An Analysis of Gérard Grisey's *Vortex Temporum I*: Perception of Musical Time

Analytical Essay in Music Theory and Analysis

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Abstract

This essay examines the first movement of Gérard Grisey's *Vortex Temporum* (1994–96) to investigate how musical time can be perceived differently from chronometric time. Drawing on Grisey's writings, especially "Tempus ex Machina," alongside Jonathan D. Kramer's theory of musical time, listening, and score study, the author of this article traces how the sine, square, and sawtooth waves Grisey associates with the movement's three sections shape the listener's experience of contraction, dilation, and granular time, and how the numerical structures in the score make those experiences traceable.

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When we talk about time and music, we encounter two fundamentally different senses or states of time: time that is measured chronometrically and time that is experienced uniquely, in its own musical temporality. The composer Gérard Grisey suggests that chronometric time serves as a tool for the measurable framework underlying what he calls the "skeleton of time," while the "flesh of time" concerns the immediate and unique perception of time in relation to sound material (Grisey, "Tempus" 239–59). Similarly, the theorist Jonathan D. Kramer distinguishes between "ordinary," or "absolute," time and "musical time" (Kramer 3–12). Gérard Grisey, one of the most important and influential composers of the late 20th century and a central figure in spectral music, is often discussed through the framework of spectralism. However, his compositional thinking extends beyond spectralism, and one of the important subjects that we can trace through his writings, program notes, and works is the concept of time and temporality. Looking at Grisey's works from this perspective leads us toward listening to and thinking about his music in a different way, not only through the framework of spectralism, but also through the ways in which Grisey develops and explores his ideas about time in his works. *Vortex Temporum* is a three-movement work written by Gérard Grisey between 1994 and 1996 for clarinet, flute, violin, viola, cello, and piano. This composition is remarkable for its approach to temporality. This analysis focuses on the first movement and examines how musical time can be perceived differently from chronometric time. To investigate this, I bring together Grisey's writings and concepts of time with listening and score study. Through this process, I have found several connections between Grisey's ideas about time, their relationship to listening, and the numerical and mathematical structures in the score, which I will discuss through four main sections in this essay.

1.1. Basic Ideas and Gestalts and behind the *Vortex Temporum*

Before concentrating on the analysis of *Vortex Temporum I*, it would be effective to first understand the basic ideas and main compositional components behind this piece by Grisey that have shaped the work. As the title of the piece suggests, there is a vortex, or a whirlwind quality of time, and Grisey tells us about this vortex quality as a story of an arpeggio in space and in time, within and beyond our auditory window. The main opening gesture of the piece, and perhaps the idea for the rest of the piece in different qualities and aspects, whether from a gestural or textural perspective, is an arpeggio whose quality of swirling was borrowed from the opening arpeggios of the *Daphnis et Chloé* Suite No. 2 by Maurice Ravel. Its diminished seventh chord quality allows the composer to modulate to relative tonal territories, as Grisey mentions, with no emphasis on an approach based on tonality, but rather on the chord's extreme modulatory characteristics, by considering each of the chord tones as a leading tone to another tonal state. The way Grisey deploys these arpeggios through the flute, clarinet, and piano differs from the way Ravel did in *Daphnis et Chloé*. Grisey uses the notes from two main harmonic spectra, C♯ and G, both of which have been stretched harmonically, meaning that each octave is stretched to approximately an octave and a quarter tone sharper (Hasegawa, "Tone" 273–74). This is what he means by "*stretching"* or "*compressing"* harmonics (Hasegawa, "Tone" 273, 278), which we will discuss later in this essay. Grisey initially states that *Vortex Temporum* is based on three main sound gestalts: an original event, by which he means "the sine wave," and two adjacent events, including the *"attack, with or without resonance"* and the *"sustained sound, with or without crescendo,"* three different harmonic spectra: harmonic*, "stretched"* inharmonic, and *"compressed"* inharmonic and three different tempos: *"ordinary"*, more or less *"dilated"*, and more or less *"contracted"* (Grisey, "Vortex").

