the horns. The two trumpets rejoin, supporting the emerging brass timbre, while the two trombones alternate their notes. Finally, the complete brass section minus the tuba is advanced to the fore.

Thus, segment XIV (starting at [17]) is in fact the final stage in TS1's timbral transformation. A process which becomes gradually apparent from [13] on. Over the 31 measures between [13] and [16], only two brass instruments are present, each representing the lower partial in each of the two groups (Group I and III). Starting at one measure after [13], the two horns alternate playing the lower partial of Group I's harmonic set derived from the E_1-based spectrum, handing off this function to the trombones at [15]. (Trumpets assume similar role in Group III.)

The remaining inharmonic note fades one measure earlier, resulting in a fully harmonic texture at [15]—variations of pitch sets based on the E1 spectrum harmonic partials—which lasts until the end of TS1. From this point forward a clear rhythmic periodicity is present, complementing the current harmonic texture. Two distinct groups play synchronously with a phase shift of half a period, or two quarters. This clear rhythmic periodicity is supported by a symmetrical amplitude curve enhancing the predictability, what Grisey calls "pre-audibility,"[65] of events.

Beginning at two measures after [16], the brass gradually becomes more present. Group I and Group III are now each represented by two instruments: Group I by hrn.1 and trb. 2 and Group III by hrn. 2 and trb. 1. This is another stage leading to the final segment of TS1 at [17], where six brass instruments finally take over the entire timbre, three for each group.

Group II enters one measure before [16], taking over one periodic duration from Group III. Its entrance serves as a "timbral patch" which, as discussed in chapter 4, helps mask the slight variation in duration of an omitted sixteenth note (a 7/16 measure takes the place of the

[65] Tempus, 258.

original 2/4) in the first half of its amplitude's fade in/out curve. The group's last appearance a measure before [17] serves the same purpose.

By [17] all spectral and timbral changes have corresponded to those occurring throughout its timbral transformation. As part of TS1's overall process, the spectrum thins and its registral range narrows and the orchestration is gradually weighted towards the brass. Similarly, the peak dynamic level of the fade in/out of each period, starting at [17], drops to *p*, which is another step down in the overall decreasing dynamic scale. This reinforces the affinity of TS1's coda (segment XIV, [17]-[18]) with the previous segments and further cements its place as part of the first temporal structure.

In fact, this coda is crucial to the overall process, which is the transformation of the prevailing timbre from percussion to brass. By [17] the orchestration involves only brass instruments, divided into two groups of three to maintain the recurring phase shift between them. One trio, a residue of Group I, consists of tpt.2, hrn.2, and trb.1. The other, a subset of Group III, consists of tpt.1, hrn.1, and trb.2. The expression marking *extrêmement calm et lointain* (extremely calm and distant) coincides with that point of arrival.

The segment, as well as the larger temporal structure, ends with the last sound of trb.1, two quarter-notes past [18]. At the same time, a different process with its own unique role has already begun.

5.2 TEMPORAL STRUCTURE 2 (TS2)

In the middle of the second measure after [17], the second alto flute enters with a concert F# doubling the second horn. The dynamic curve of the flute's note is similar to that of the horn.

However, since its duration is prolonged by approximately a sixteenth note, its dynamic peak is slightly delayed (Figure 8). This marks the beginning of TS2, where six woodwinds—two alto flutes, two clarinets and two bassoons—gradually disturb the prevailing periodicity, and modulate from the spectrum based on E down a half step to one based on E♭.

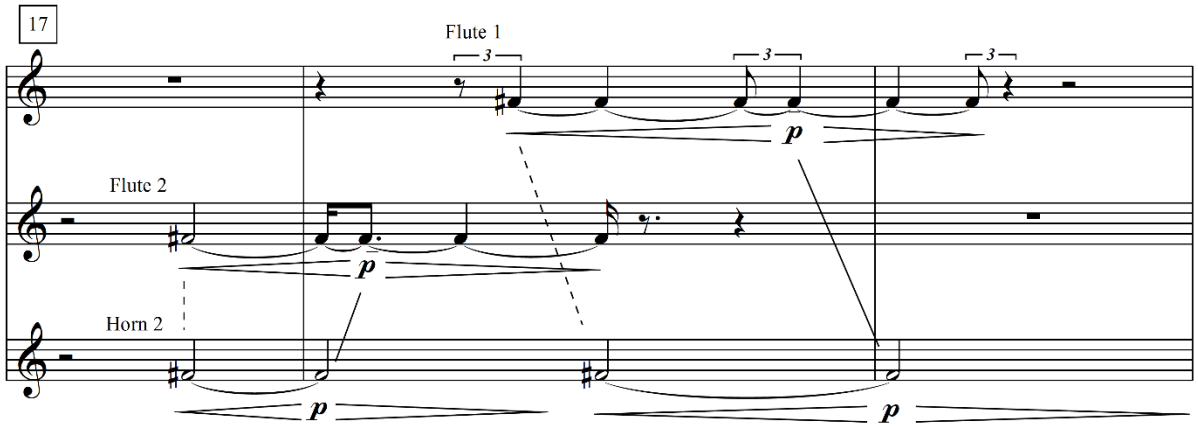


Figure 8 entrance of TS2 with a phase shift over TS1, after [17]

Grisey fashions a smooth overlap between the two structures. The first alto flute follows the synchronized entrance of the second with the same F#, anticipating the next period of the second horn, and almost matching its duration of two quarter notes. As a result, the phase shift that occurs between the beginnings of the first flute and the horn is maintained between their peaks and endings.

The second alto flute takes over the next entrance with a G# doubling the first horn, creating a delayed phase shift of at least an eighth note. Each one of these entrances slightly prolongs the original four quarter note period, interfering with the periodicity still carried by the brass, and thus with the sense of pre-audibility.

This process in the time domain accompanies a significant operation in the frequency domain which defines the role of this structure as a modulating apparatus. Slightly after the fourth beat of the fourth measure after [17], the first flute not only performs a kind of phase shift (horizontal shift) in relation to the brass but also a kind of pitch bend (vertical shift) in relation to the note played by the second horn.

Where the horn is playing the sustained F# coinciding with the 9th harmonic of the fundamental E, the first alto flute enters a quarter tone lower producing an F ¼#. From here on all six wind instruments proceed in playing a set of notes located a quarter tone lower than the set of E harmonics played in TS1 (Figure 9).

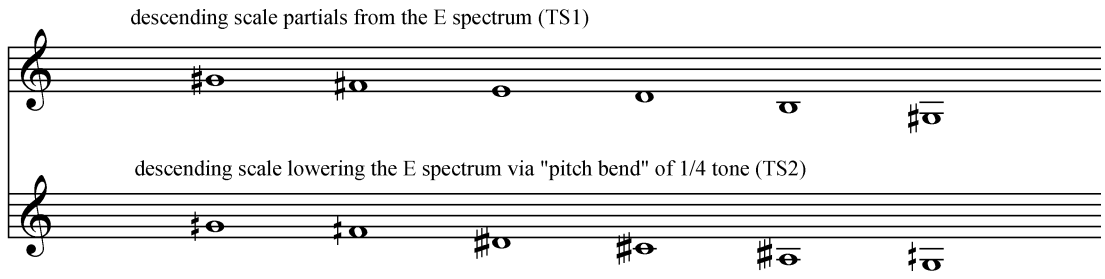


Figure 9 E harmonics of TS1 lowered ¼ tone in TS2, ([17] to [18])

These notes are played in varying durations, always maintaining their fade in/out amplitude curve. The stretching of amplitude swells occurs up to the entrance of the first clarinet, at six measures after [17], which at that point is playing the longest period in the structure, nearly seven quarters.

From here on, the general process of time compression creates a sense of accelerando towards the end of TS2, beginning in the middle of the sixth measure after [18]. The second

bassoon is the last to play the lower G ¼# of the scale completing its various cycles and concluding the structure.

As before, a superimposition of two structures takes place. TS3 has begun in the second beat of [18] with the first English horn playing G, the arrival note—the extension—of the pitch shift process occurring throughout TS2 (Figure 10).

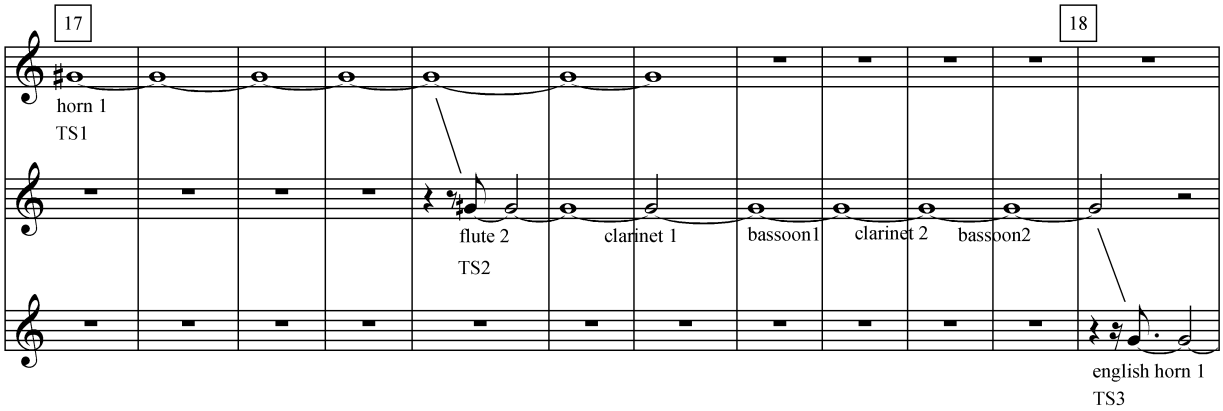


Figure 10 modulating E spectrum (TS1) to E♭ spectrum (TS3), via ¼ tone pitch shift (TS2), [17]-[18]

5.3 TEMPORAL STRUCTURE 3 (TS3)

While TS2 runs its course, slowly modulating the harmonic partials of the E-based spectrum (in TS1) half a step lower via a ¼ tone pitch shift (as shown in Figure 10), a new E♭-based spectrum is slowly surfacing in TS3. A larger instrumental group is participating in this process, anchoring the arrival to the new E♭ spectrum. Each instrument enters individually on G_4, playing a descending scale based on the harmonic partials of the E♭ spectrum (Figure 11).

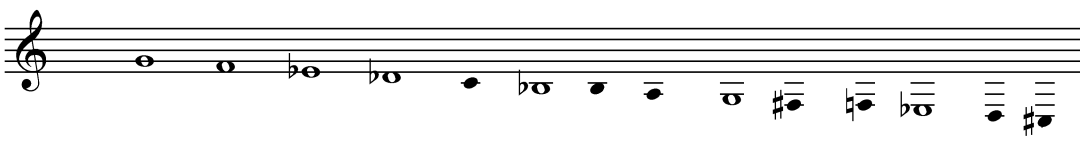


Figure 11 descending E♭ harmonics with added inharmonic notes (TS3)

Here again, durations decrease beginning with the longest period of seven quarters, played by the first English horn starting at [18]. To distinguish the timbre of TS3 from TS2, flutes, clarinets and bassoons now create a new timbre by flutter-tonguing. In addition, Grisey instructs the players to "growl" (*avec la gorge ou 'growl'*) advancing the timbral transformation to its dynamic and spectral climax at [19].

The use of the current scale, with its harmonic and inharmonic partials serving as passing notes, is less rigorous than its predecessor in TS2. Grisey introduces notes as needed in order to allow for a broad frequency range inharmonic texture at [19].

Beginning at [18], the first English horn plays seven notes from the scale, with only the last two being inharmonic (Figure 12). Then beginning with the same starting note (G_4), it plays nine notes in a shorter time span and with more inharmonic partials (Figure 12), helping to obscure the E♭ harmonic spectrum by the time the low F_3 of the scale is reached, at the beginning of [19].

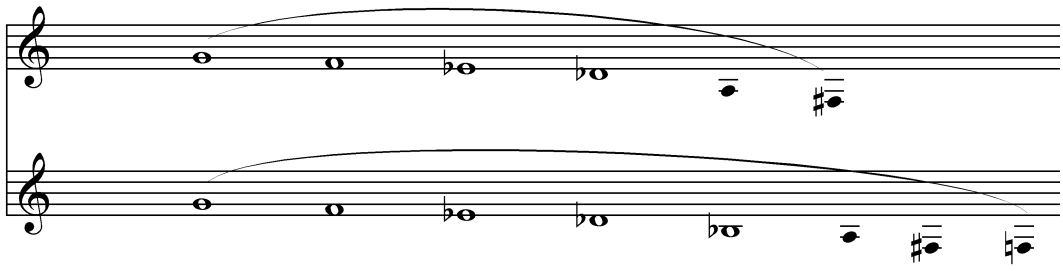


Figure 12 the first two phrases of English horn 1 in TS3 ([18]-[19])

Making use of the boisterous, inharmonic chaos at [19], Grisey initiates yet another detour, ending the structure with a set of harmonic partials from the F spectrum. At the climax ([19]), a repeated $B\flat_3$ extended via various instruments is heard until the middle of the fourth measure after [19] (Figure 13). The B♭, along with $D\flat_4$, is a residue of the E♭ harmonic spectrum. Example 17 illustrates the presence of these two harmonics and their discontinuation at the second half of the fifth measure after [19].

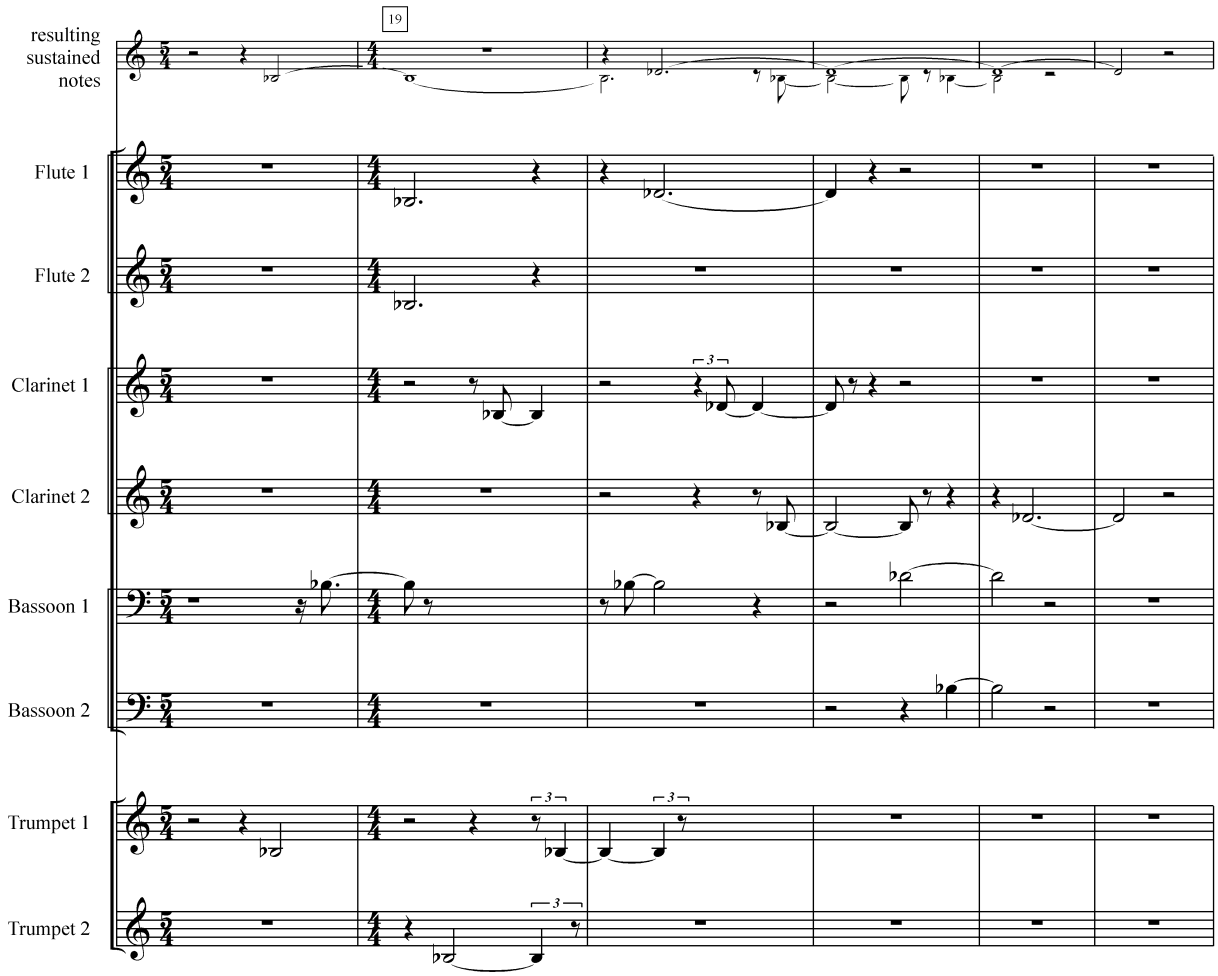


Figure 13 final manifestation of the E♭-based spectra (5th and 7th partials) in TS3 as F spectrum Emerges

Starting at two measures after [19], a new collection based on the natural harmonics of a fundamental F overlaps a harmonic collection based on the fundamental E♭, using the common tones E♭, F and G. $E♭_4$ serves as the "enharmonic" note between the two spectra. As the scale ascends the E♭ takes on a new role as the 7th harmonic of the targeted new spectrum (Figure 14).

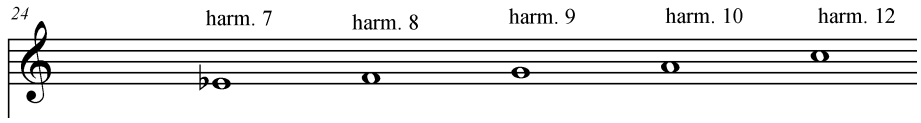


Figure 14 the ascendance of F spectrum in TS3 (starting two measures after [19])

Beginning the third measure after [19] both flutes alternate on notes from the F harmonic series, ending on the 10th harmonic (C_5), at three (fl.1) and two (fl.2) measures before [20]. As the passage ascends melodically, the amplitude decreases. Throughout this portion of TS3 the rhythmic duration increases, imparting a sense of deceleration.

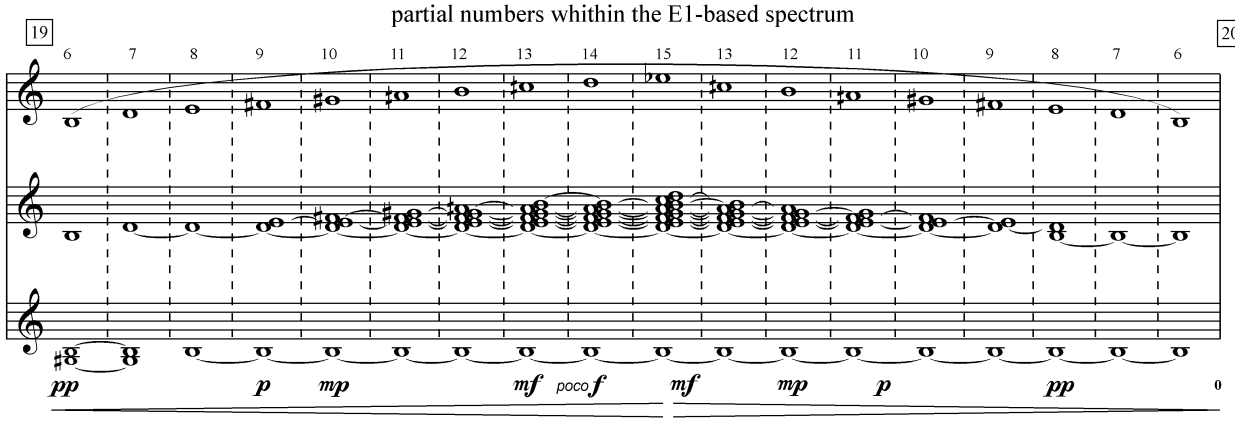
While notes from the previous harmonic series (including some non-harmonic ones) are gradually discontinued, a clear F-based collection emerges towards the fifth measure of [19]. From the second half of that measure, after the final D♭ withdraws, only notes belonging to the F harmonic series are present.