The first movement of the *Vortex Temporum* is made of three main sections, both listening-wise and from a structural perspective. The first section is about the continuation of the main arpeggio that was mentioned before, the second section is the central part of the piece in which strings play with heavy rubber mutes and the section generally feels slightly distinct gesturally while retaining elements such as harmonic spectrum, arpeggio and vortex quality of the initial section. Finally, the third section is a long piano solo (cadenza) that combines material from the first and second sections with transformations of these materials, creating a different sense of narration and structure. Gérard Grisey has pointed out the analytical approach behind these three sections, when he talks about these three sections corresponding to the three waveforms: *"the sine wave," "the square wave" and "the sawtooth wave"* (Grisey, "Vortex").

There are different angles and perspectives that allow us to associate the sine wave with the first part of the first movement. A sine wave with a fixed amplitude looks like a repetitive and periodic wave, and the first section of the first movement develops along the same logics and attitudes, at least through the first half of the section. It is also worth mentioning that the sense of ordinary time is understandable in a sine wave with a fixed amplitude. The first section contains repetitive materials, namely the arpeggios between the piano, clarinet, and flute, and they have different rates of periodicity, which we will discuss later in this essay. This aligns with the quality of a sine wave. In addition, the shape of the notes that make up the piano arpeggio, when broken down into a graph, resembles a double oscillatory sine wave (see fig. 1). It is significant that focusing on the bottom note of the piano arpeggio over time in the first section, with its semi periodicity or sense of steadiness, reminds us proportionally of the moments when the x-intercept (the point on the x-axis where the wave meets it) occurs on the x-axis of the sine wave (Mailman).

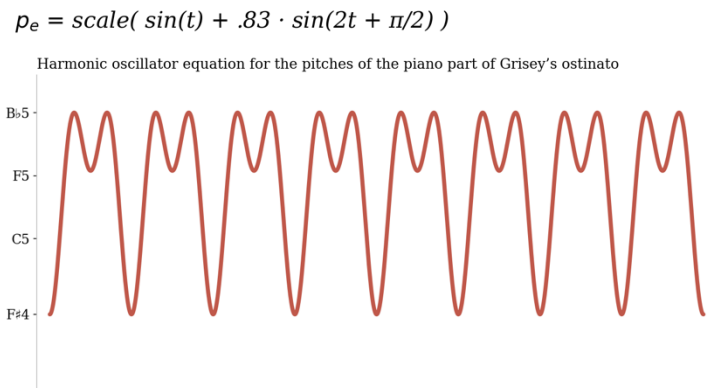


Fig. 1. Pitch contour of the piano ostinato modeled as two combined sine waves. Mailman.

One of the clues Grisey provides for understanding the square wave analogy in the second section of the first movement of *Vortex Temporum* is the use of *dotted rhythms*. However, to better understand this analogy, it is important to consider the very shape of a square wave and its defining characteristic: the abrupt alternation between two states. This characteristic can be perceived through different musical parameters throughout the section, including rhythm, dynamics, register, tempo, duration, and pitch material (see fig. 1b.).

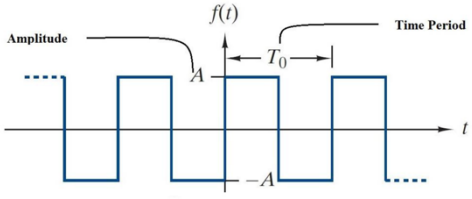


Fig. 1b. Square wave. Allelco Limited.

For a better understanding of how the dotted rhythms associate with the quality of a square wave, we need to compare this section's gestures with the first section's arpeggios, which were all in continuous sixteenth notes and created a sense of floating regardless of the interruption in their periodicity. However, in the second section, for instance, the quality of a dotted eighth note followed by a handful of sixteenth notes, and then coming back to the dotted eighth note and repeating this phrase, resembles the abrupt alternation of two different states, like an uneven square

wave (see fig. 2). When this rhythmic quality is combined with the uneven register or intervallic change (see fig. 3), it emphasizes the other aspect of the abruptness of the square wave.