5.4 TEMPORAL STRUCTURE 4 (TS4)

At the heart of the climax of TS3, at [19], lies the seamless beginning of TS4. The loud complex texture with its erratic articulated accents is an effective way to begin a new temporal structure based on an unrelated harmonic series.

The first violin, on B_3, is part of a new, contrasting timbral constellation consisting of chimes and six bowed upper strings (five violins and one viola), playing phrases of various lengths using notes from the harmonic series of the E-based spectrum. All contribute to a larger bell-shape spectral envelope of TS4 (Figure 15a), occurring between [19] and [21]. This spectral envelope is supported by an amplitude envelope with a similar curve (Figure 15b).

(a) TS4 spectral envelope



(b) TS4 amplitude envelope

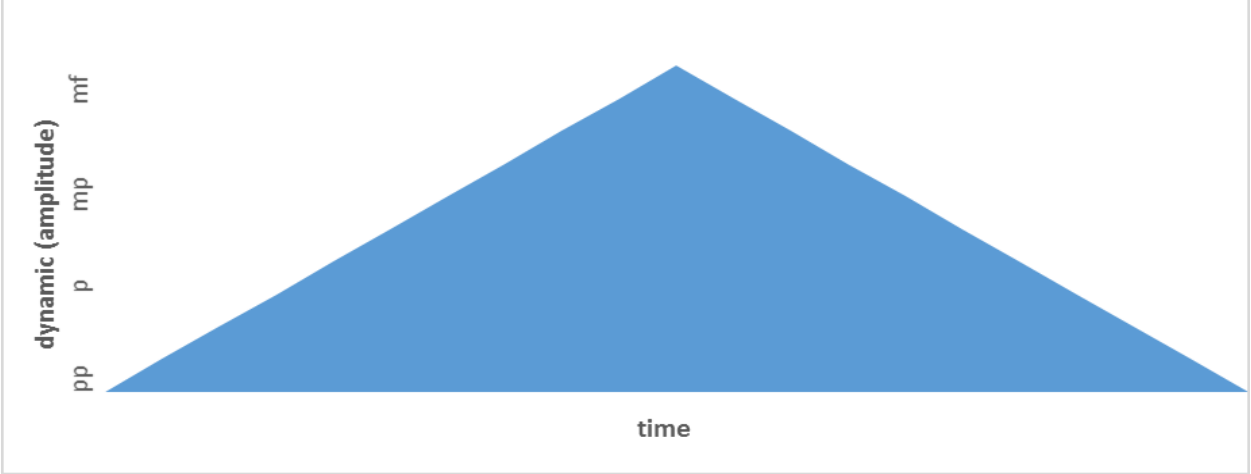


Figure 15 spectral and amplitude envelope of TS4

The strings are added one by one, each earlier than the previous, creating a sense of acceleration. Each entrance contributes to an expansion of the harmonic texture, staring with the 6th harmonic—the initial B_3—to the 15th—the $E\flat_5$ (=$D\#_5$)— played by the chimes on the downbeat of [20] and followed immediately by the first violin.

The movement towards and away from the climax is that of symmetrical advance and withdrawal. The duration of the final B, at one measure before [21], is the same as that of the initial B (approximately three quarter notes). The overall duration of the process from its beginning ([19]) to the climax at [20] is 34 quarters; its withdrawal from [20] to [21] (the end of TS4) occupies 31 quarters. TS5 begins directly at this climax on the downbeat of [20] with the entrance of the celesta playing A_4.

5.5 SPECTRAL DISSONANCES

As the F-based harmonic collection of TS3 surfaces it clashes with the emerging E-based collection of TS4. This mirrors the dissonance alluded to at [18] between the E spectrum at the end of TS1 (represented by the G# of the first trombone) and TS2's E♭ spectrum, which begins with the G of the first English horn as illustrated in Figure 10.

TS4 serves as a timbral patch between TS3 and TS5, allowing for a smooth transition between the two. Its dynamic peak (*poco f espressivo e sostenuto*), at [20], over a spectral climax of a wide frequency range—the 10^{th} through the 15^{th} harmonic partials of its E-based spectrum—masks the shift between the two structures (TS2 and TS4) it overlaps. The constant E-based spectrum maintained throughout TS4 prompts a chromatic juncture between the three neighboring spectra: the F-based spectrum at the end of TS3, the steady E-based spectrum of TS4 and the new E♭-based spectrum of TS5. This chromatic gesture initiates TS5, the final process concluding Part I.

5.6 TEMPORAL STRUCTURE 5 (TS5)

TS5 starts with the pivotal A_4 played on the celesta at [20], the 10th harmonic of the previous F-based collection and the 11th harmonic of the new E♭-based collection. Similar to TS3, TS5's harmonic partials from the E♭-based collection are presented in a descending passage incorporating added passing pitches (Figure 16). Phrases within the various instrumental parts gradually shorten, accelerating towards a climax at [21].

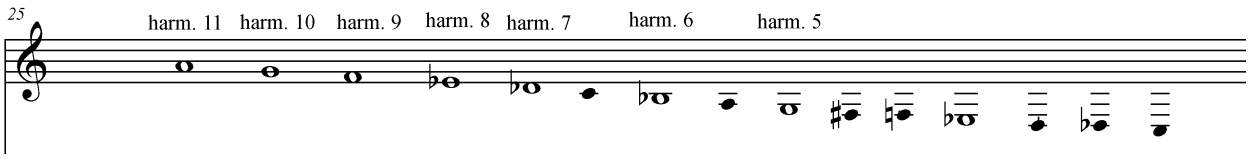


Figure 16 descending scale of harmonic partials based on E♭ with additional passing pitches

If at TS3 the timbre was characterized by sustained wind sounds, here the timbre is percussive. All instruments involved have a short attack and short initial decay. The low strings (consisting of three violas, two cellos and the two basses) are playing pizzicato *laisser vibrer*. Similar instruction is given to both celesta and harp, lending the structure a pointillistic, yet resonant and rich quality.

Similar to TS3, TS5 is also divided in two. Its climax is placed in a lower register as well, functioning as an axis between its two sections. In TS3 the climax was dynamic, serving as an intersection of a dissonant, complex collection with a new F-based harmonic set; here the climax is a true culmination of textural density. From this point forward its encapsulated energy—both dynamic and textural—is resolved, via thinning of its texture over a gradual deceleration.

Starting at [21] dynamics gradually decrease from *fff* to *ppp* ([22]). A complex texture steadily dissolves as the pace of the attacks decreases. In the process, the lowest pitches descend chromatically (Figure 17), supporting an overall harmonic descent ending on a low C_2 in the harp one measure before [22]. A single attack on a low bass drum at [22] marks the end of TS5 and the start of TS6, serving as an elision between Part I and II.

Figure 17 descending chromatic scale in the lower register of the harp's chords in TS5, [21] to [22]

5.7 CONCLUSION OF PART I

As a unit the aforementioned temporal structures (TS2-TS5) invert the process that characterized TS1. These four temporal structures combine to transform the clear brassy timbre at the end of its timbral transformation at [17] to the indefinite single percussion pitch at [22]. This note, with its own inherent inharmonic spectrum, concludes Part I and prepares Part II.

The overarching process taking place throughout these combined four structures begins with a modulation—a pitch shift occurring throughout TS2—between the E-based collection at the end of TS1 to the E♭-based collection at the beginning of TS3. The latter structure progresses towards an inharmonic juncture at its core ([19]) where a new F-based collection gradually emerges. TS5 takes over from TS3 at [20] with its own E♭-based spectrum, moving vigorously towards another dense inharmonic climax ([21]) which is eventually diffused, ending the entire process on a single note at [22].

Throughout this process the E-based harmonic collection of TS4 ([19] to [21]) acts as a mediator between the F-based harmonic collection of TS3 and E♭-based harmonic collection of TS5, resulting in chromatic tension. With its consistent string timbre, TS4 helps to conceal momentary timbral alterations and spectral changes occurring within TS3 and TS5, allowing a larger process of timbral transformation to take place.

Whereas TS1 is perceived as a single, coherent process—a continuum of timbral transformation standing on its own, these four structures (TS2-TS5) only cohere as a group. Though individually each serves a brief transitional role, combined they project a spectral and timbral presence contrasting with that of TS1. The tension created between the two sections of Part I over the course of its structure contributes to its being perceived as a unit—a larger temporal structure.

6.0 PART II: TEMPORAL STRUCTURES 6 AND 7

6.1 TEMPORAL STRUCTURE 6 (TS6): SECTION 1

6.1.1 Empty Spaces

As described earlier, Part II and therefore TS6 start [either with silence or] at [22] with the low bass drum note that also serves as the concluding gesture of Part I. TS6 ends at the end of the second measure after [31] with the receding notes of both vla.1 and vla.2. At that point, TS7 has already begun, three measures earlier. Here again, Grisey introduces a structural polyphony, to be discussed later.

In the beginning measures of TS6 ([22] to [23]), Grisey destabilizes pulse and decimates any precise sense of temporal expectation: the "when" of future events becomes vague. In the slowing-down at the end of Part I, periodicity gradually disappears, and no pulse (i.e. chronometric time) can be sensed at the beginning of Part II, where Grisey places the first significant silence— "empty space"—of *Modulations* (a 4 quarter-note rest prolonged by the first fermata of the piece).

In a 1978 lecture in Darmstadt, Grisey urged composers to "not merely work out the material, but the 'empty space'—the distance—that separates one tone from another."[66] He follows his own advice in various passages in *Modulations*, the first instance being the one under discussion, between [22] to [23]. Here, the first indefinite "empty space" via a long fermata is introduced, contributing to the loss of time—the "disorder" at the bottom of the scale of complexity (see Table 2).

Grisey admits that while working on *Modulations* he was conscious that "the focus of attention is not always the substance but rather an 'emptiness,' a distance that separates one given moment from the next (the degree of change or development),"[67] and that he believes that through working this idea into the score he has "come a bit closer to real time: psychological time with its relative values rather than chronometric time."[68]

A close examination of the pattern of time signatures between [22] to [23] (the beginning of TS6) reveals patterning of chronometric time units defined by the number of quarter-note pulses per measure (Table 4).

Table 4 scale of quarter note pulses and order of time signatures in TS6 ([22]-[23])

(a) scale of quarter-note pulses per measure, from shortest to longest:

2/4	3/4	4/4	5/4	6/4

(b) order of time signatures in the score:

5/4 (x3)	4/4 (x2)	6/4 (x2)	3/4 (x2)	2/4

[66] Die Entstehung, 121.
[67] Les espaces, 9.
[68] Ibid.

Observing the “empty spaces” (i.e. measures of silence) reveals a less precise scale: a range of fermatas from very long to very short (see Table 5)

Table 5 range of fermata durations and they appearance in the score

(a) range of fermata durations, long to short:

very long	long	less [long]	short	very short

(b) fermata durations in [22] and following, as they appear in the score:

long	very long	less	very short	short

Thus, Grisey disrupts the progressive order of each scale. And, in combining these two ‘altered’ scales the “skeleton of time” is disrupted if not destroyed (Table 6).

Table 6 actual order of measure, time-signatures and corresponding hold markings

[+5/4]	5/4 [+5/4]	4/4[+4/4]	6/4[+6/4]	3/4[+3/4]	2/4
Long	very long	less [medium]	very short	short	none

Holds are placed randomly. The longest measure of rest gets the shortest hold, whereas the longest hold is placed on a shorter 5/4 measure. This distribution of holds makes time signatures unintelligible and hinders the perception of pulse. If holds are performed faithfully, the listener should be completely unaware of the notated relationship between the “empty spaces.”

A long measure with a short hold can last chronometrically as long as a short measure with a long hold. Expectations are defeated, even when following the score. The beginning of Part II is thus a perfect complement to the beginning of Part I, the evasive, erratic and disorienting opening of the piece.

Furthermore, the juxtaposition of the first empty space at [22] with the periodicity at the end of TS1 serves to emphasize its structural role: a time without time, a "disorder" (see the scale of complexity, Table 2) where the only expectation is that of awaiting "order."

Grisey's manipulation of the "skeleton of time" here drastically alters the "flesh of time." Commenting on his scale of complexity, Grisey acknowledges that it is not hermetic and that its viability is determined by "the musical context and the perceptual capacities of each person."[69] He recognizes that:

> one of the most arduous tasks for the composer will be to determine up to what point complex structuring affects perception in a non-negative way. On either side of such a point are two poles of boredom due to a lack or saturation of information, but this threshold is not any less dependent upon the complete subjectivity and responsibility of the composer.[70]

6.1.2 From Vibrations to Frequency

While the pairing of reordered time signatures and various fermata durations blurs our sense of time and robs us of the ability to predict when the next musical event will occur, another process is taking place. The metrical/fermata process discussed thus far addresses the horizontal axis of music, the time domain; this one involves the vertical axis, our sense of pitch through the frequency domain.

Following the first empty space, each of the sounding measures contains a periodic rhythmic pattern played by three low percussion instruments. As the process unfolds the number of subdivisions of the beat increases. Through this increase, the resulting periodic rhythms form an ascending scale of pulsation (Table 7).

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[69] Tempus, 245.
[70] Ibid.

Table 7 scale of pulsation used in low percussion trio from [22] to [23], slow to fast

Subdivision of quarter-note beats [♩=60]	frequency in Hz
9:5	1.8
3:1	3
14:3	4.66
7:1	7
8:1	8
9:1	9
13:1	13
16:1	16

Each layer enters and withdraws gradually and symmetrically within the measure, in relation to the other layers, using the scale of pulsation shown in Figure 18. The amplitude envelope of each layer is equally symmetrical; each envelope coincides with the acceleration and deceleration of the compound rhythmic pattern, resulting in a mirroring increase and decrease.

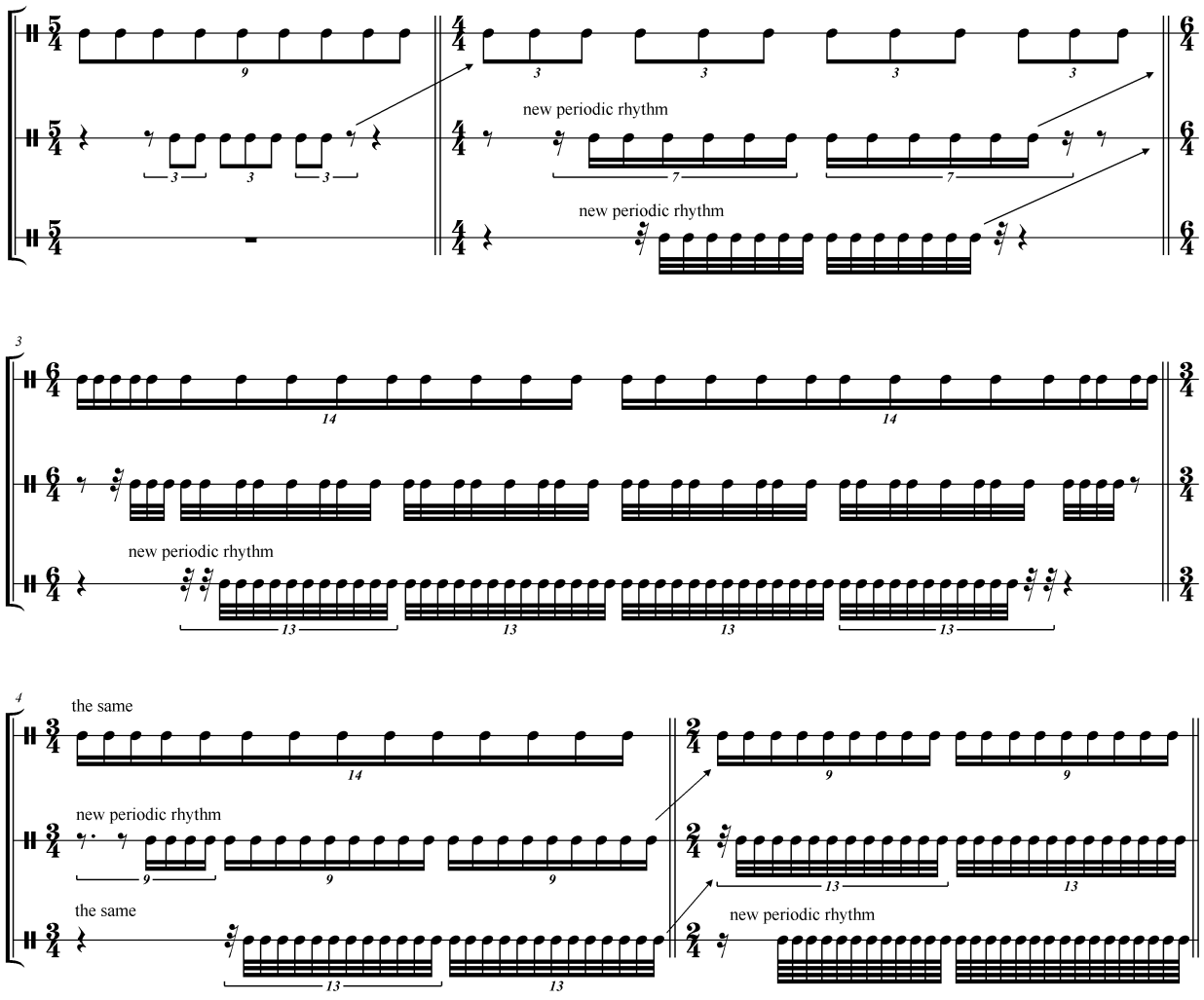


Figure 18 periodic rhythmic layers in the percussion part at TS6, from [22] to [23]

As a result, both the dynamic and the combined three-layer periodic rhythms peak at the center. In between the non-measured "empty spaces," Grisey repeats this process three times building an expectation from one sounding measure to the next, while also gradually increasing the peak dynamic level.

This expectation—or pre-audibility, as Grisey refers to it— is interrupted in the fourth installment (three measures before [23]) where the envelope is cut off at its peak (*mf*) and

dramatically shifts into another empty space. Pre-audibility is disturbed once again as the fifth and last installment occurs, starting one measure before [23]. Here, instead of cutting off the envelope at its peak—the *f* at the downbeat of [23]— and falling into an empty space as in the previous installment, the entire orchestra, led by a sudden entrance of the brass and Hammond organ, plays *ff*.

Following this peak, the unpitched percussion trio concludes with a proportional amplitude decrease supporting the compound rhythmic deceleration as in the first three installments, and is no longer in the fore. From this point forward, the unpitched percussion trio presence is diminished through thinning of the compound three-layer periodic rhythm from three layers to two to one, and is eliminated entirely by [24]. Pitched percussion (vibraphone, crotales and chimes) then take over in supporting various orchestral groups through the rest of TS6.