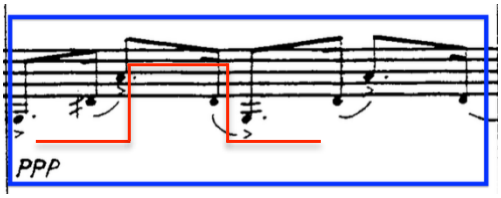


Fig. 2. Dotted-rhythm gesture in the second section. Grisey, *Vortex* 21.

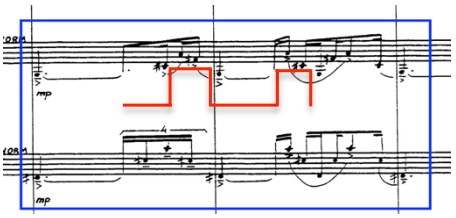


Fig. 3. Uneven register and intervallic change in the dotted-rhythm gesture. Grisey, *Vortex* 24.

Even at the very beginning of this section, we can see rapid changes between tempos (even though this happens only two times, it is still relatable to the square wave attitude), and, more significantly, the long durations of the held notes, which end with a long crescendo and are followed by another sudden state change while keeping the same manner, with another instrumentation and a focus on another tone as a long-held note and a rhythmic variation, but still carrying the nature of the gesture (see fig. 4 and fig. 5). The previous example is importantly related even from a moment-form perspective, but not in a strict way as composers like Stravinsky have done before, but rather as a temporary shift in a continuous narration of materials.

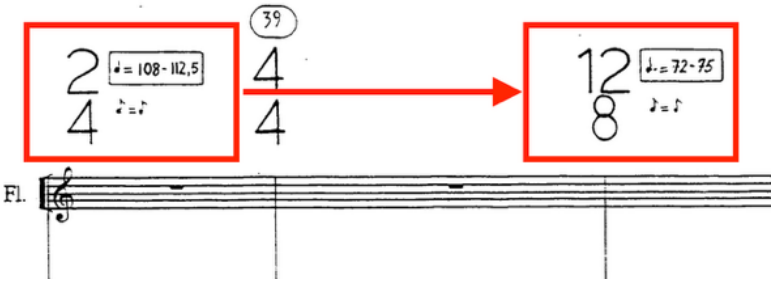


Fig. 4. Tempo change at rehearsal 39. Grisey, *Vortex* 21.

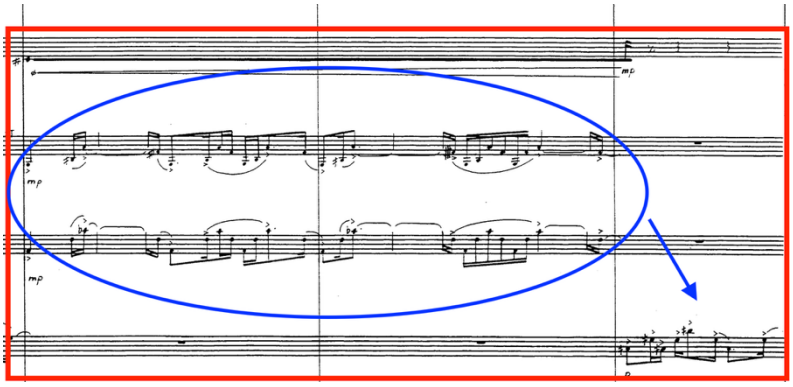


Fig. 5. Held notes ending in a crescendo, followed by a sudden change of instrumentation. Grisey, *Vortex* 23.

The way dynamics are used also contributes to the square-wave character of the section. The section is built around recurring cycles that recall the abrupt, alternating character of a square wave. These cycles are shaped by long-held notes, which establish their duration, alternating with moments in which the motoric gesture either decrescendos or reaches a very quiet dynamic, before being suddenly followed by the next state, characterized by a sharper attack and louder dynamic (see fig. 6). From a more microscopic perspective, the articulation of individual components within the motoric gestures, particularly when accompanied by register changes, further emphasizes the overall square-wave character of the section.