The overall process involved herein is once again that of gradual transformation, from a single unpitched percussion note at the beginning to a complex orchestral tutti at the end. In his 1956 article "How Time Passes By…"[71], composer Karlheinz Stockhausen, following extensive sound research and experimentation in the Electronic Music Studio of Nordwestdeutscher Rundfunk (NWDR) in Köln, addresses the perception of these two domains:

"…our sense-perception divides acoustically-perceptible phases into two groups…durations and pitches."[72] He goes on to explain that when a length of a phase (i.e. periodic pulse) is gradually shortened, "until about a 1/16" [0.0625 sec.], we can still just hear the impulses separately, [therefore] until then we can talk about *durations.*"[73]

[71] Stockhausen, Karlheinz. "…How time Passes….." *Die Reihe English Edition* 3 (1959): 10-40. Original version 1955.
[72] Ibid., 10.
[73] Ibid.

As the process of acceleration proceeds and pulse doubles its frequency at 1/32" (0.03125 sec.) the impulses are no longer separately perceptible, "one can no longer speak of 'duration' of a phase. The latter process becomes perceptible, rather, in a different way: one perceives the phase-duration as the pitch of the sound."[74]

Roads adds that due to new technologies such as spectrum analysis "Stockhausen's spectral view of rhythm can be measured now by applying the short-time Fourier transform to signals in the range [between] 0.06Hz to 30Hz, in order to obtain frequency analyses of rhythm."[75]

It is thus clear that Grisey, equipped with these "new technologies," is using the scale of pulsation (Table 7) as he layers the three low unpitched percussions into compound rhythmic patterns, in order to embody this fascinating phenomenon in the indicated passage of *Modulations* ([22] to [23]). From measure to measure, the length of a phase is gradually shortened as the three periodic rhythmic layers increase their subdivision. Furthermore, layering periodic rhythms in various speeds should, at least conceptually, produce a much faster vibration which could eventually result in a sensation of pitch.

The passage starts with slow pulsations on three low unpitched percussion instruments. However, though the frequencies of these pulsations allow for "a sensation of a continuous sound—[as] opposed to a fluttering succession of brief microsound,"[76] they still fall below the frequency range of pitch perception.

[74] Ibid.
[75] Microsound, 79.
[76] Ibid., 17.

In the *The Sensation of Musical Tone* Helmholtz concludes that "notes do not begin to have a definite pitch till about 40 vibrations are performed in a second."[77] Examination of the two sounds produced by the contrabass clarinet and the second contrabass in their first appearance (the fourth measure after [22]) show that the fundamental frequency of the first is about 33Hz and the latter close to 39Hz.

Very low pitched instruments (cb.cl. and bass) are added in a range where their notes, according to Helmholtz, do not yet clearly project a perceived pitch but rather a pulsation.[78] They boost the increased pulsation gaining momentum in the percussion trio.

The rest of the pitched instruments are added gradually, expanding the overall register of the texture from low to high. Lower strings are followed by higher strings, finally joined by the entire woodwind section. The orchestral climax at [23] is marked by the brass which at this point takes the lead and articulates the beginning of the main section of this temporal structure.

From [22] to [23] Grisey is engaged in two contradictory processes. One discourages expectation, as already discussed in the previous chapter. The other gradually encourages expectation of increasingly high frequencies as pulse is gradually transformed into frequency.

6.2 TEMPORAL STRUCTURE 6 (TS6): SECTION 2

Following the unpredictable introductory section of TS6 a new continuum arises, constituting the second section of the structure and involving the entire orchestra, and proceeds through thirteen

[77] Hermann von Helmholtz, *On the Sensation of Tone: as a Phycological Basis for the Theory of Music,* (London; New York: Longmans, Green, and Co: 1895), 177.
[78] Even though some partials could be sensed and the fundamental is perceived as a virtual pitch, pulsation dominates the perceived acoustic phenomenon.

segments, from [23] to two measures after [31]. At the start (segments I through V), [23]-three measure after [24]) the overall amplitude envelope of each segment, dominated by the brass, reflects a clear attack and an immediate decay lasting the duration of each segment (Figure 19).

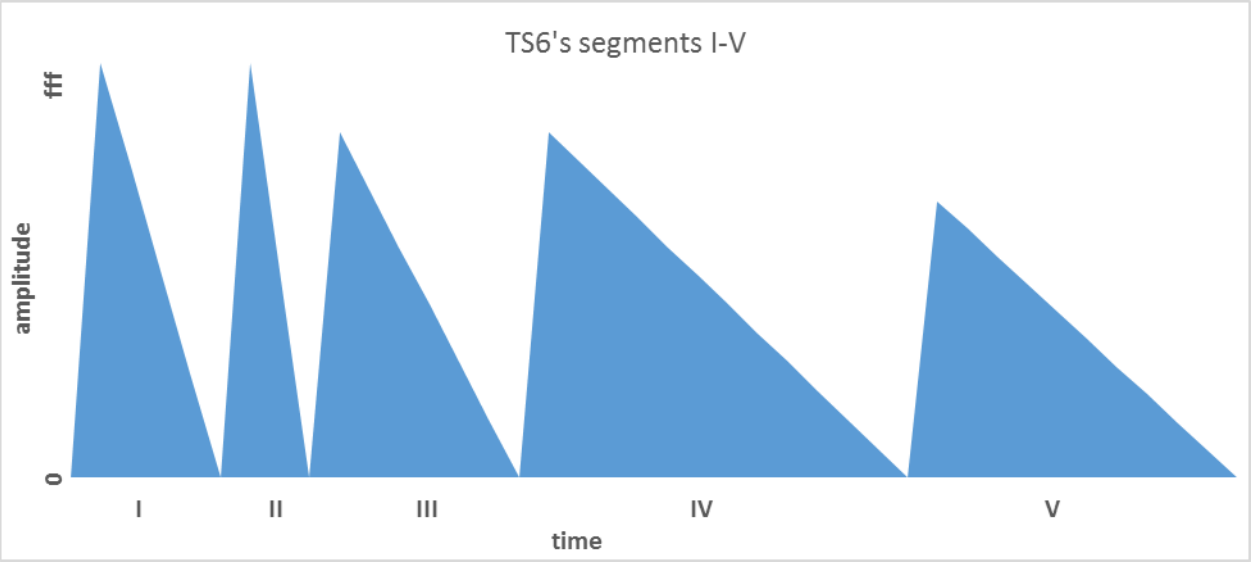


Figure 19 amplitude envelopes of the first five segments in TS6, [23]-three measure after [24]

As TS6 progresses from segment to segment, the dense inharmonic texture of the initial orchestral tutti ([23]) diffuses to various less dense pitch combinations, each played by a unique instrumental group (segment VI-IX). These gradually disperse to a polyphony of single notes played by individual instruments (segments X-XIII), each representing a partial within the resulting spectrum in each segment.

TS6 ends with a harmonic texture consisting of notes from the E-based spectrum (segment XIII). Throughout its process, the full ensemble, each instrumental group and

eventually solo instruments are defined by discrete amplitude envelopes (indicating various levels of temporal structures).

Grisey starts the process with a timbre dominated by brass instruments. As the music progresses, homophonic orchestral texture breaks down to a texture defined by non-synchronized multiple instrumental layers and various amplitude envelopes.

Each segment behaves as a lower scale temporal structure—discrete amplitude envelopes occupy their specific spaces on a time-line. Each of these smaller temporal structures (segments I-XIII) reflects a unique timbre, contributing to the piecemeal process of timbral transformation that defines TS6.

A timbre dominated by actual brass instruments ([23]) playing inharmonic components of a dense texture of inharmonic spectrum, gradually transforms to that of a synthetic brass timbre ([30]) reconstituted through other orchestral instruments, which project sparse texture of an E-based harmonic spectrum.

The length of individual segments, defined by the number of quarter notes in each, originates in a sequence of thirteen odd numbers: 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27.

However, the segments are reordered in the score, as with the introductory section of TS6 ([22]-[23]): 5, 3, 7, 13, 11, 17, 9, 21, 27, 25, 19, 23, 15[79]

Initial analysis suggests that all segments are included in the reordering of the sequence except the 15 quarter note segment. According to Grisey's markings in the score (i.e. score number [31] with its tempo change to ♩=60), the 15 quarter note segment is the final (13^{th}) segment, located between [30] and [31]. Yet the treatment of dynamic patterns established

[79] Since it is obvious that Grisey used the numbers sequence shown above, others have concluded that what is called here segment XIII should end at [31] and last 15 quarters. However, as this analysis shows, the last segment XIII of TS6 is extended 8 measures after [31]. Thus, the duration of segment XIII is in fact 23 quarters.

throughout the work, especially those observed within segments in this second section of TS6 ([23] to [31]), suggests otherwise.

At [31], besides a slower tempo, nothing in the music suggests the ending of a section or the beginning of a new one. In fact, the next temporal structure (TS7) begins two measures before [31], overlapping with the ending of TS6. Residue partial-like components from TS6's 13th and last segment spills over to [31] (Figure 20).

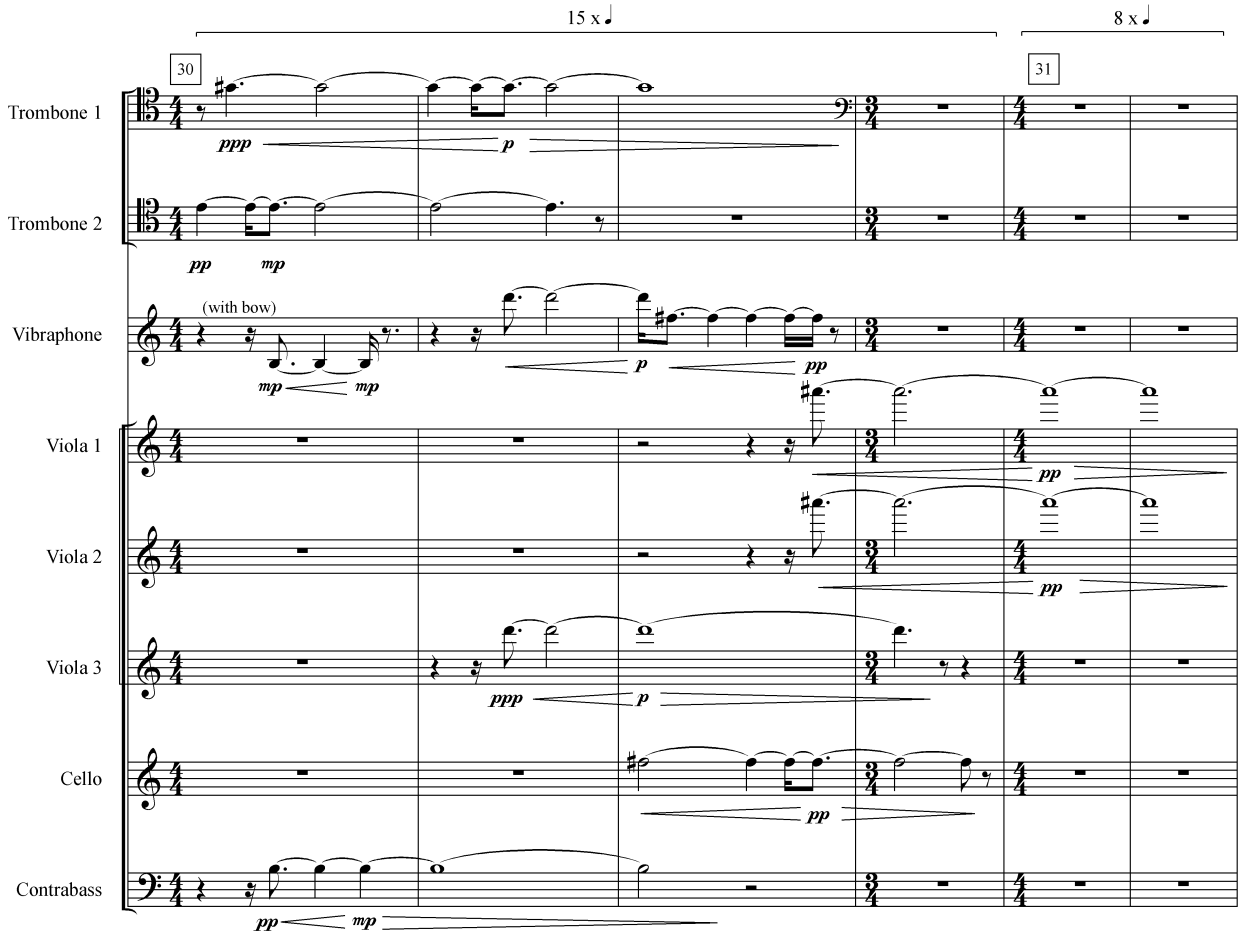


Figure 20 segment XIII and the boundaries of its temporal structure, [30] to two measures after [31]

The last remaining component of the segment, played by violas 1 and 2, ends two measures—8 quarters—into [31]. Thus, the ending of the final segment of TS6, two measures after [31], overlaps with the beginning of the next process (TS7).

The eight overlapping larger structures (TS1-TS8) serve as the higher-level building blocks of *Modulations*. On a lower structural level, temporal structures within them (e.g., each of the thirteen segments of TS6) behave similarly. Various amplitude envelopes of smaller scale partial-like components superpose to create a continuum perceived as timbral change.

The evolution of sound through 13 increments, each defined by its own smaller temporal structure (i.e., the non-synchronized amplitude envelopes of individual partials) project a unique progression of timbres along TS6.

6.2.1 The Hammond Organ in TS6

Since segments are separated by either breath commas or brief pauses, Grisey utilizes the Hammond organ as a bonding timbre, masking halts and allowing for continuity. The organ enters with the orchestra tutti at [23], always doubling the brass pitch content. As TS6 progresses, the organ initial attack in each of its segments progressively delays, anticipating the brass attack and its pitch content in the succeeding segment (Table 8). This delay masks segmental borderlines and allows for continuity between them.

As the percussion trio retreats following its rhythmic climax at [23], the Hammond organ gains momentum. Entering at [23] with a division of 9:5 (identical to that of the bass drum at the beginning of the structure, following the first fermata), its periodic pulse increases gradually from segment to segment reaching a climax at [26]. At [26], the articulation of the pulse shifts

from the keyboard repeated notes to the vibrato mechanism of the organ via the vibrato drawbar (segment IX), indicated by specific vibration rate instructions (Table 8).

Table 8 segments and Hammond organ in TS6

Segment	I	II	III	IX	V	VI	VII	VIII	IX	X	XI	XII	XIII
measure	[23]				[24]		[25]		[26]	[27]	[28]	[29]	[30]
Segment length													
Duration in 𝄜	5	3	7	13	11	17	9	21	27	25	19	23	15+8
Brass dynamic (at IX winds)	fff>	fff>	ff>	ff>	f>	f>pp<p	f>	mf><p>	f><mp>	mp>	mp>	p>	pp<mp>
Hammond Organ													
Pickup in 𝄜	0	0	0.25	0.6	1.2	1.1	1.875	1.125	3	4.5	5	4.75	7.33
Subdivision of 𝄜	9:5	5:3	5:3	11:4	12:5	11:3	13:6	11:2	0	0	13:3	0	3:1
Pulse per 𝄜	1.8	1.6	1.6	2.75	2.4	3.66	2.16	5.5			4.33		3
Vibrato drawbar	none								Very fast	fast	none	medium	
Vibrato pulse as indicated in the score									24:1	11:1		7:1	
Number of “partials”	1	2	3	6	5	6	4	9	13	9	10		
Dynamic	ff>	ff>	f>	f>	mf>	mf>	mf>	mp>	mp>	p>	p>	pp>	ppp>

This extreme shift in timbre (from keyboard attack to vibrato knob) and pulsation rate (from 11:2 to 24:1) constitutes an axis at [26] from which the pulse rate retreats, ending on the rather slow periodic movement of 3:1 at the end of TS6 (Figure 21).

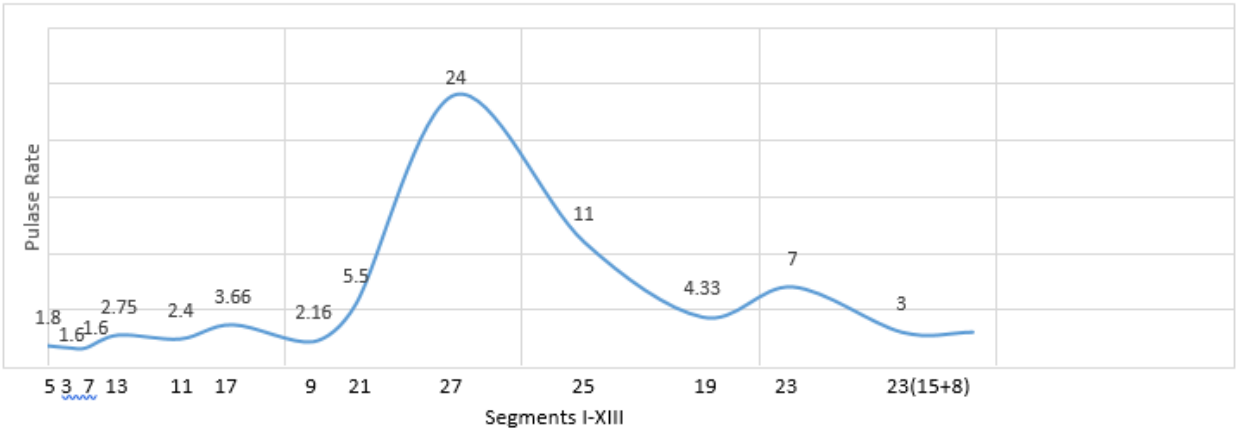


Figure 21 Hammond organ's pulse per quarter over the 13 segment of TS6

Until this point the decreasing amplitude curve in the organ part contradict the increasing curve of its pulsating keyboard attack rate. From [26] forward, both curves—the dynamic as well as the vibrato mechanism rate—exhibit the same decreasing tendency.

Furthermore, the dichotomy in the Hammond organ between vibration and amplitude modulation marks [26], with its abrupt shift of timbre, is a pivotal moment within the process. This moment is further emphasized by timbre variation in the rest of the orchestra. As the organ timbre changes at [26] (with the vibrato drawbar and alteration of various harmonic stops), the brass drops out, momentarily overtaken by the high woodwinds.

At this point the spectrum is harmonic for the first time in TS6 (Figure 22). This F-based harmonic spectrum marks one important stage in the transformation towards Grisey's goal—the original E-based collection, supporting a synthetic brass timbre.

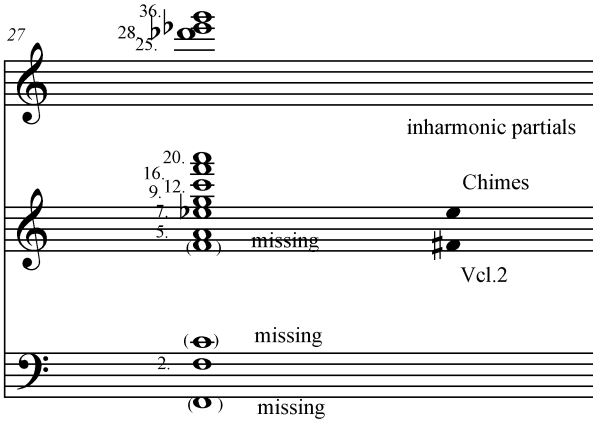


Figure 22 F spectra in segment IX of TS6, [26]

Finally, measuring the progress of TS6 against the scale of complexity (Table 2), one observes that TS6 begins with Grisey's "smooth" stage (represented by "rhythmic silence") and arrives at the "statistical" stage, due to the complete re-division of its musical segments (or "unpredictability of durations"). The next temporal structure of Part II (TS7) moves up yet another stage to "discontinuous-dynamic" which is represented via "acceleration and deceleration by stages and elision" (see Table 2).