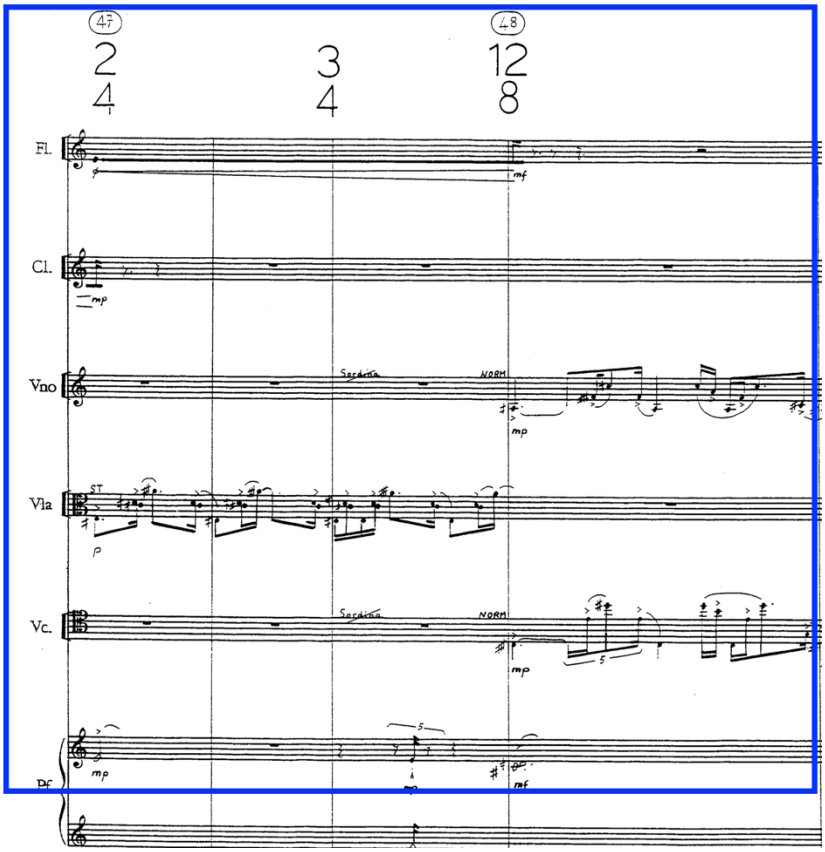


Fig. 6. Long-held notes alternating with quiet motoric gesture and louder attacks, rehearsal numbers 47–48. Grisey, *Vortex* 28.

Lastly, there is one more important aspect of a square wave that Grisey might have used either intuitively or intentionally: the fact that a square wave is constructed from only odd harmonics. This manner is quite noticeable in the harmonic language of the duos between violin and viola or viola and cello, with their motoric character in the second section, accompanied by the piano attacks. For instance, look at the example in *Fig. 7*, where we can see how the odd harmonics of the note E, which is played by the piano, are being arpeggiated by the viola and cello. We need to keep in mind that some of the notes might not be the exact odd harmonics, since they might have been lowered or sharpened by a quarter tone, as we discussed earlier regarding harmonic compression and stretching.

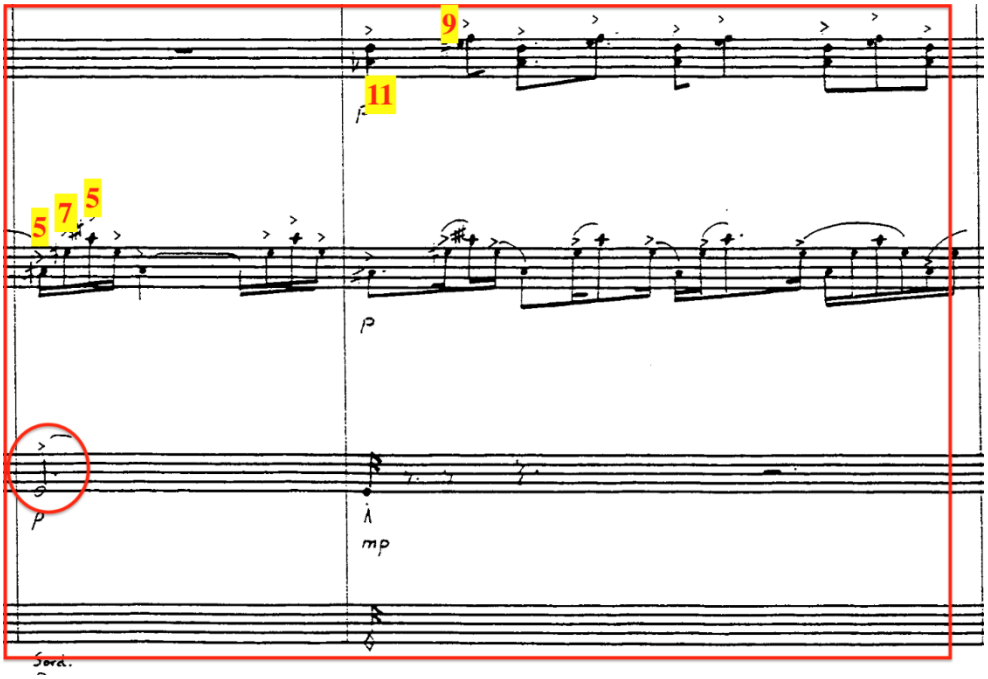


Fig. 7. Odd harmonics of E in the viola and cello arpeggios, with partial numbers marked. Note that first line is in alto clef (viola) and the second line (cello) in tenor clef. Grisey, *Vortex* 22.

1.2. Special Focus on The Piano Solo (cadenza) – Third Section of the First Movement

Looking back at the sound-wave analogy that Grisey has associated with each section of the first movement, we find that Grisey has mentioned the long piano solo in the third section as being associated with the idea and development of the "sawtooth" wave analogy. A sawtooth wave rises gradually and steadily in a straight line before suddenly dropping back to its lowest point and beginning the cycle again. Visually, it looks like a diagonal line followed by an abrupt vertical drop. In this sense, the sawtooth wave combines characteristics of the other two fundamental waveforms: it shares the gradual rise of the sine wave while also having the sudden, sharp transition found in the square wave.

It is worth mentioning that a sawtooth wave includes all the harmonics, compared to the square wave, which contains only odd harmonics. This fact might have been a metaphorical reason that Grisey used the piano for the third section, which, in terms of register and harmonic resonance (especially in this piece, where some strings have been tuned microtonally and would activate the resonance of other overtones), is vast and complete. Looking through the gestures used in the piano solo, we can associate the contour of the opening gesture of the piano solo, right after the first piano attack at the very end of the second section, with the shape of the sawtooth wave. We can see the shape of a negative ramp in the six descending notes (four sixteenth notes, ending on the downbeat of the next bar), followed by a sudden leap upward to larger intervals in two different octaves. The opposite attitude, or positive ramp, happens in the first measure of page 45 in the score (see fig. 8). Of course, Grisey also employs different durations for the ramp-ups and ramp-downs each time he represents this sawtooth-wave contour in the gesture.

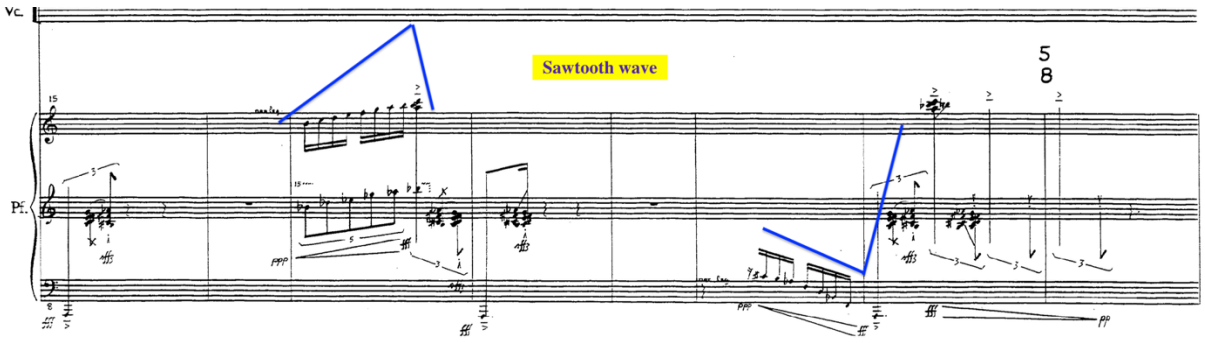


Fig. 8. Sawtooth-wave contours (negative and positive ramps) in the piano solo. Grisey, *Vortex* 45.