6.3 TEMPORAL STRUCTURE 7 (TS7)

6.3.1 The Four Voices

The seventh temporal structure is characterized by the division of the orchestra into four mixed instrumental groups which Grisey labels A, B, C & D. Each group contains an orchestral mix of five instruments: two strings, one woodwind, one brass and one pitched percussion instrument or harp. Following the axis of TS7's process, after [37], at the end of an accelerando, a reverse

process of deceleration emerges. The overall process by which TS7 proceeds could be described as accelerated/decelerated phase shifting. (discussed later in chapters 6.2.3 and 6.24)

TS7 begins as the four groups enter gradually, with a total of 20 instruments taking part. As TS7 evolves towards its climactic axis at [37], the lower line in each group descends. Starting at [36], groups gradually drop their four upper lines, reaching the axis with only the low register instruments, which share a timbral affinity (trb. 2, trb.1, hrn.1, hrn.2).

At [37] after the *ffff* dynamic climax, all groups are represented solely by their fundamental line, and begin reforming towards the middle of the measure. It is at this point that the orchestration of the four upper "partials" is changed systematically. Each of the four groups claims another group's timbre via a symmetrical axis (Table 9) and are now relabeled A', B', C' and D'.

The instrumentation of their four upper voices is altered, in a manner shown in Table 9, still maintaining the mixed combination of strings, woodwinds and percussion. The lower voice in each group, however, maintains its brass timbre unaltered.

Table 9 Instrumentation of Groups A, B, C and D and their parallels A', B', C' and D' in TS7

Group	Instrumentation	Group	instrumentation
A	Violin I Violin II Percussion II (crotales) Flute I, later Flute II **Trumpet I**, later **Trombone II**	A'	Viola II Viola III Harp Bassoon I **Trombone II**
B	Violin III Celeste Violin IV Clarinet I **Trumpet II**, later **Trombone I**	B'	Violin V Viola I Percussion II (vibraphone) English Horn II **Trombone I**
C	Violin V Viola I Percussion III (Glockenspiel) Oboe I, later English horn II **Horn I**, later alternating with **Horn II**	C'	Violin III **Percussion I** (Chimes), later Piano Violin IV Bassoon II **Horn I+II**, then **Horn II**
D	Viola II Viola III Harp Clarinet II **Horn II**, later **Tuba**	D'	Violin I Violin II Percussion III (vibraphone) Clarinet II **Tuba**, then **Horn I**
providing an organ point and harmonic support towards and from the climax between the two sets of groups	Contrabass Clarinet Hammond Organ		

Throughout the structure, Grisey uses each of the four groups as a compound voice, a hyper instrument. Each of the five instruments within each voice occupies its own registral space. The resulting chromatic texture is analogous to an inharmonic artificial spectrum with the lowest instrument serving as its fundamental. Grisey emphasizes this idea by always attaching a higher dynamic to the fundamental in relation to its upper four partials.

Such distribution of lines, their durations and dynamic levels, simulates additive synthesis, and each voice represents a synthetic timbre.

As in the rest of the piece, but more so in this section (TS7), Grisey composes his sounds by layering individual instruments and manipulating their attack and decay, aiming to give each

moment of sound a unique timbre. Each voice has its own dynamic spectral content, creating a counterpoint Grisey calls "spectral polyphony."[80]

6.3.2 Defining the Boundaries of TS7

As mentioned earlier, the beginning of TS7 overlaps with the end of TS6. Each of its four groups (voices) enters in the same manner, proceeding in short phrases which will be referred to as Phases (Figure 23). After two introductory stages (labelled Phase X and Y), Phase 1 introduces all five voices including the fundamental which leads the period of each phase throughout TS7. From here on groups proceeds in their complete form. (Figure 23 outlines the progression of the four groups and their interaction throughout TS7).

[80] Les espaces, 10.

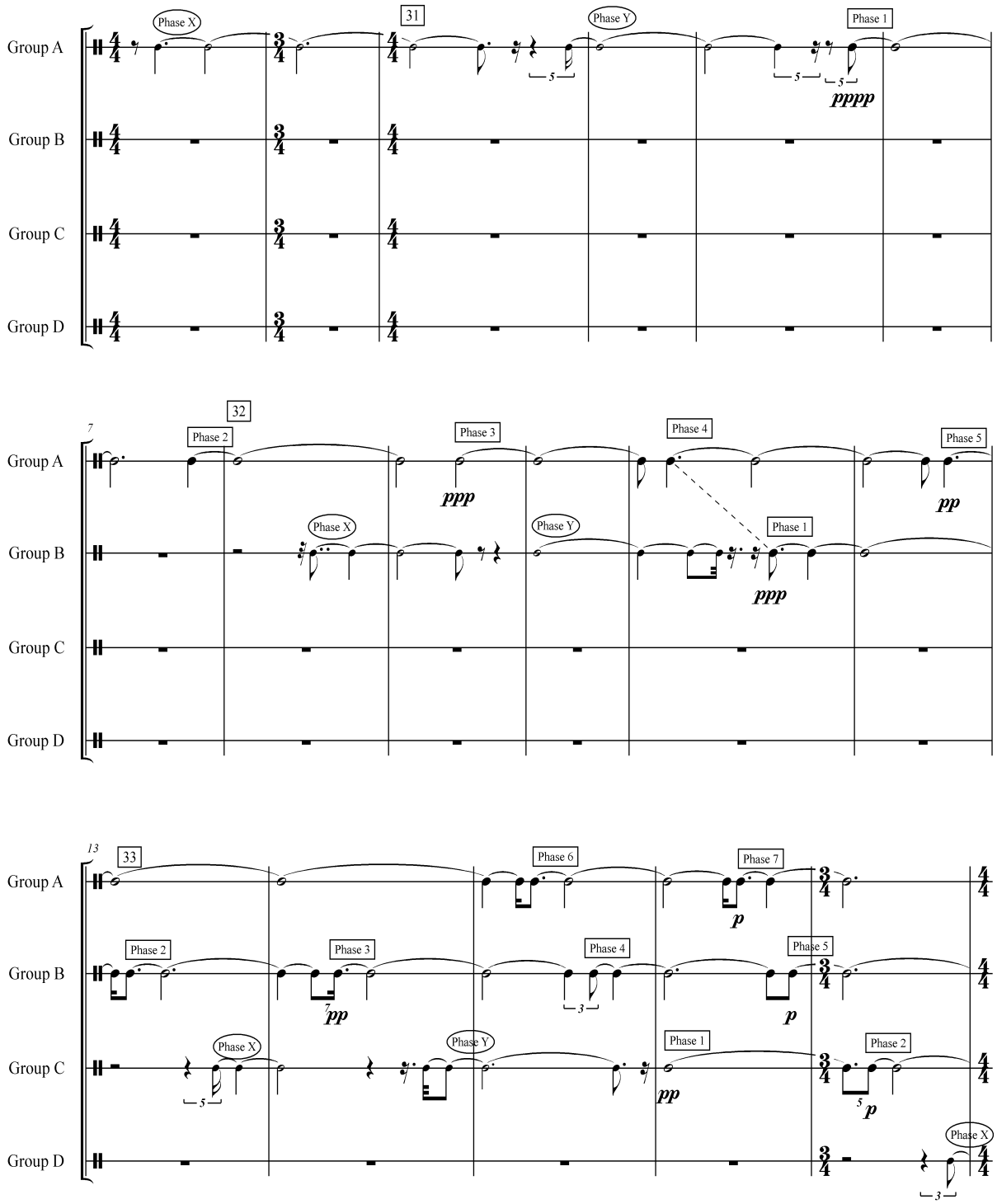


Figure 23 rhythmic reduction of the four groups of TS7

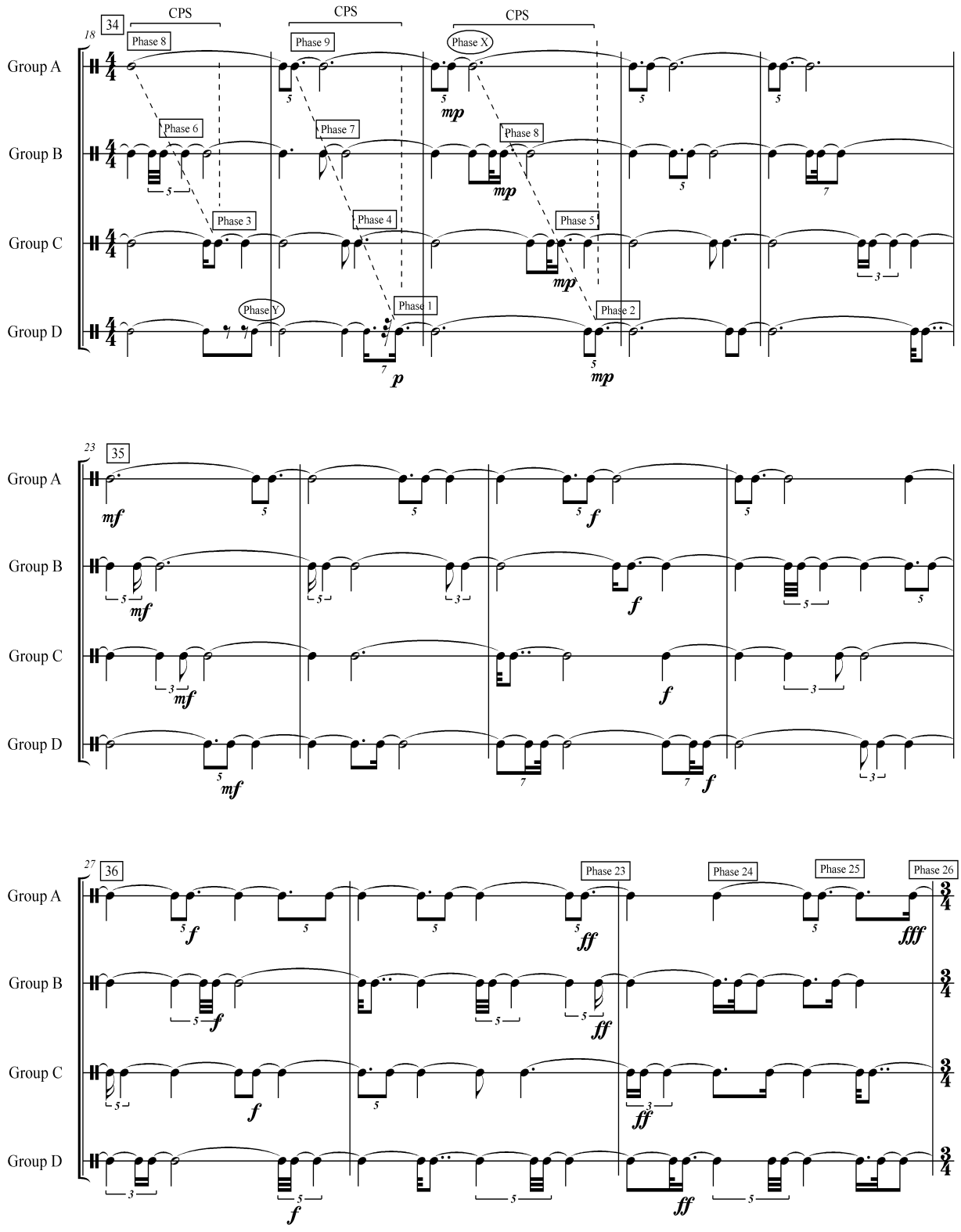
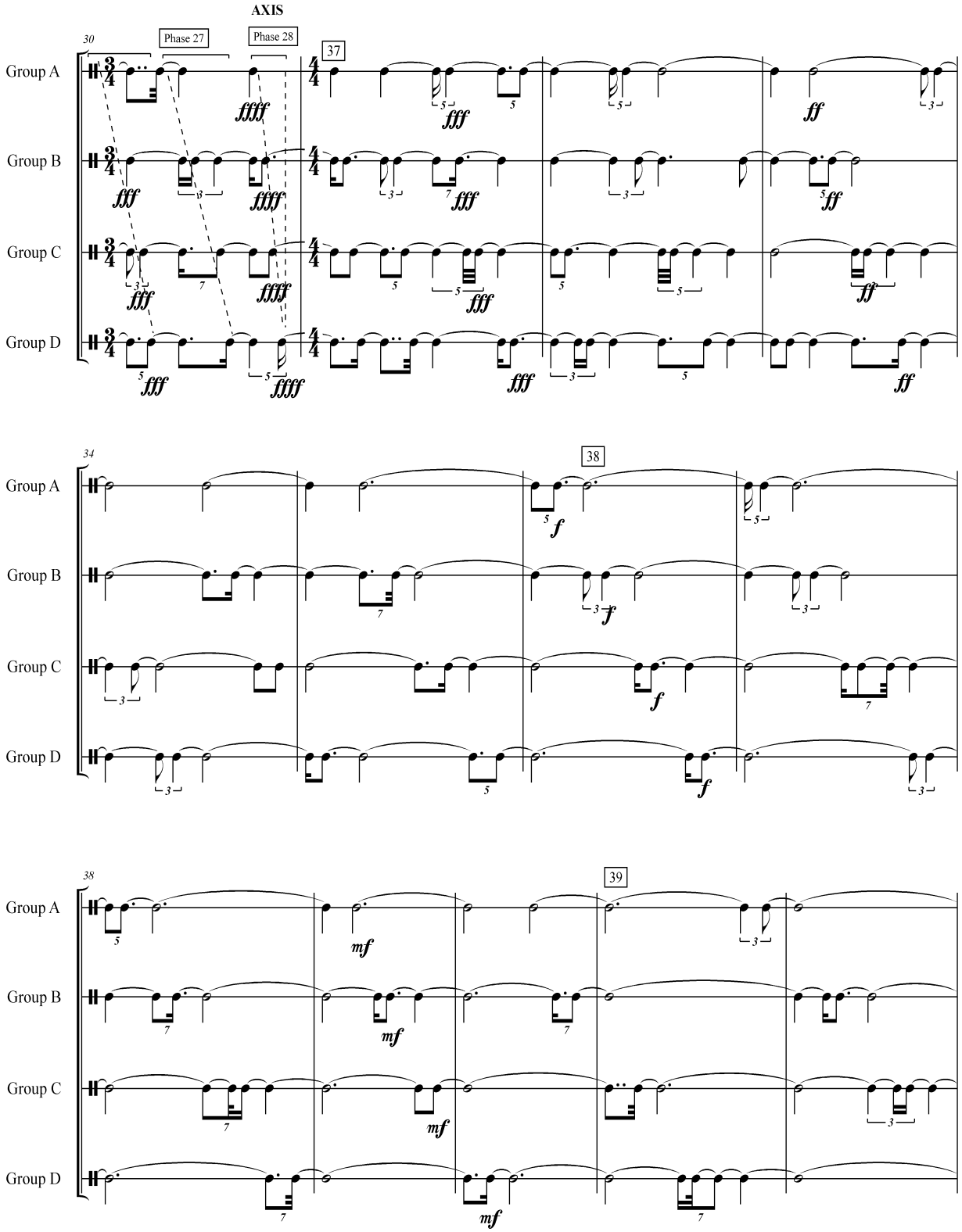


Figure 23 (continued)



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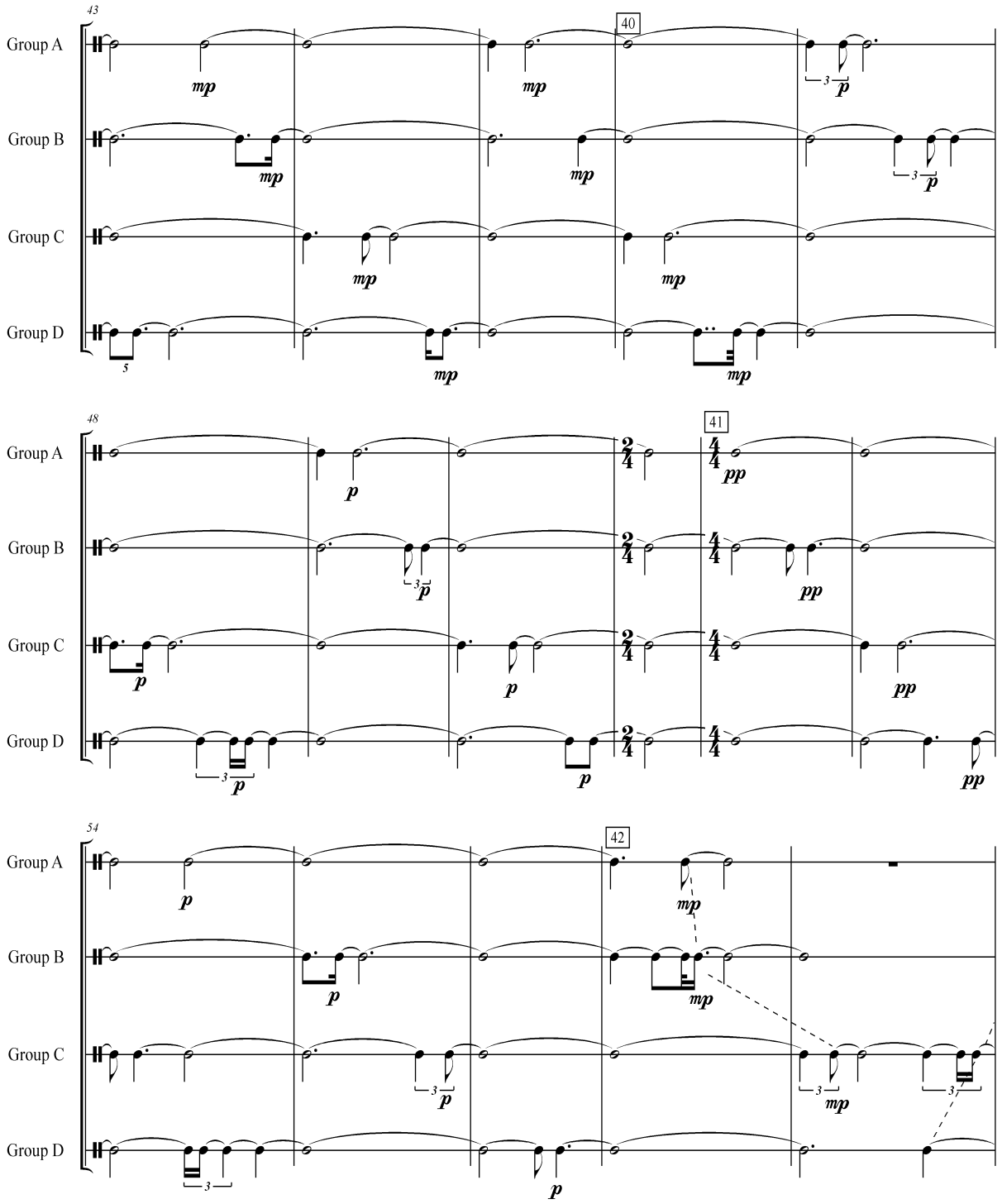