There is another important point about this section that makes it sound like a proper conclusion to the first movement: Grisey has written this section in a "granular" way. Grisey has basically adopted the swirling arpeggio of the first section and the dotted-rhythm gestures (square wave) of the second section, and he taps them in and out at sudden moments, weaving them into

the fabric of this section alongside the new material of the piano solo. This is an important point of view regarding the perception of musical time in this section of the first movement, which I would call granular. In piano solo, Grisey seems to move an imaginary listening cursor back and forth between the piano materials and the two main characteristic gestures of the first and second sections; this moment-based flux, might feel as if we are listening to a fast, granular version of the first two sections (see fig. 9).

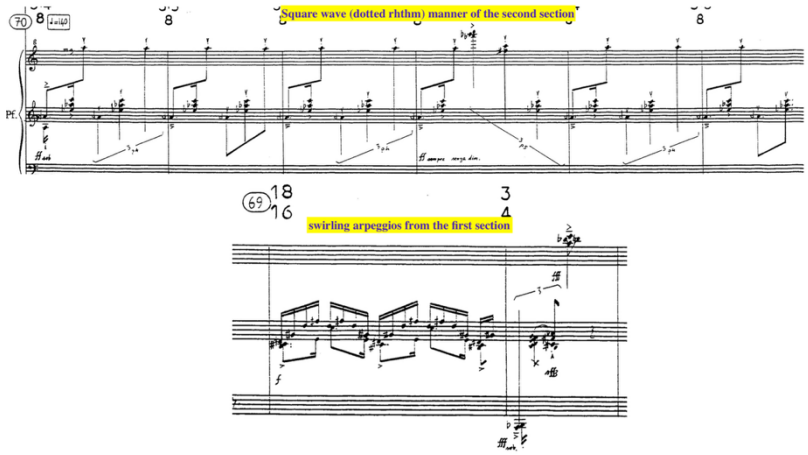


Fig. 9. Piano solo: dotted-rhythm gesture (rehearsal 70) and swirling arpeggio (rehearsal 69). Grisey, *Vortex* 44, 46.

1.3. Temporal perception of the first movement (1st section)

In the first section of the first movement of *Vortex Temporum*, in order to find evidence that can help us better understand Grisey's approach to the perception of time, we need to take a look at some numbers. These numbers can lead us toward finding relationships between the perception of time and the composition. Grisey starts the first section of the first movement with a solid, eight-measure-long phrase based on the *Daphnis et Chloé* Suite arpeggio, as we discussed earlier. This eight-measure phrase and the repetition of materials, such as the arpeggios between the piano, clarinet, and flute, are sufficient to establish an expectation of further repetitions. The periodic nature of this phrase places the listener in an experience of repetition, somewhat reminiscent of

minimalistic music, and creates an expectation that the phrase will repeat in the following moments. After stating the first phrase, Grisey presents the second phrase with a slight difference: we notice that three sixteenth notes are missing from the sixty-four sixteenth notes of the first phrase, disrupting the expected repetition. This slight change is very imperceptible and does not yet create a dramatic shift in the listener's perception of the temporal framework established by the phrase. One important reason for this may be the decrescendo and the continuous low note of the piano arpeggio, which can easily become the center of attention. However, we can still sense that some kind of change has occurred. Another important point concerns the way each phrase ends with a long, gradual decrescendo and begins with a loud attack. This pattern resets or refreshes our experience of periodicity, allowing the listener to perceive the beginning of each new phrase as a renewed temporal starting point.

In his important article, *"Tempus ex Machina: A Composer's Reflections on Musical Time,"* Grisey discusses the idea of acceleration and its effects on the perception of musical time. He explains acceleration in relation to the shortening of durations and the resulting changes in the temporal density of musical events. His chart also presents acceleration in terms of an increasing number of events occurring within a shorter time frame. As durations become shorter and events occur more frequently, the present becomes denser, and the listener experiences a progressive fading of past sounds in memory. At the same time, the listener feels propelled forward toward an event that is not yet known. In this sense, acceleration is not simply a matter of events occurring more rapidly in chronometric time; it also affects how the listener experiences the passage of time. According to Grisey, this process can make us lose awareness of chronometric duration as our attention is increasingly drawn toward an uncertain future.

In the first section of the first movement of *Vortex Temporum*, there are five main cycles, each consisting of multiple phrases. As discussed earlier, we examined the first two phrases of the first cycle. By analyzing the number of sixteenth notes in each phrase across these cycles, we can observe an overall tendency for the number of sixteenth notes to decrease from the opening phrase to the final phrase of each cycle. As illustrated in Fig. 10, for example, the first cycle begins with a phrase consisting of 64 sixteenth notes and ends with a phrase containing 51. Similarly, the second cycle begins with 65 sixteenth notes and ends with a phrase containing 42.

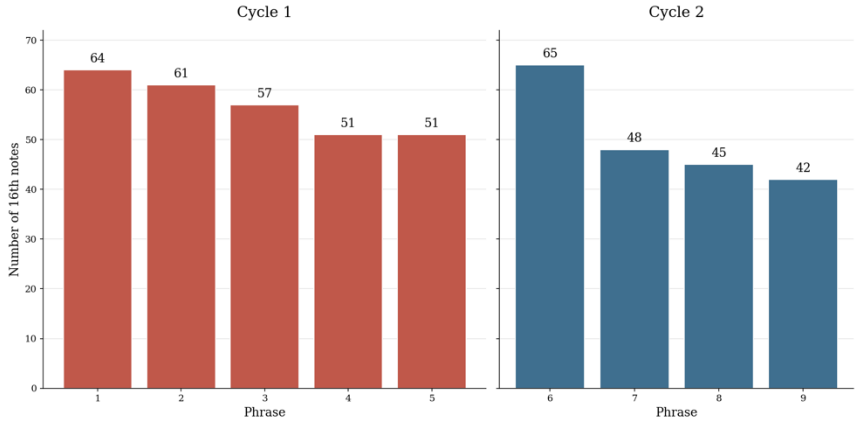


Fig. 10. Number of sixteenth notes per phrase, cycles 1 and 2. Data compiled by the author from Grisey, *Vortex*.

However, this tendency should be understood as an overall trajectory of change rather than a consistent, uninterrupted decrease. Some phrases do not follow this downward trend, and Grisey occasionally surprises the listener by introducing a subsequent phrase with a greater number of sixteenth notes. When we examine the graph of all five cycles together, we can observe an overall downward trajectory in the number of sixteenth notes, while the number of phrases increases toward the end of this section. These changes, however, do not follow a smooth or uninterrupted progression, as some phrases contain more sixteenth notes than the phrases that precede them. Nevertheless, the overall arc shown in the graph reveals a general tendency toward shorter phrases and an increasing number of phrases toward the end of the section. Taken together, these

observations support an interpretation of this passage considering Grisey's definition of acceleration in time, in which shorter durations and a greater density of musical events contribute to the perception of acceleration or in another way this section leads towards a temporal contraction (see fig. 11).