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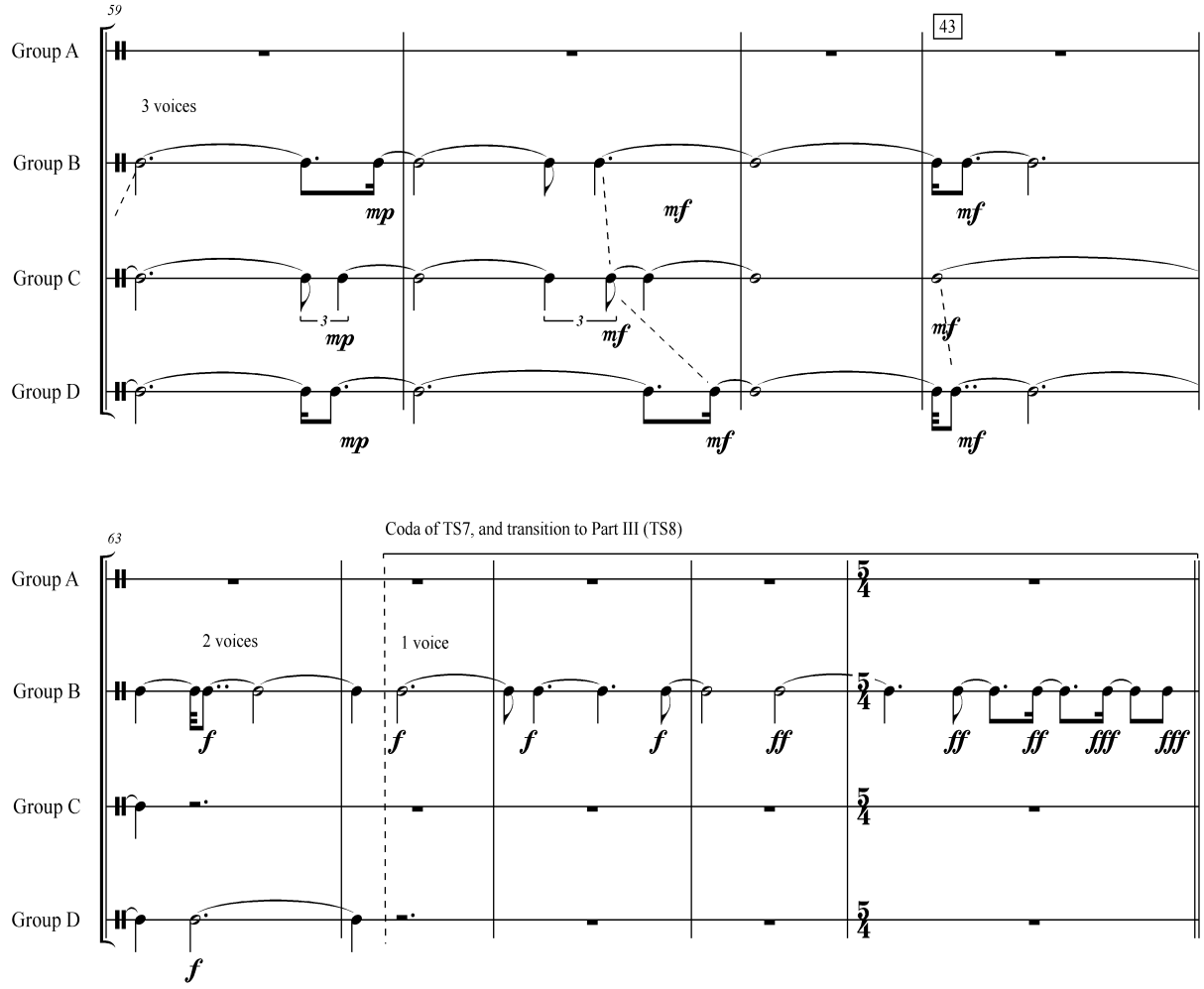

Figures 23 (continued)

The structure begins at the second measure after [30] with Phase X (see Figure 24) which introduces an incomplete Group A and includes the upper three of its five lines. Phase Y, Group A's next appearance starting at the end of [31], is more comprehensive but still incomplete, and includes an additional fourth line (Figure 25).

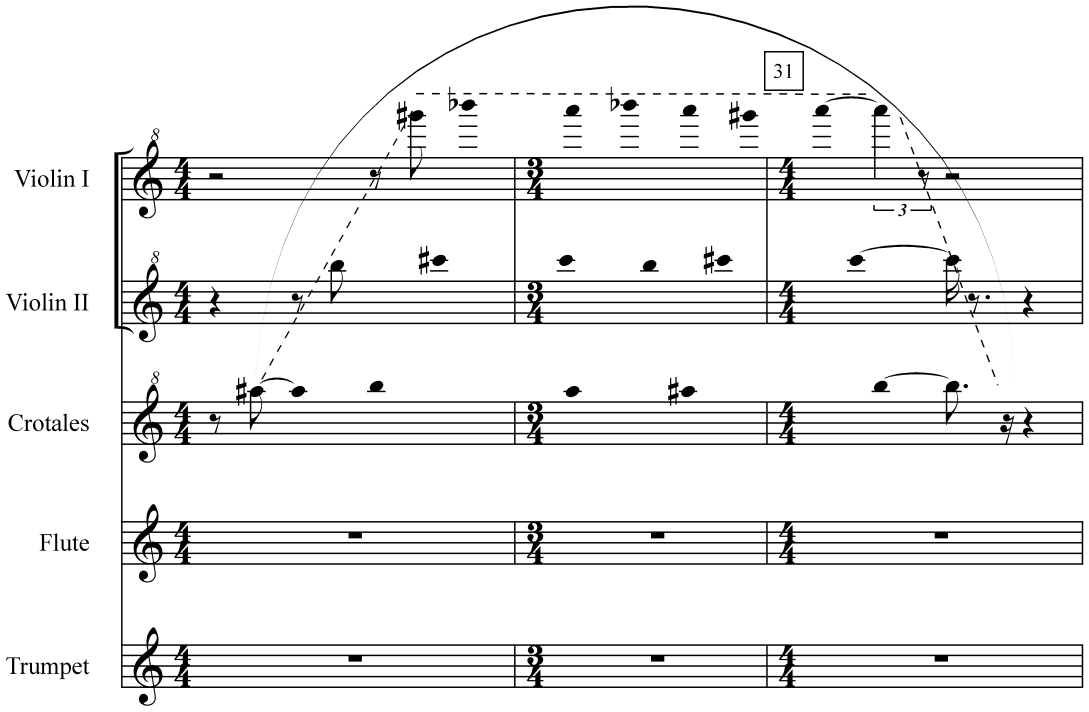

Figure 24 the three lines of Group A in Phase X

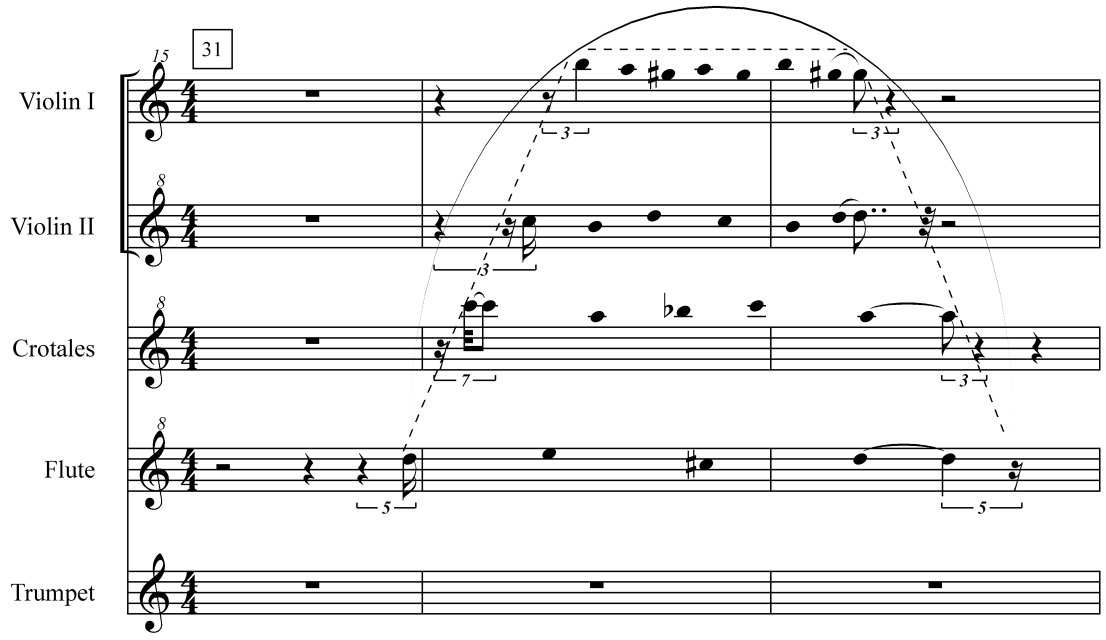

Figure 25 the four lines of Group A in Phase Y

Following the instrumental build up over these two preliminary phases (Phase X and Y), Phase 1 finally offers the complete compound voice of Group A with its five lines (Figure 26), starting with the entrance of tpt.2 (marked “Groupe A”, but still in its original disposition in the score) three measures after [31]. It is then followed by the rest of Group A: fl.1 (at the end of that measure), then crotales, vl.2 and vl.1, which are already placed in their appropriate location within the new layout of the score, (clearly dividing the orchestra into four groups: A, B, C and D). The spectral behavior of the complete compound voice in each of the phases (starting with Phase 1) along the process can be described as a “Gaussian curve” (see Figure 26).

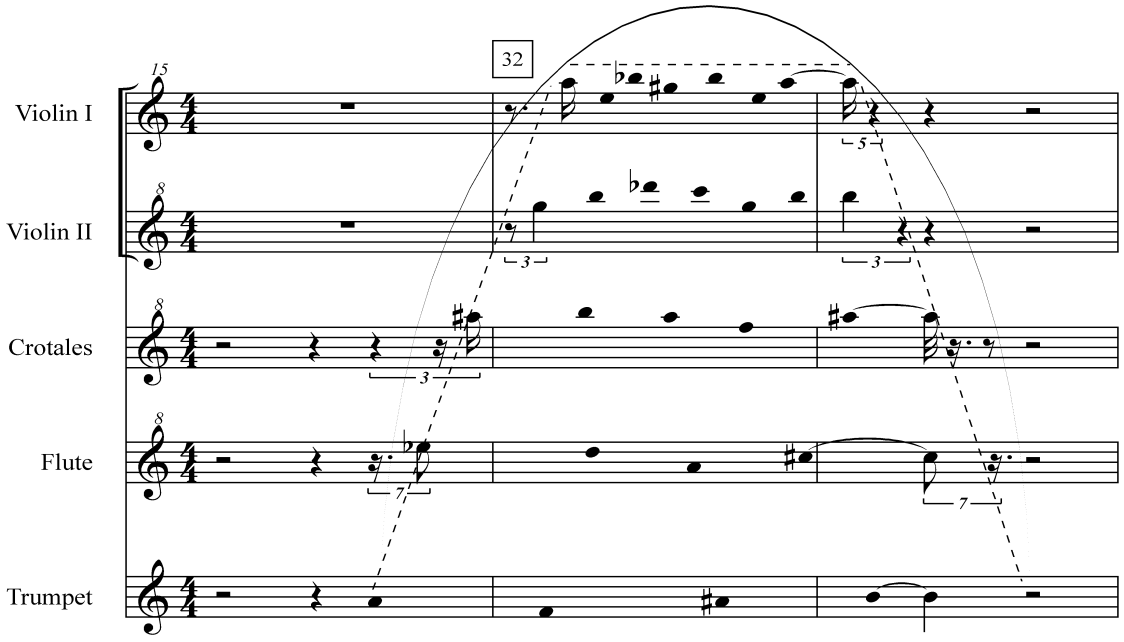

Figure 26 complete compound “voice” (5 lines) of Group A in Phase 1

The rest of the groups (Groups B, C and D) behave in the same manner. Consequently, the borders for TS7 can be defined as starting in the third measure of [30] with the entrance of

the bowed crotales (introducing Phase X of Group A), and ending at the climatic attack of the structure at [44]—the end of Part II.

6.3.3 Grisey's Scale of Proximity

Each of the four compound voices (Groups A, B, C & D) in TS7 progress by using what Grisey calls the "scale of proximity"[81] (see Table 10). The lower line of each voice—the fundamental—defines the boundaries—duration—of each phase. Moving between phases the duration of these lines decrease steadily, creating a sense of acceleration, until the climax—axis—at [37]. From here on an inverse process takes place. Phase durations steadily increase, projecting an overall gradual decelerating tendency until [43].

[81] Tempus, 268.

Table 10 scale of proximity throughout TS7

a) decreasing "scale of proximity," (zooming out) until the last quarter before [37]; phase durations defined by the lower of the 5 lines in Group A.

Phase no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
Decreased by:		0.6	0.5 →			0.25 →			0.35	0.2 →																0.075	0	0.125
Duration (sec.)	**7.6**	**7**	**6.5**	**6**	**5.5**	**5.25**	**5**	**4.75**	**4.4**	**4.2**	**4**	**3.8**	**3.6**	**3.4**	**3.2**	**3**	**2.8**	**2.6**	**2.4**	**2.2**	**2**	**1.8**	**1.6**	**1.4**	**1.2**	**1.125**	**1.125**	**1**
dynamic	*pppp*		*ppp*		*pp*			*p*			*mp*			*mf*			*f*						*ff*			*fff*		*ffff*

b) increasing "scale of proximity," (zooming in) from [37] – phase durations defined by the lower line of the 5 line in Group A.

Phase no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**		
Increased by:		0.2 →					0.33 →			0.4 →					0.66 →						1	1.5 →					
Duration (sec.)	**1**	**1.2**	**1.4**	**1.6**	**1.8**	**2**	**2.33**	**2.66**	**3**	**3.4**	**3.8**	**4.2**	**4.6**	**5**	**5.66**	**6.33**	**7**	**7.66**	**8.33**	**9**	**10**	**11.5**	**13**	**14.5**	**16**		
dynamic	*ffff*		*fff*				*ff*			*f*				*mf*			*mp*		*p*		*pp*	*p*	*mp*	*mf*	*f <*	*ffff*	

c) "scale of proximity" in the four groups at the climax of TS7 ([37])

	C1	C2	C3	x
dynamic	*ffff*			*fff*
A	1	1	1.2	1.4
B	1	1.41	1.23	1.83
C	1	1.2	1.3	1.5
D	1.05	1.125	1.375	1.58

d) "scale of proximity" at the coda of TS7

Pulse no.	0	1	2	3	4	5	6	7	8	9	10
durations	4	3.5	3	2.5	2	1.5	1.25	1	0.75	0.5	0.25
dynamic	*f*	*f*	*f+*		*ff*			*fff*			*ffff*

The result of this acceleration/deceleration is a relatively slow transformation, allowing for a better perception of the process taking place throughout TS7. Movement towards the pivotal axis point then retreating from it, is clearly perceived. "This play of the zoom lens back and forth," Grisey reveals, "can in turn become structural and generate a new dynamic of sound forces relative to the spatial density of sounds and their duration."[82]

Grisey's "scale of proximity" has its origin in Stockhausen's "subharmonic series of proportions" (see Figure 27). In "how time passes by…" Stockhausen argues that "durations are distinguished by the relationships, not by the differences, of phases."[83]

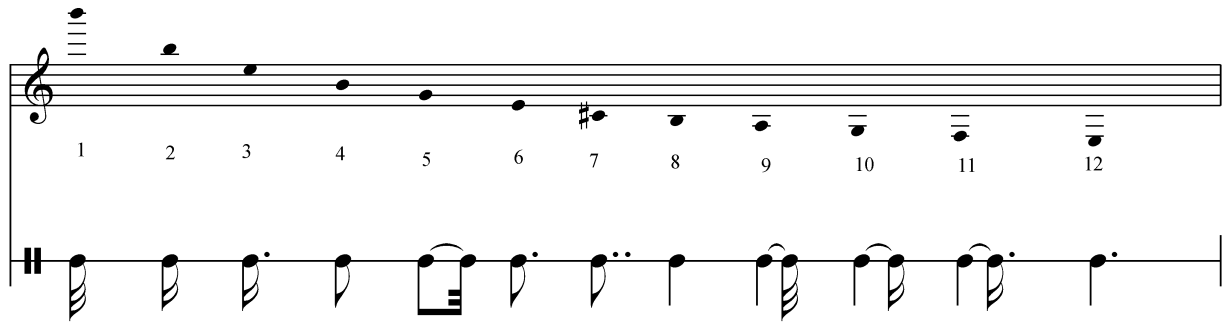

Figure 27 Stockhausen's subharmonic series of proportions (phase durations)

While accelerating towards the climactic axis at the last beat before [37], each phase becomes texturally denser and harmonically more chromatic (increasingly dissonant). Larger number of notes in each of the five lines of the compound voice gradually occupy smaller time units (see Figure 28). That increase in spatial density (together with a steady crescendo) creates a sense of urgency, leading to a climactic axis—a turning point.

[82] Ibid.
[83] How Time passes, 12-13.

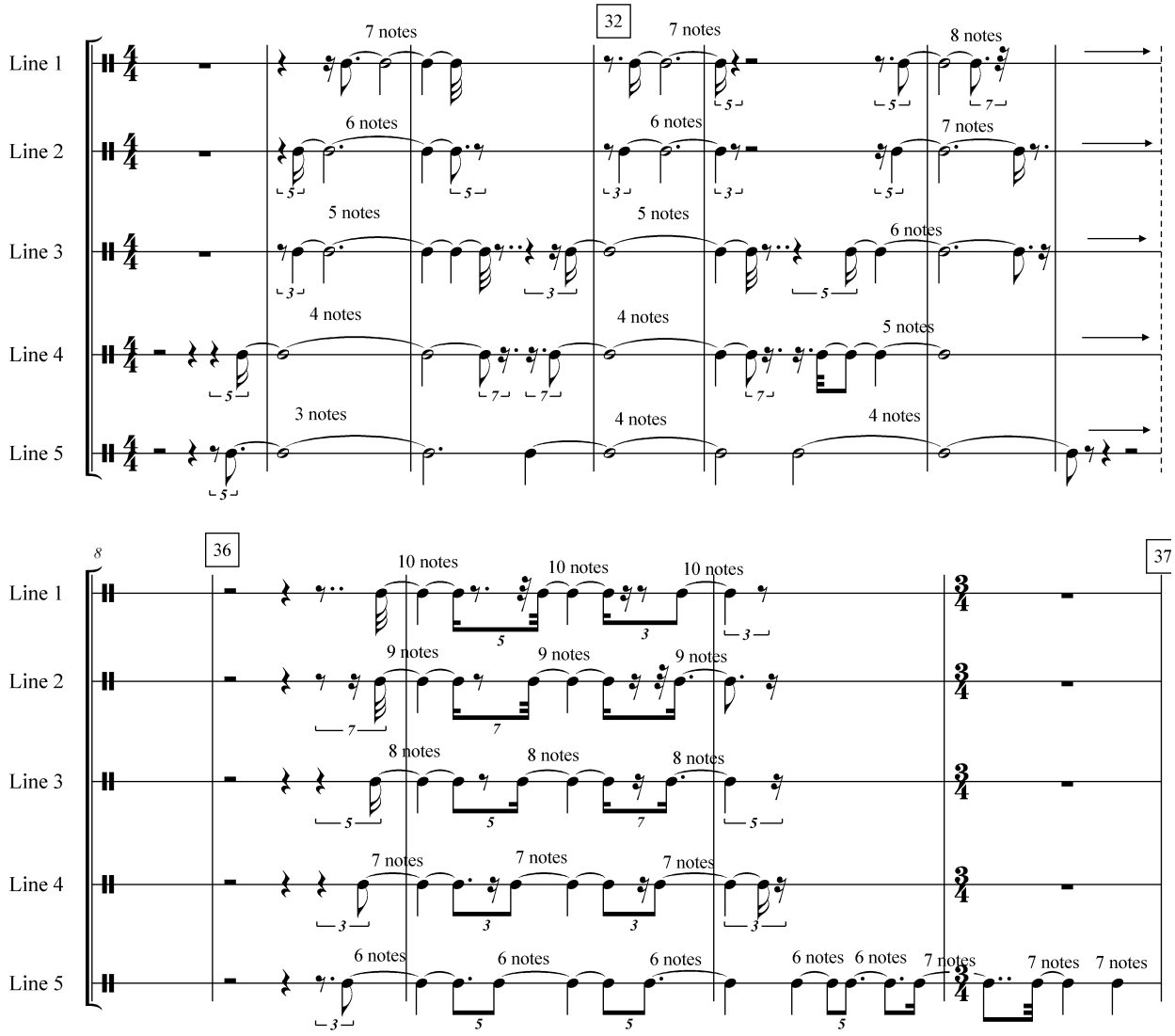

Figure 28 gradual spatial density towards the "axis" at [37] in Group A of TS7

From this point, the process is reversed. A descending "scale of proximity" is partnered with a sparser harmonic texture. Following the axis, as groups are reforming at the middle of [37] (reaching their full dynamic in the following measure,) each of the five lines constituting the compound voice in each of the four groups plays seven notes.

However, since lines vary in durations, occupying shorter times from the bottom up, the texture is still somewhat dense, as if picking up from where it left (one measure before [37]), right before the four fundamental lines (of Groups A, B, C and D) were left on their own.

More significantly, each of the seven notes of the lower—fundamental—line now receives one inharmonic partial-like component on each of the lines. Here Grisey emulates the varying spectra on a smaller scale. Partials along these artificial spectra have their own attack and decay time.

Moving forward with seven notes in each group along an increasing scale of proximity allows Grisey to slowly shift from a structural polyphony to the orchestral homophony at the coda of TS7 (four measures before [44]), aiming towards the climatic gesture at [44].

The temporal placement of "partials" in each of the compound voices gradually align. As a result, the textural density in each of the voices is steadily reduced, until finally arriving to a homophonic texture, starting at the end of [39].

The polyphonic treatment of the four individual voices becomes clearer as the "compound phase shift" (CPS) between the voices, which will be discussed later (chapter 6.2.4), is decreasing. This decrease ultimately eliminates phase discrepancies between voices as a clear homophonic texture is attained.

At the beginning of the coda of TS7, the second beat of the last four measures before [44], all voices are in rhythmic unison. At this final segment of Part II, Grisey once again applies the "scale of proximity" together with a directional dynamic scale to approach a climactic final gesture (see the end of Figure 23). This gesture, a loud short attack on the downbeat of [44], also serves as a border between two temporal structures and, more importantly, between Part II and Part III.

Significant to this relatively larger structure (TS7) is the relationship between its frequency evolution and the applied dynamic scale (i.e. amplitude curve). While the melody falls and rises in an inverse bell curve, the dynamics curve forms a bell shape (Figure 29).

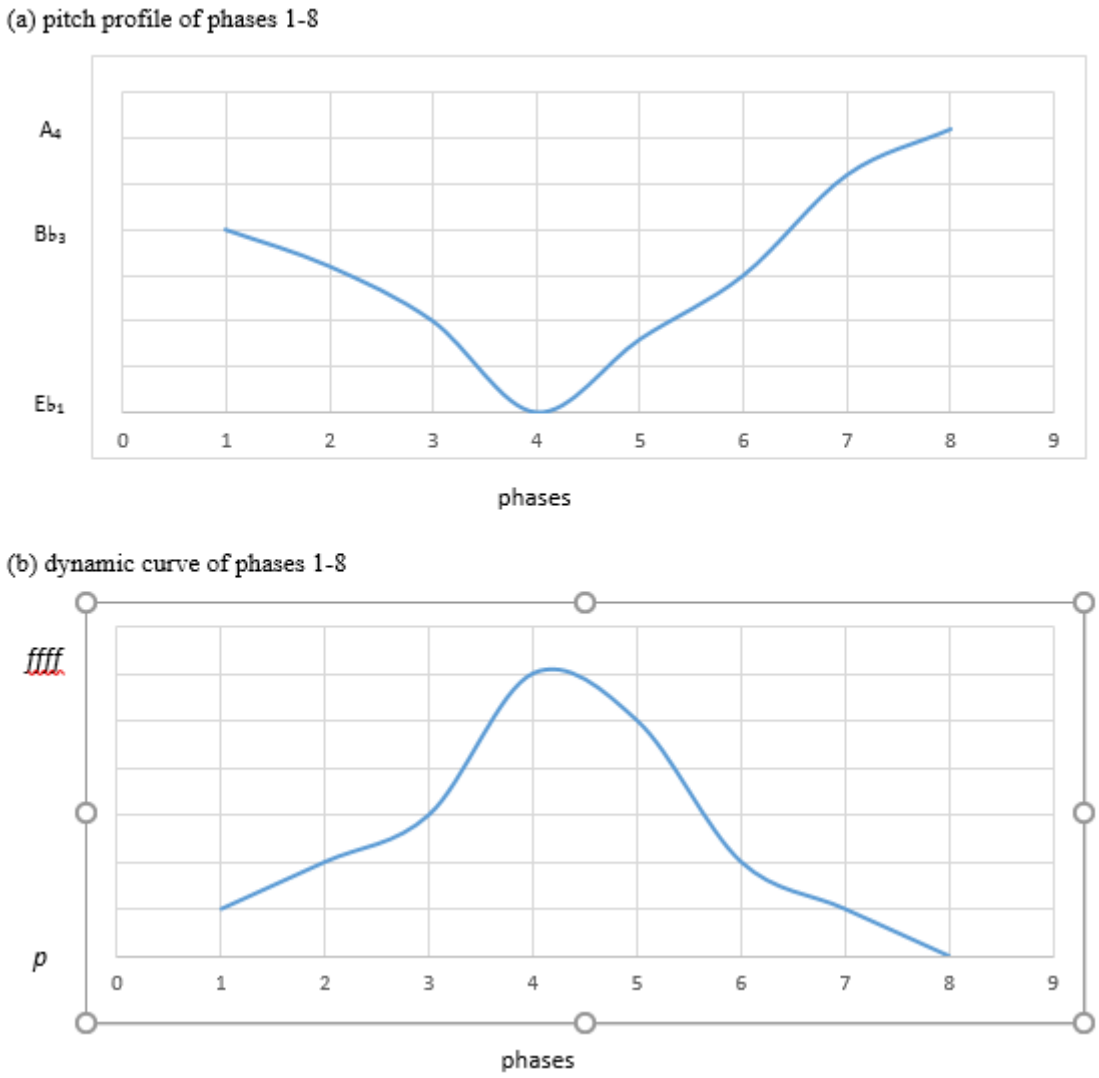

Figure 29 first eight phases of Group D

The dynamic climax of the structure occurs in its lowest frequency range, producing a wider acoustic spectrum. The actual played pitches combined with their projected spectra result

in a highly dense inharmonic texture, contributing to the sense of arrival at a moment of maximal tension.

Upon the immediate and foreshadowed retraction, the perception of the entire structure (TS7) is within reach. Grisey's use of the scale of proximity allows for "average predictability" (following Grisey's complexity scale in Table 2) towards and from an axis. The "skeleton of time," (time performed) being slow and steady, is potentially closer to synchronizing with the "flesh of time" (time perceived).

6.3.4 Compound Phase Shift at TS7: The Relationship Between the Voices

In the course of TS7, as the four groups advance individually, each makes an unsynchronized entrance in relation to the preceding group. For the purpose of this analysis, the phases of Group A are taken as reference: their placement on the "scale of proximity" serves as a marker for the phase progression of each of the other three groups. The overlap of the four groups/voices results in a combined phase delay, or compound phase shift (CPS) (Figure 23).

Amplitude is steady during each CPS, and the dynamic level of the four groups is similar. Maintained throughout TS7, this relationship between the four groups allows Grisey to focus attention on the temporal procedure and its structural role.

Since each new group enters with a phase shift in relation to the preceding voice and at the dynamic level already established by that group, the first two complete phases of Group A (Phases 1 and 2) establish the temporal character of the structure, and initiate a tendency toward acceleration, or decreasing "scale of proximity," over the first section of the structure until [37]. The dynamic of these initial two phases is *pppp*.

The dynamic level of Group A's third phase (second measure of [32], Figure 23) is *ppp*, one gradation higher on the dynamic scale, beginning the process of an incremental crescendo towards the *ffff* climactic axis (one quarter-note before [37]).

As Group A progresses to its fourth phase (fourth measure of [32]), the dynamic level of *ppp* is maintained. Group B joins in with a delayed phase shift of 1.75s, at the same dynamic. These two compound voices establish two more phase shifts at the increased dynamic (*pp*) before Group C joins at the beginning of the fourth measure after [33].

The entrance of Group C follows the fourth phase of Group B and the fifth phase of Group A (see Figure 23). The layering of these three groups initiates the first compound phase shift (CPS), lasting 2.75s, starting with Group A's Phase 6 at the middle of the third measure after [33], followed by Group B's Phase 4, and ending with the entrance of Group C's Phase 1.

Group D enters at the end of [34] immediately following the third phase of Group C, the sixth of Group B and the ninth phase of Group A at the beginning of [34]. This establishes the first "compound phase shift" between the four voices lasting 3.5s. From here on, the relationship between the four groups is maintained, until the end of the structure. The "compound phase shift" whether condensed or expanded, following the tendency of Grisey's scale of proximity, always occurs in the same order (A—B—C—D).

Several observations can be made. As a result of utilizing the "scale of proximity" in all the voices, the general tendency of the CPS is toward compression until the axis, and expansion from that point on until the coda of the structure, four measures before [44]. At this point phase shifting is eliminated as all voices combine in rhythmic unison.

At the climax—defined by the highest amplitude level of the entire structure—the CPS is reduced to its most condensed state, spanning less than a quarter, or 1s; the shortest thus far. In

addition, the granular density resulting from the combined pitches of the groups' climactic phases (Figure 30) is at its peak. The four low instruments, each represents the fundamental of their respective group: trb.2 (A), trb.1 (B), hrn.1 then hrn. 2 (C), and tuba (D).

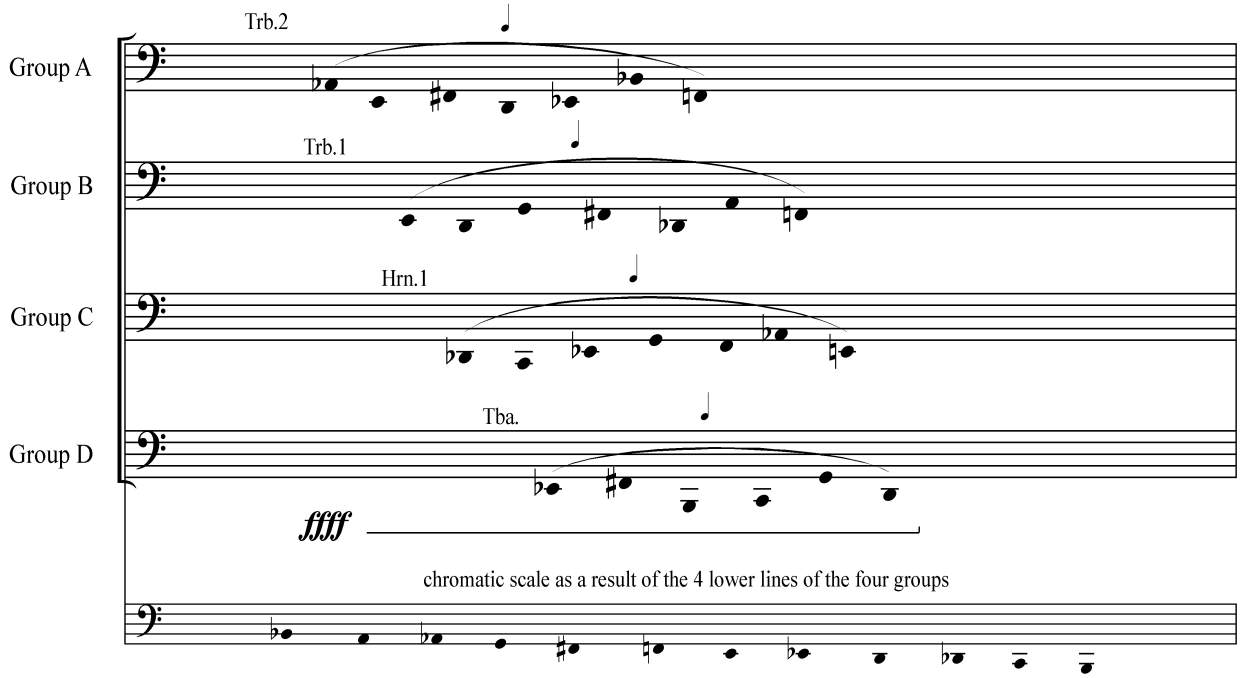

Figure 30 spatial density and chromatic texture at the climax ([37]) of TS7

At the climax of TS7 the lowest line of each group plays seven notes per second (except the tuba, which plays six notes,) representing the richest note density in the groups' fundamental lines throughout the entire structure. That density is even greater, considering that groups, represented here by their "fundamental" lines, are never synchronized, resulting in durations between notes which push the limit of their perception as separate events.

Thus, as "they are organized into [larger] events," Grisey is able to "vary the parameters *en masse*" from phase to phase, creating "uniform textures or mix[ing] grains with different parameters to create clouds of evolving sound spectra."[84]

By [37] the zoom lens extend so far back that it is difficult to perceive the core of the sound. What is perceived is a larger gesture which takes preceding events into account. One second after the downbeat of [37] (the second quarter note of the measure) an inverse process of expansion begins through an increasing "scale of proximity" in each of the four groups. The process, which causes a deceleration, affects the compound phase shifts. (see Figure 23 after [37]). The perception of the complete structure is enhanced since following the axis, expectation of a climax is met. This is emphasized by inversing the tendency of TS7 temporal evolution as well as its dynamic curve.

Arriving at the axis (one quarter note, a second, before [37]) the CPS nearly disappears (see Figure 23). The four instruments with similar timbral features span the chromatic range of an entire octave, almost simultaneously (Figure 30). Combined with the chromatic cluster played by the Hammond organ, a climax is reached and the groups are perceived as one. From here on the process is run in reverse.

The turning point between the decreasing (acceleration) and increasing (deceleration) on the scale of proximity is found with Group A at [37]. The CPS gradually expands following the interaction between the voices. As a result, the climax is spread out over the combined three short phases in each group, altogether lasting about four seconds. (see Figure 23, starting one quarter before [37])

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[84] Curtis Roads, "Introduction to Granular Synthesis," *Computer Music Journal*, 12, No. 2 (Summer, 1988): 12.

Considering the musical context this climax stands out not just as a turning point, but as a subsection on its own (see both Figure 23 at [37], and Table 10c). After the climax concludes, the compound voices are reforming. During this process the CPS gradually expands, along with an incremental dynamic decrease to *pp* at [41], starting with Group A.

As mentioned before, starting at [38] the five lines within each group gradually align, allowing for the homophonic texture of individual groups to emerge. By the end of [39] the five lines of Group A, are completely aligned as the group proceeds in rhythmic unison, followed by similar texture by rest of the groups.

The CPS between the four groups is easily perceived one measure after [40] at the dynamic level of *p*, where the texture within each of the groups is homophonic. The CPS becomes increasingly clearer as the overall texture (of the four groups combined) approaches homophony.

At [41] the decreasing dynamics hit their lowest level of the section. From this point forward there is a dynamic increase, from pp to a climactic *ffff*, at the downbeat of [44]. This marks the end of TS7 and the beginning of TS8.

In an effort to end the process by a complete elimination of the CPS, allowing the four groups to act as one, the CPS of 5.5s (starting in the middle of [42]) is not evenly distributed between the four groups as before. At [42], upon reaching a dynamic of *mp*, there is a short delay of 0.125s between Groups A and B, followed by a longer delay of 3.035s between groups B and C, and finally a delay of 2.33s between groups C and D (see Figure 23 at [42]).

The significance of this distribution is the aim of Grisey to gradually merge Groups A and B, leaving a total of three compound voices in play in the next stage of the process. And indeed, by the middle of two measures before [43] the orchestra is playing three distinct

rhythmical patterns (representing three groups) at a dynamic level of *mf*. At this point, again, the two upper voices are nearly aligned (Figure 23).

By [43], the *mf* CPS between the three voices currently at play is so compressed that the delay between groups is almost indistinguishable. And by the second beat of the second measure after [43], only two voices remain. In the coda of TS7, beginning at the second beat of the following measure, the CPS is finally eliminated and the four groups are synchronized as the entire orchestra plays in rhythmic unison.

Grisey again uses a scale, this time a decreasing rhythmic scale, emulating Stockhausen's subharmonic scale, shown in Figure 27. Here the direction is inversed, shortening the first four durations by 1/8 notes and the rest by 1/16 notes. The resulting duration sequence (in seconds), starting with the second beat of the third measure after [43] and ending on the downbeat of [44], is as follows: 3.5, 3, 2.5, 2, 1.5, 1.25, 1, 0.75, 0.5, 0.25.

The coda serves both as a culmination of the entire TS7 as well as an effective and swift transition from Part II to Part III (see the last four measures of Figure 23).

7.0 PART III

7.1 TEMPORAL STRUCTURE 8 (TS8)

The first sixteenth note of [44], an accented *ffff* tutti, acts as both the conclusion to Part II and as the opening stroke of Part III. It is analogous to the short and quiet bass drum downbeat (*ppp*) of [23]. Both downbeats serve as junctures between two parts.

At [23], a rhythmic deceleration and a gradual attrition of textural density ends the single bass drum note. Conversely, at [44] an acceleration by the full ensemble ends in a strong, sharp attack. Immediately after, the dense dissonant texture. This attack at [44], the loudest so far (strings are marked *sffff*), denotes the culmination of the entire piece, followed by a coda.

The overall process of Part III's TS8 mirrors that of Part I's TS1. Whereas TS1 transforms a texture based on an inharmonic spectrum to one based on a harmonic spectrum, in TS8, inversely, the harmonic spectrum-based texture—heard in the winds and supported by the strings following the sixteenth note attack of [44]—gradually transforms, by the end of the piece, to a texture based on an inharmonic spectrum.

Another parallel between the opening and the closing temporal structures is the division of the orchestra into two distinct timbral groups. Group I consists of all the non-string instruments: woodwinds, brass, harp and percussion. Group II consists of the strings. These two groups follow distinct procedures, with some connections between them.

7.1.1 Group I: Winds and Percussion

Group I is transformed over eleven segments, ten of which are linked via descending chromatic movement from E to G (Figure 31). Individual segments also include rests—"empty spaces"—which play an integral role in the process.

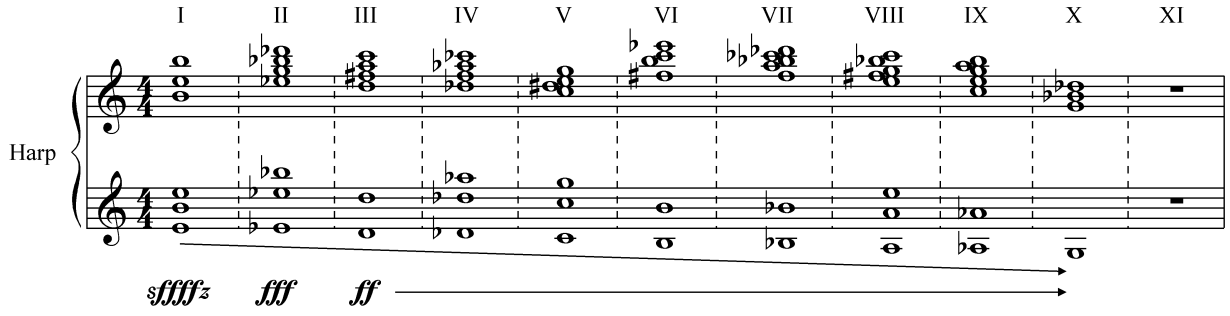


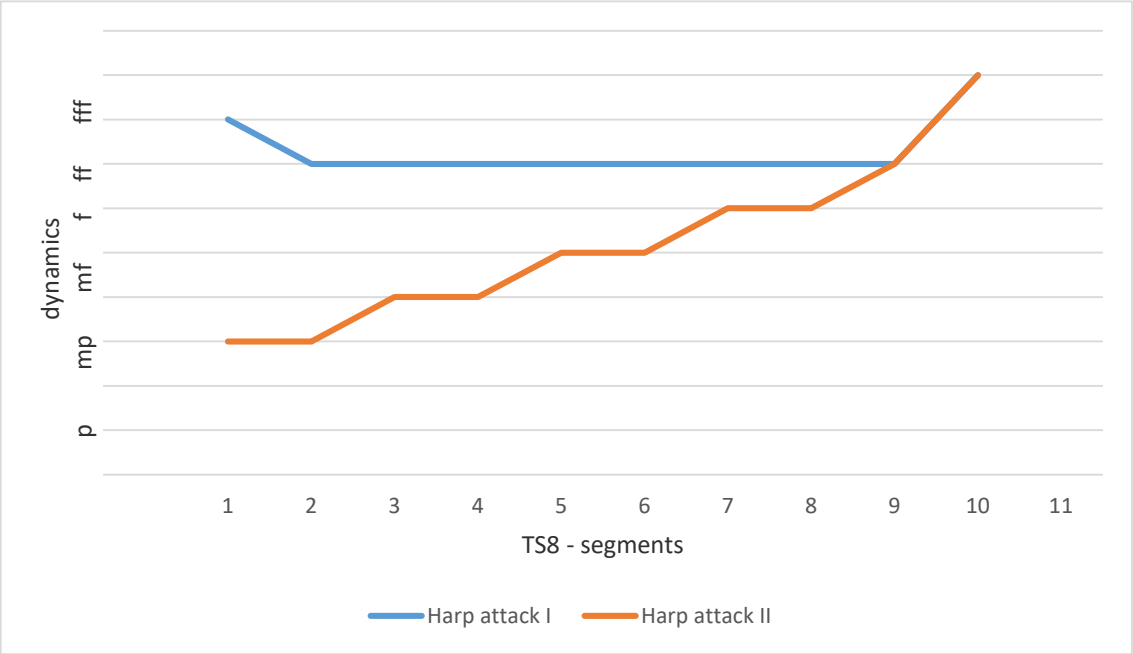
Figure 31 descending chromatic movement of the harp's first chord in each of the 11 segments of TS8

Each of these segments functions as its own temporal structure with an initial presentation of a harmonic spectrum, and a concluding presentation of a subharmonic spectrum based on the same fundamental. The latter spectrum is artificially constructed by inverting the order of the harmonic intervals, resulting in wider intervals on the top and a very chromatic low register.

The harp effectively articulates this subharmonic mirroring gesture. The initial *sfffz* harp attack occurs right at the beginning of TS8 (segment I) at [44], together with the rest of the orchestra. In the next segment (II) at [45] the first harp chord is played *fff*. From there on, the attack of the first harp chord in each segment maintains a constant *ff* throughout. However, the

second harp chord undergoes a dynamic transformation: beginning with *mp* in the first two segments (fourth measures of [44] and [45]), a crescendo builds until its dynamic aligns by the ninth segment, then exceeds that of the first chord attack (Figure 32).

As a result, at the start of the process the harmonic-based spectrum is brought to the fore, while the subharmonic spectrum is left in the background. As the music progresses from segment to segment, the dynamic of this subharmonic spectrum is raised and its presence eventually overwhelms that of the harmonic spectrum based texture (Figure 32).



Notice that the amplitude of the subharmonic spectra is increasing steadily until taking over from segment IX until the end of the piece.

Figure 32 evolution of dynamic curves of the harp's first and second attacks in each of the segments over TS8

Furthermore, at the seventh segment at [50], Grisey splits the harmonic spectrum chords into two distinctly articulated gestures, emphasizing the higher partials with a greater dynamic

(*fff*). The subharmonic texture chords are split as well with additional dynamic emphasis on the lower frequency components. The chromatic texture of the combined upper harmonic and lower subharmonic frequency components results in the emergence of an inharmonic spectrum at segment IX.

From [50] (Segment VII), the dynamic levels of both harp chords roughly match at a very loud dynamic (between *ff and ffff*). The reverberations of the undamped harp strings create a collision between the two harmonies, further contributing to the chromatic evolution of the process.

The rest of Group I, winds supported by percussion, reinforces the harp. Each of the harp chords is orchestrated by a unique instrumental combination from that group, reflecting a somewhat symmetrical amplitude envelope: an attack with followed by a rise in amplitude peaking in close vicinity to the harp attack, then followed by a gradual decay (Figure 33). These envelopes are smaller scale temporal structures (sub-structures) on their own; their relationship emulates the structural polyphony seen between the larger temporal structures (TS1-TS8).

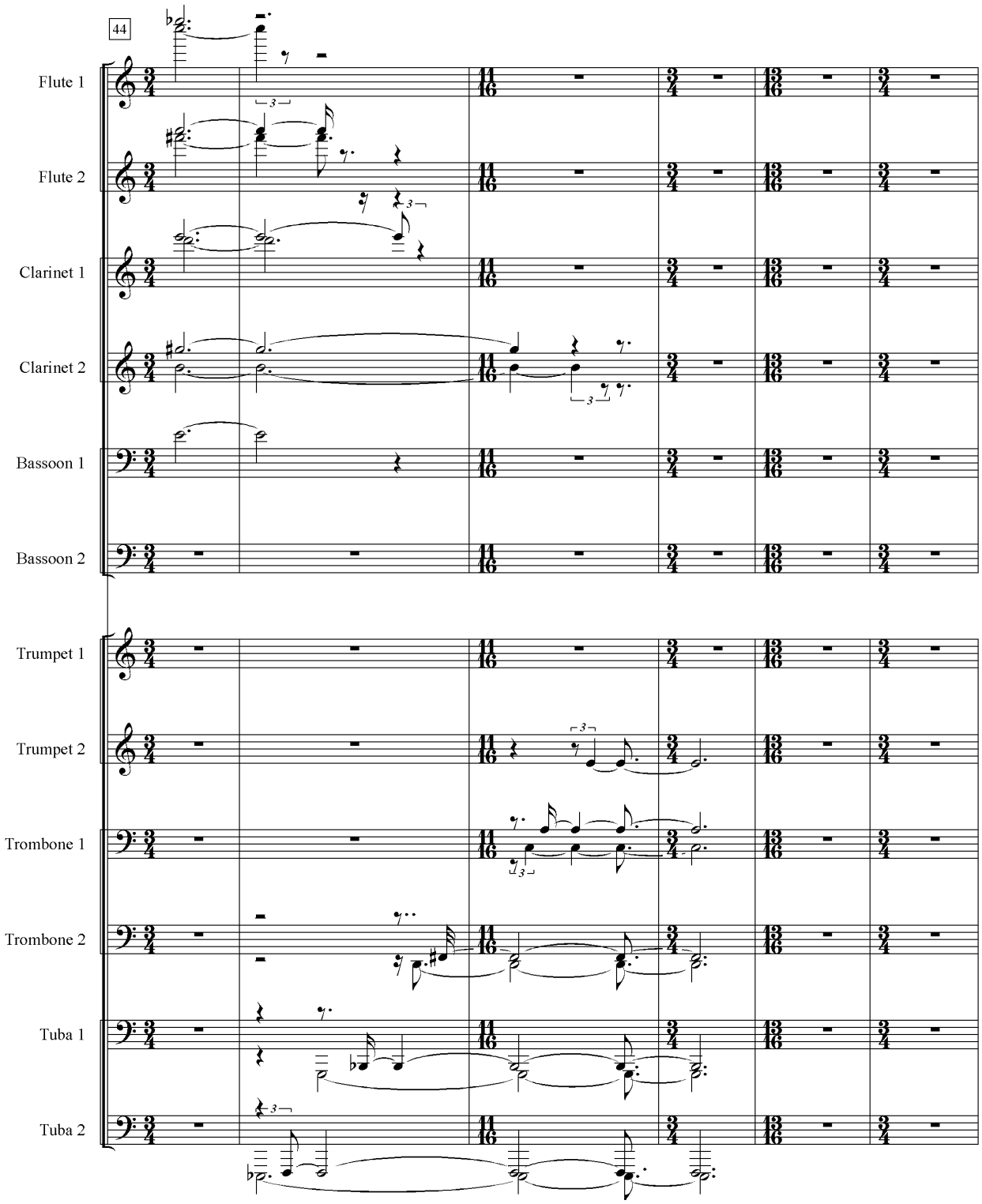


Figure 33 lower level temporal structures in TS8

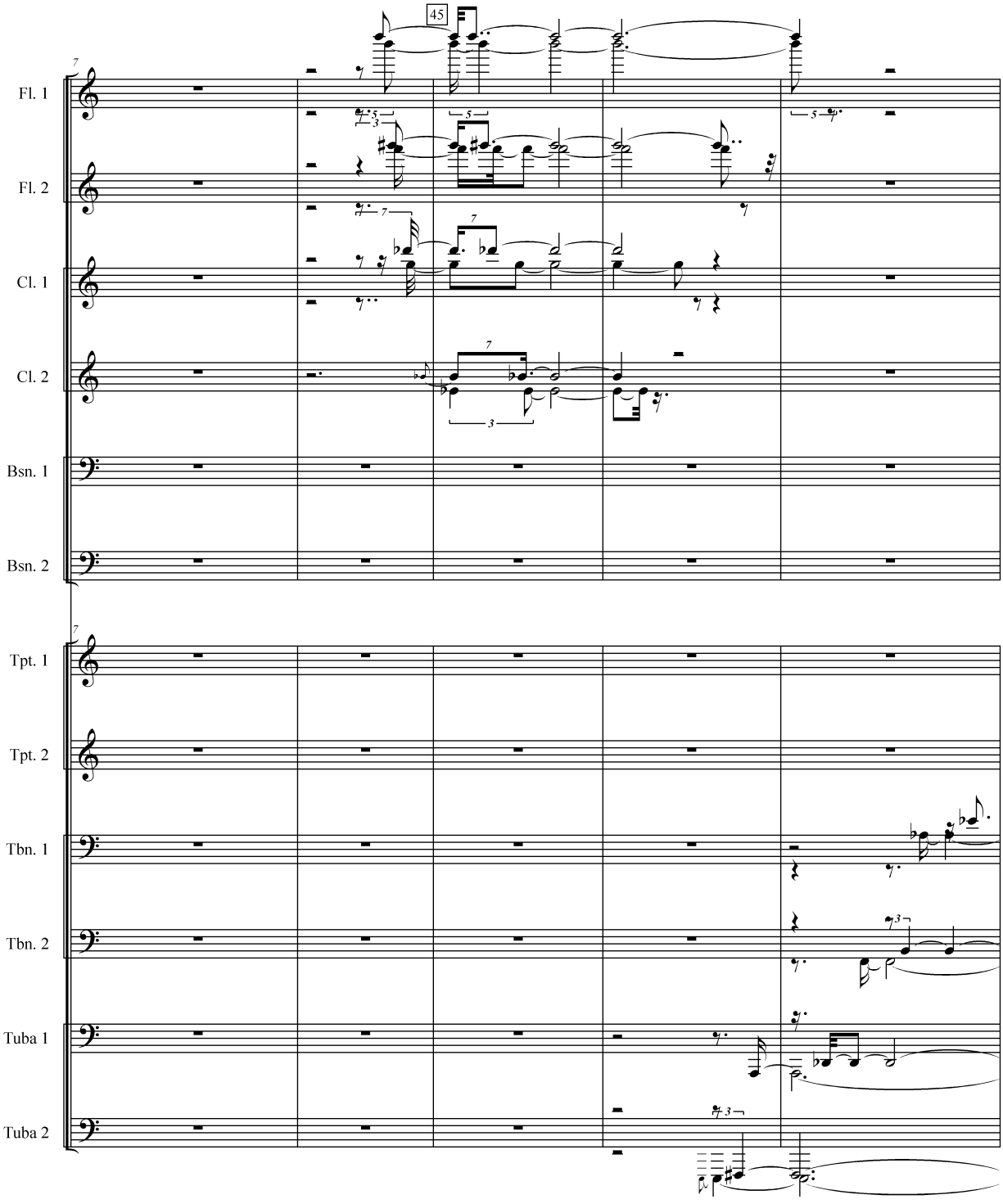


Figure 33 (continued)

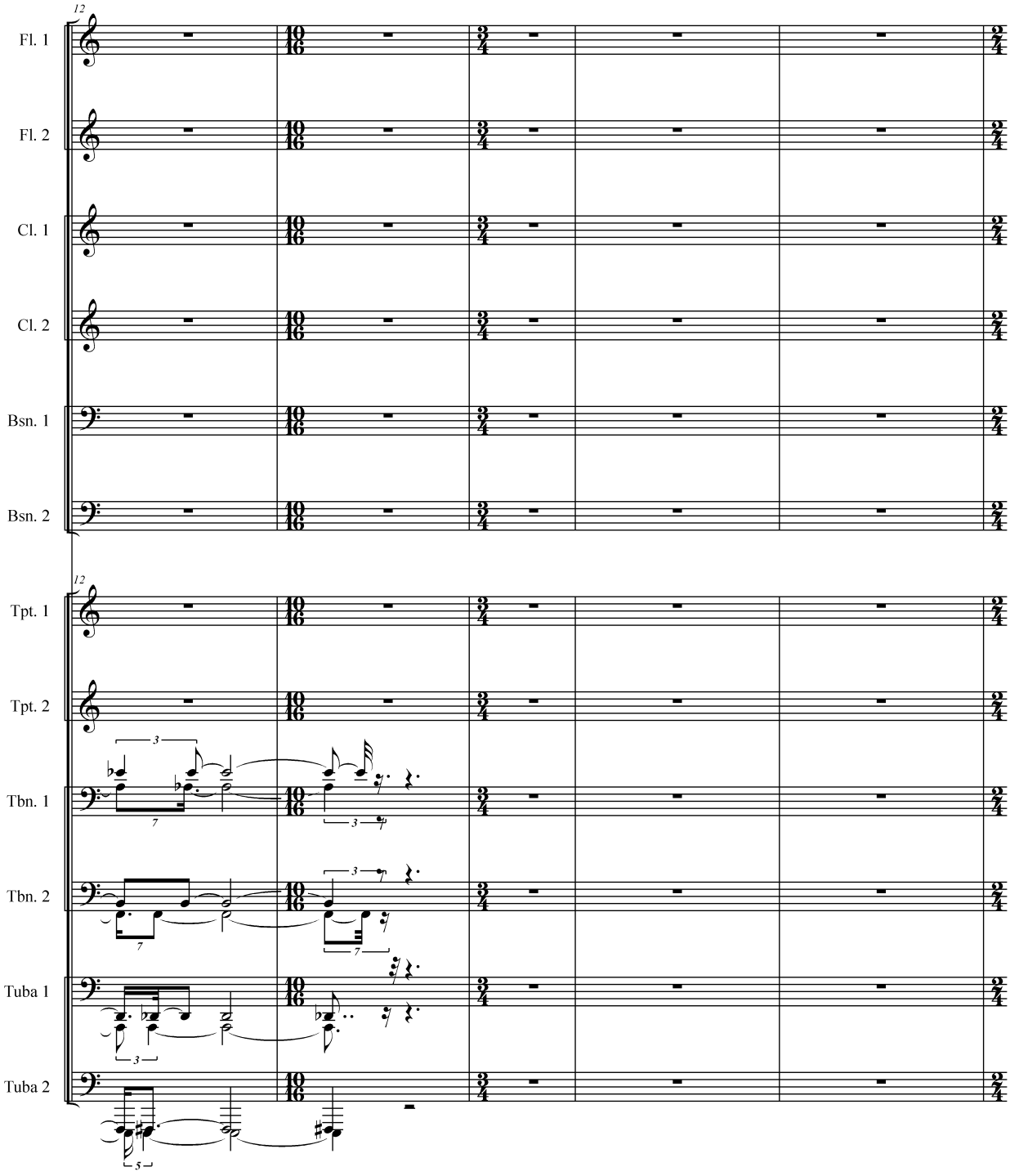


Figure 33 (continued)

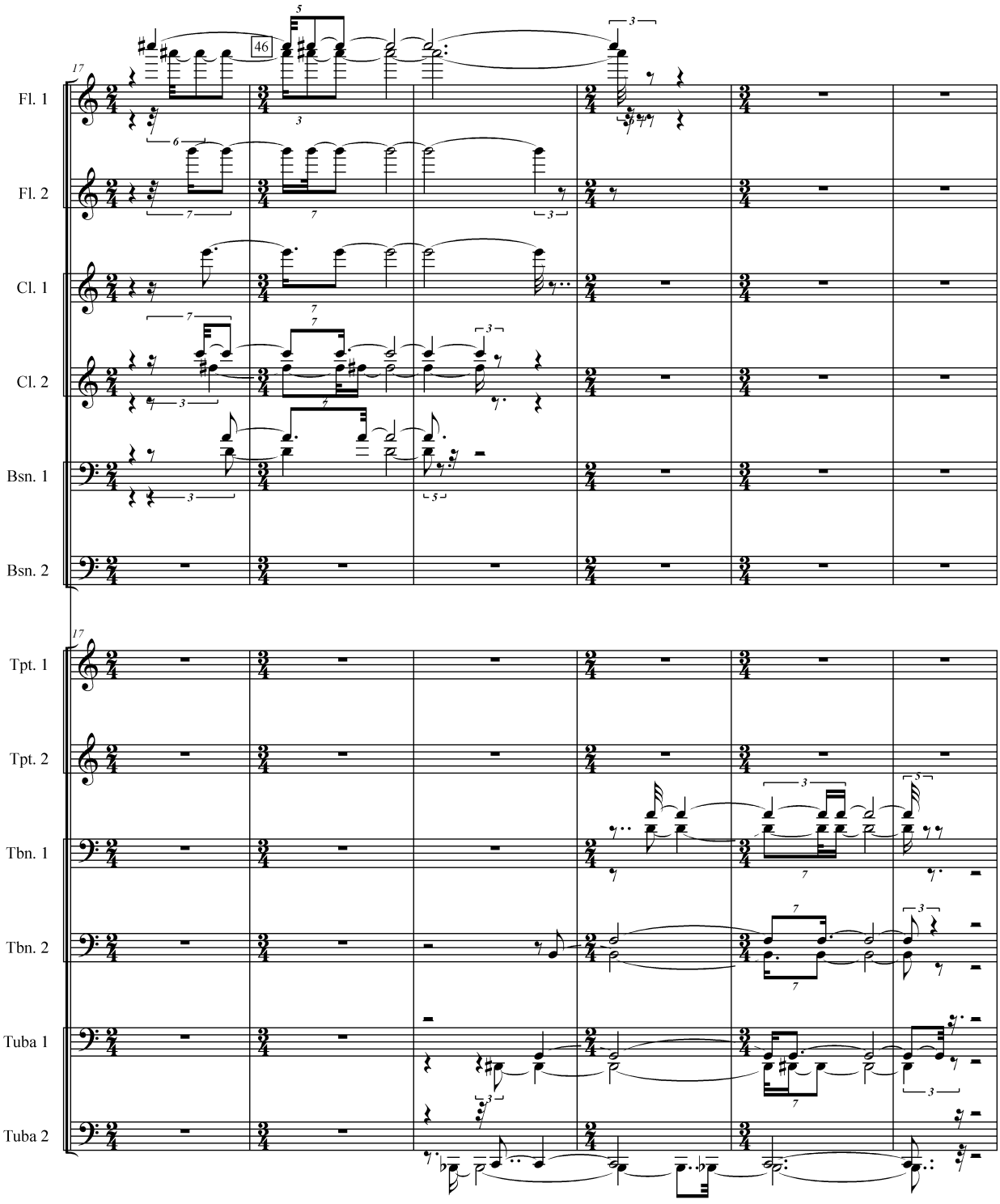


Figure 33 (continued)

The harp articulates the peak, not the beginning of the attack transient. Thus, Grisey defines two sub-temporal structures: one of a harmonic spectrum followed by a subharmonic spectrum. As TS8 progresses and the process of timbral transformation advances through its eleven segments, more sub-structures surface.

The two original sub-temporal structures are gradually partitioned, and represented by additional smaller instrumental ensembles. This distribution follows the additional split occurring in each of the harps chords (Segment VII to XI). Smaller temporal structures surface enhancing the density of the structural polyphony which culminates in the dense texture of the last segment ([54]).

7.1.2 Group II: Strings

Group II begins with a tutti E, spanning the string section's six octave range, from the piece's signature fundamental—the low E_1—played on the open fourth string of the bass, up to harmonic E_7 of the first four violins.

Grisey leaves several gaps within the strings' dispositions to allow some E's to be taken by instruments from Group I. The E_4 is played by the first bassoon and doubled by lower brass and a long vibraphone tremolo. The E_6 is played by the first oboe. These notes support the harmonic E-based spectrum as it gradually transforms throughout TS8 to an inharmonic one.

The transformation in Group II from an E-based harmonic spectrum (segment I) to an inharmonic spectrum (Segment XI) is rather smooth and without interruption. Throughout this process, minor inflections in pitch gradually disturbs the original E tutti. Each inflection is accompanied by a crescendo gradation, over eleven stages, starting with the initial *pppp* E tutti

and reaching a *fff* at the start of the 11th and final segment. In preparation for the final gesture of the piece, the segment crescendos from *fff at* [54] to *ffff,* articulating its abrupt ending.

7.1.3 Process Through 11 Segments

As in TS1, in TS8 the orchestra is divided into two groups. Its process of timbral transformation takes place over eleven segments (Table 11). Group II—the strings—are constantly present. A minor change in harmonic content occurs in each of the segments.

The part of Group I—winds and percussion—in each segment is divided into two: the first includes the temporal structures surrounding the harp, the second, an "empty space" located right after. Both of these sections (sounding and empty space) within each of the TS8 segments, play equally important roles throughout the overall process.

At the beginning of TS8, the ratio between these two sections is equal. As TS8 progresses, the audible material gradually occupies the larger portion of the segment and eventually takes precedence over the silent portion. Empty space is completely eliminated in the 11th and final segment of TS8 (Table 11).

Table 11 duration and amplitude characteristics in TS8, [54] to end

segment	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Location in the score ([no.]±duration)	[44]	[45] -0.5	[46] -1	[47]+1	[48]+2	[49]	[50]	[51]	[52]	[53]	[54]
General											
Total duration (♩=1sec.)	23.5	24	19	19	20	18	21	16	17	15	14
Group I: duration of sounding portion	11.75	13.75	13	14	17	13.5	16.8	13.6	15.2	14.25	14
Group I: duration of gap	11.75	10.25	6	5	3	4.5	4.2	2.4	1.8	0.75	0
Group I: ratio between sound and gap	1:1	1.34:1	2.16:1	2.8:1	5.66:1	3:1	4:1	5.66:1	8.44:1	19:1	0
Group I											
Harp											
Dynamic I	*sfff*	*fff*	*fff*	*fff*	*fff*	*fff*	*fff/ffff*	*fff/ffff*	*fff/ffff*	*ffff*	-
Dynamic II	*mp*	*mp*	*mf*	*mf*	*f*	*f*	*ff/fff*	*ff/fff*	*fff/ffff*	*ffff*	-
Attack from start	0	0.875	1.5	2	2.66	3.25	4	3.8	4.6	4.75	
Distance between chords	9	9	7.7	6.42	6.66	5.625	6.2	4.6	4.6	4	
Group II											
Strings											
Location of change within the segment	0	4.83	5.83	7.83	11.5	12.5	14.25	11.875	13.5	13.25	0
Sustain duration	-	19.17	13.17	11.17	8.5	5.5	6.75	4.125	3.5	1.75	0
Ratio before/after	-	0.25:1	0.44:1	0.7:1	1.35:1	2.27	2.11	2.87	3.85	7.57	-
Dynamic	*pppp*	*ppp*	*pp*	*p*	*mp*	*mf*	*poco f*	*piu f*	*ff*	*fff*	
Hammond Organ											
Playing with:	Group I			Group II							
Expression											
Vibrato	-	-	-	-	gradual until the end →						
Vibrato swell	-	-	-	-	-	-	on →				
Leslie	-	-	-	-	-	-		on →			

All the durations in seconds relate to ♩=60

These silent gaps are structurally significant. When the ratio between sounding space and empty space is equal, the sense of time is expanded; expectation is, yet again, not met and manipulated. As the sounding space gradually takes over, the sense of time is contracted; sound events occur rapidly and regularly prompting expectation. The music becomes more active, driving the final temporal section (TS8) to an abrupt—and expected—culminating gesture. Referring to Grisey's scale of complexity (Table 2) the overall progression of TS8 can be thought of as statistical acceleration.

Even though a detailed investigation reveals some discrepancies "the Gestalt of [the] temporal sequence… remains orientated vectorially whatever the statistical meanderings."[85] Even though not fully predictable, the structure discounts "pure chance" and allows "the general dynamism [to] take over."[86]

This last temporal structure can be perceived as one complex sound gesture. The compositional treatment is similar in approach to that of the opening temporal structure, TS1. At the macro level, they bear some similarities. Both structures involve two defined instrumental groups, the first consisting of winds, brass and percussion, the second, primarily strings.

In both of these larger structures, new timbres emerge throughout their processes. In TS1, a third group emerges via the arco strings, evolving into a new temporal structure. In TS8, more instrumental sub-groups emerge as the winds of Group I are gradually partitioned into two to four timbral groups—smaller scale temporal structures.

Similarities on the macro-level highlight some key reversed processes between TS1 and TS8 (Table 12). Both similarities and differences, between the opening and the closing

[85] Tempus, 253.
[86] Ibid.

structures of *Modulations*, make the latter a suitable mirroring companion to its predecessor and, as a result, an architecturally satisfying final gesture of the piece.

Table 12 comparison between TS1 and TS8

	TS1 (opening TS)	**TS8** (closing TS)
Spectrum	inharmonicity→harmonicity	harmonicity→inharmonicity
Texture	dense→sparse	sparse→dense
Range	wide→narrow	wide—wide
Dynamic	very loud (*ffff*) →soft (*ppp*)	very Soft(*pppp*)→very loud (*ffff*)
Segments length	expanding	contracting
Vectorial movement	statistical deceleration	statistical acceleration
Opening/ending gestures	abrupt→sustained (via process)	sustained→abrupt
Transformation	rather smooth with some minor spaces	segmental with noticeable gaps
Timbral enhancement (H.O.)	begins with strings/percussive	ends with strings/sustained

8.0 CONCLUSION

8.1 PERCEPTION, ANTICIPATION AND MEMORY

Modulations is defined by its continuum—the process of "becoming."[87] The "becoming" of *Modulations* determines its overall structure. Precisely, as this analysis demonstrates, it is the process of timbral transformation, the metamorphosis of a perceived phenomenon—timbre—with which the composer is engaged throughout the course of the piece.

Our perception of timbre is determined by our own sense of time (duration), frequency (pitch) and sound pressure (amplitude or dynamic evolution). These all embody a sound's dynamic harmonic spectrum (and its overall amplitude envelope)—its temporal structure—which constitutes the essential building block of the entire piece.

To review, processes in *Modulations* emulate the behavior of the sound spectra of acoustic instruments, mainly that of brass instruments. Grisey utilizes his compositional zoom lens to go from the macro to the micro, addressing various structural levels in between.

At one end—the macro-level of the structural spectrum—larger temporal structures (TS1-TS8), each embodying a process of timbral transformation, are formed by multiple partial-like components, represented by various instrumental alliances, which project various synthetic timbres. Zooming out further, one can discern a structural polyphony where each of the larger

[87] Les espaces, 9.

temporal structures (TS1-TS8) behaves as a partial-like component in and of itself with its own overall amplitude envelope (Figure 2, Macro-structure of *Modulations*). That structural polyphony emulates the behavior of the brass time-varied spectra, ultimately forming *Modulations'* continuum.

On the other end—the micro-level of the structural spectrum—smaller temporal structures consist of an individual partial-like component, represented by a single note played by an instrument with its own amplitude envelope. Here, the zoom lens advances to the very core of the sound, exposing its atomic element—the sound object—which serves as the smallest building block of *Modulations*.

Temporal structures define the boundaries in which sound evolves—its "becoming". Via the sound's amplitude envelope, a temporal structure directly affect how we perceive the transformation of the sound's timbre.

Perception relies on memory, as "perceiving an object would be meaningless without the ability to recall and link it to corresponding memories."[88] Expectation is prompted by memory of past events, and the predictability level of future events is based on how past events have been perceived.

Grisey is not only aware of these phenomena, but understands that they cannot be ignored, since their existence affects the reception of his composition. On the one hand, the physical sound (like any other physical object) exists regardless of the listener. It has "no memory or anticipation of itself—it simply is."[89] On the other hand, the experience of sound

[88] "Perception, Learning and Memory," Research Perspectives (Max Planck Society [2010]): 20-21, https://www.mpg.de/13795/Learning_memory_perception, December 10, 2016.
[89] Bob Snyder, *Music and Memory: An Introduction* (Cambridge: MIT Press, 2000), 228.

necessarily relies on the listener's subjective perception. That perception exists only within the realm of the listener's experience of time, which defines the "becoming."

Putting the listener at the center and, hence, attributing greater significance to the subjective experience of time—the "flesh of time"—Grisey addresses objective time—the "skeleton of time"—as a tool and not as an object. Through this tool, he can focus not only on the substance (the sound material), but on "[the] distance that separates one given moment from the next (the degree of change or development),"[90] which Grisey aptly calls "emptiness."[91]

In *Modulations* Grisey proves that both silence (or "empty space") and sound (occupied space) can inhabit that "emptiness" towards the purpose of tapping into the listener's perception. It is in the temporal structure within which similar "temporal skeleton[s] may be enveloped [differently] and therefore perceived differently according to the way in which the volumes and weights of the musical flesh are distributed."[92] Consequently, it is at that level of structural formation that the listener "will be attentive to the relativity of any temporal structure from the moment a sound materializes it."[93]

Thus, the skeleton of time as manifested in *Modulations*' temporal structures aims to affect the flesh of time perceived by the listener. It is used as a compositional tool through which the composer aims to prompt the listener's anticipation and to manipulate expectations.

[90] Les espaces, 9.
[91] Ibid.
[92] Tempus, 258.
[93] Ibid.

8.2 RECALLING THE SCALE OF COMPELXITY

Grisey's use of temporal structures is evidence to his utilizing time as a compositional tool with which he addresses the listener's perception of sound and musical flow, and through which he aims to prompt anticipation and manipulate expectations.

To that end, the scale of complexity—where perception and anticipation are constantly conversing—is realized through processes of timbral transformations occurring within *Modulations*' temporal structures. A desired progression is thus advanced between various stages along the scale's continuum.

That progression, the "process of musical flow and 'becoming,' that constantly changes and cannot be captured at any one moment,"[94] is manifested through timbral transformations, allowing for Grisey's "emptiness"—the time interval between momentary points along a continuum.

8.2.1 Moment-form and the Pattern of Change

In short, the various levels of temporal structures in Modulations prove that time is indeed the "the very object of form"[95] with which Grisey is occupied. Pitch, on the other hand, has been deemed not as crucial to the perception of timbre as the sound's dynamic evolution, the amplitude envelopes of its partials. Pitch plays merely a supporting role to the processes materializing within *Modulations*' various levels of temporal structures.

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[94] Les espaces, 9.
[95] Gérard Grisey, "Did you say spectral?" *Contemporary Music Review* 19, no. 3 (2000): 2.

Each of these processes is characterized by a series of "degree[s] of change," occurring from "one given moment to the next,"[96] resulting in a "pattern of change,"[97] which Stockhausen calls "moment form,"[98] where "moment may inside itself contain parts of the preceding moment or the following moment, in 'reminiscences' of the earlier moment and 'expectations' or 'hopes' for the next moment."[99]

Grisey adapts Stockhausen's "moment form," to establish continuity, defining time as the very object of his musical (or sound) structures. Pitch, which has occupied the major part of previous analyses of Grisey is shown instead, in this analysis, to be utilized for the purpose of articulating the direction (the "pattern of change") of a desired process of transformation.

In "Moment Form in Twentieth Century,"[100] an article written around the same time as *Modulation*'s composition, Jonathan Kramer comments that "continuity…is an optional procedure" and that "it must be created or denied anew in each piece, and thus it is the material."[101] This is what Grisey refers to as the "musical flow and becoming, that constantly changes and cannot be captured at any one moment."[102]

8.2.2 The Significance of Temporal Analysis: Pitch vs. Spectrum

This discovery has implications for future analysis of Grisey's music and possibly the work of other spectral composers. Even though *Modulations*, as well as the rest of the pieces comprising

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[96] Les espaces, 9.
[97] Karlheinz Stockhausen, *Stockhausen on Music: Lectures and Interviews* (London; New York: M. Boyars: 1989),
[98] Ibid.
[99] Ibid.
[100] Jonathan D. Kramer, "Moment Form in Twentieth Century Music." in *The Musical Quarterly*, 64 No. 2, (Apr., 1978): 177-194.
[101] Ibid., 179.
[102] Les espaces, 9.

Les espace acoustique, is based on a spectrum rooted on a fundamental E, the pitch which is derived from this complex phenomena's frequency structure does not serve as a prime factor in the piece's formation.

The spectrum and our perception of it are defined by the amplitude envelope of each of its individual partials, as exhibited over time. Thus, time is the key consideration in construction of *Modulations*. The spectrum's duration and the dynamic evolution of its individual amplitude envelopes unfold in time.

To adequately address Grisey's method of composition, his approach to musical structure, and as a consequence the analysis of his work, it is important to understand that whereas pitch patterns can be analyzed outside time, at a larger level spectrum cannot.

The spectrum and our perception of it are defined by the amplitude envelope of each of its individual partials, as exhibited over time. Thus, time is the key consideration in construction of *Modulations*. The spectrum's duration and the dynamic evolution of its individual amplitude envelopes unfold in time. And, as already discussed, these envelopes with their transients and dynamic evolution directly affects the perception of timbre. That perceived timbre is for the listener an inextricable reality of sound.

In *Modulations*, Grisey's synthetic timbres and their transformations aim to affect our perception of the piece's form. Its temporal structures allow for the piece to evolve and for expectations to form. These expectations, however predictable prompt a speculation for a structure (via the "flesh of time") which, as it is realized via the "skeleton of time," meets expectations or defies them.

8.3 AN APPROACH TO FUTURE ANALYSES

In view of these findings, an investigation into the rest of Grisey's work, especially those comprising *Les espaces acoustiques*, might productively concentrate on time and the effect it has on timbre and processes of timbral transformations. Temporal structures from the macro to the micro, can provide the framework for discovering each piece's overall structure and how they are perceived.

8.3.1 *Les espaces acoustiques*: Its Six Pieces and the Cycle

Les espaces acoustiques, written over the ten years that established Grisey as a prominent spectral composer, can serve as an entryway to his entire oeuvre. The six pieces of the cycle can be analyzed separately, bearing in mind the idea of "becoming" and the essential role that temporal structures play in shaping each piece's continuum as well as that of the entire cycle. The present analysis of *Modulations*, a piece situated between *Les espaces acoustique*'s smaller and larger instrumental forces, can serve as a model for exploring various levels of temporal structures, by zooming the analytical lens in and out between the cycles' extreme ends—from *Prologue* (a single instrument) to *Transitoires* and *Epilogue* (large orchestral tutti)

Processes of timbral transformations are clear in *Modulations*, in part due to its large mixed instrumental force of thirty-three musicians. The ensemble provides Grisey with multiple possibilities of instrumental combinations which vary in both size and in sound quality. The size of its larger ensemble (a small orchestra), allows Grisey to create slow transitions from very dense textures of various inharmonic spectra into the sparse texture of the E-based harmonic

spectrum. On a lower level, temporal structures' processes are given a careful, chamber-like treatment, involving small instrumental combinations and single instruments.

This wide palette of timbres allows for the creation of various synthetic timbres and for their slow transformation. Similar processes are evident and expanded in the larger ensembles of *Transitoires* and Epilogue. And, even in pieces like *Périodes* and *Partiels*, where Grisey is presented with more restricted instrumental possibilities, examining temporal structures illuminates various timbral processes. Even in *Prologue*, a solo viola piece written after the completion of *Périodes* and *Partiels*, temporal structures are used as well to create a continuum "as pitches gradually depart from the original [E-based] spectrum finally transforming into noise."[103]

Equally interesting would be to use the findings of this analysis to examine the cycle as a whole—a mega structure—on what Roads refers to as the Macro time scale, an overall artistic structure which can be "measured in minutes or hours, or in extreme cases, days."[104] Even though the component pieces were written at different times, Grisey makes ample provisions for the cycle's coherence and its integrity as a unified, large formal entity.

[103] Microsound, 3.
[104] Les espaces, 8.

9.0 A FINAL THOUGHT

At first glance it seems that addressing the entire cycle in one single analysis might be a daunting task. However, limiting the analysis to temporal structures and larger processes would make it possible to grasp the cycle's overarching form. Concentrating on its temporal skeleton could allow for the understanding of its temporal perception, without being distracted by the frequency components which have occupied other analysts.

Even in *Prologue* where the "melodic silhouette and transformations…undergo continual change as the pitches gradually depart from the original spectrum [and] finally transforming into noise,"[105] the continuum is still informed by temporal structures (as reflected mainly through various amplitude envelopes). This process is expanded in *Périodes,* then leads to the textural treatment of clearer additive synthesis in *Partiels, Modulations* and *Transitoires.*

Finally, *Epilogue*, as an extension to *Transitoires*, brings the structure to an end. Over its relatively short span, it reminisces and timbrally transforms material from the opening piece (*Prologue*), concluding the cycle with "a process of filtering and decomposition of the overtone spectrum of an 'E'."[106] Grisey reveals that he "arbitrarily had to interrupt an 'entropic' process,

[105] Ibid., 8.
[106] Les espaces, 10.

which was gradually attacking the open system of *Espaces Acoustiques*."[107] He asks "is it the end?"[108] and concludes "I doubt it."[109]

[107] Ibid.
[108] Ibid.
[109] Ibid.

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