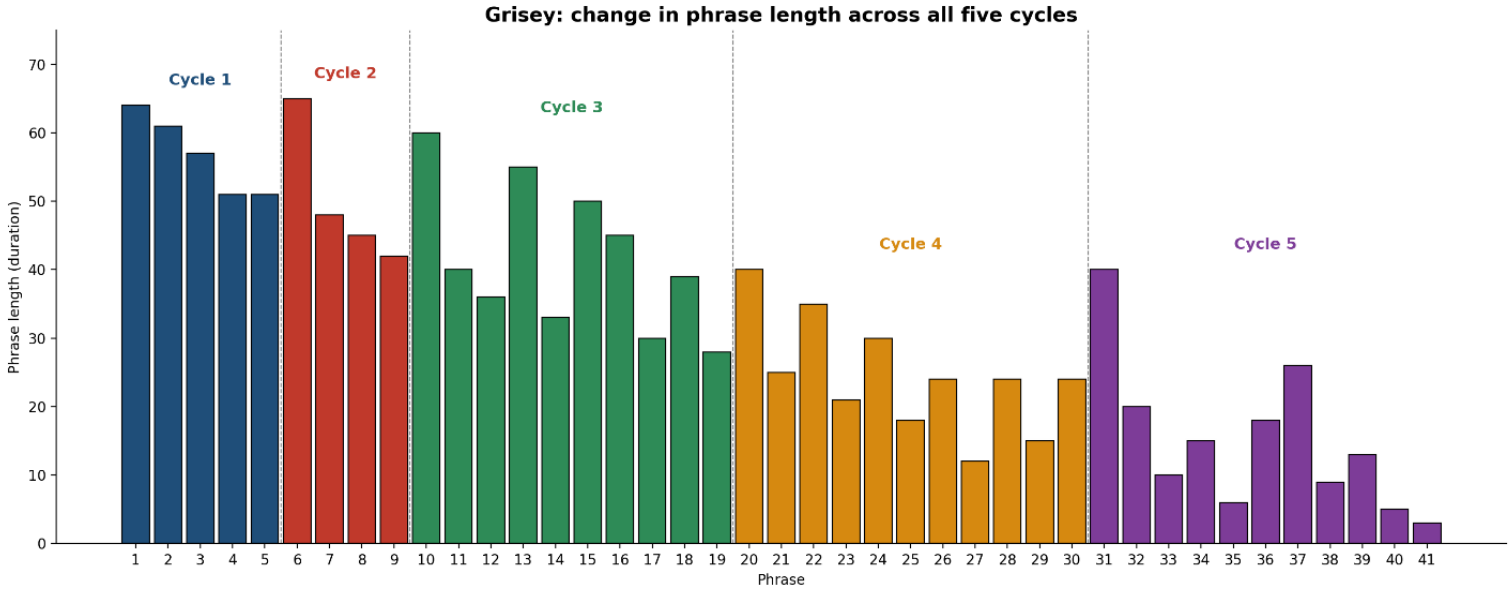


Fig. 11. Change in phrase length across all five cycles. Data compiled by the author from Grisey, *Vortex*.

Another important point to consider is Grisey's addition or subtraction of sixteenth notes at the ends of phrases, sometimes drastically and sometimes almost imperceptibly. When sixteenth notes are removed and a phrase becomes shorter than expected, this change can create a momentary jolt in the listener's perception. As discussed earlier, the beginning of the following cycle can then reset or refresh the listener's sense of the musical timeframe especially when it is accompanied with a harmonic shift based on another spectrum. However, this renewed temporal starting point does not necessarily restore the listener's previous expectations; instead, the fluctuation between periodicity and aperiodicity makes the continuation of the musical events less predictable. These irregularities, combined with the overall tendency toward acceleration, may contribute to the

listener's diminishing awareness of earlier events, connecting the compositional processes in this section to Grisey's discussion of the fading of sounds from memory.

1.4. Temporal perception of the first movement (2nd section)

The second section of the first movement in Vortex Temporum, starts with a continuous motoric characteristic motif which sounds like an ostinato by viola and cello. This motif which we have discussed before, how it carries the square wave quality, sounds like a false periodicity, the reason is that the pitch material and the rhythmic motifs are so limited and they are in constant repeats but with slight rhythmic changes and harmonic shifts, or in another way, the nature of these motoric continuous motifs is being maintained in different ways throughout the beginning of this section. Grisey, in his writings on the article titled *"Tempus ex Machina"* introduces a type of periodicity called "fuzzy periodicity" which he associates with the analogy of heartbeat, footsteps and breathing (Grisey, "Vortex" 245). Grisey defines this type of periodicity as a pattern in which events fluctuate slightly around a constant, preserving an underlying sense of regularity without being mechanically exact and the example he brings up about the usage of this idea is his work *Périodes.* I believe that the idea of fuzzy periodicity applies to the second section since we are able to follow and sense a regularity of pattern which is the motoric motif but, being disrupted by piano attacks on very unexpected points of the measure, but more importantly than this which make this fuzzy periodicity is the slight change of the same motif in terms of the duration and harmonic shift (see fig. 12).

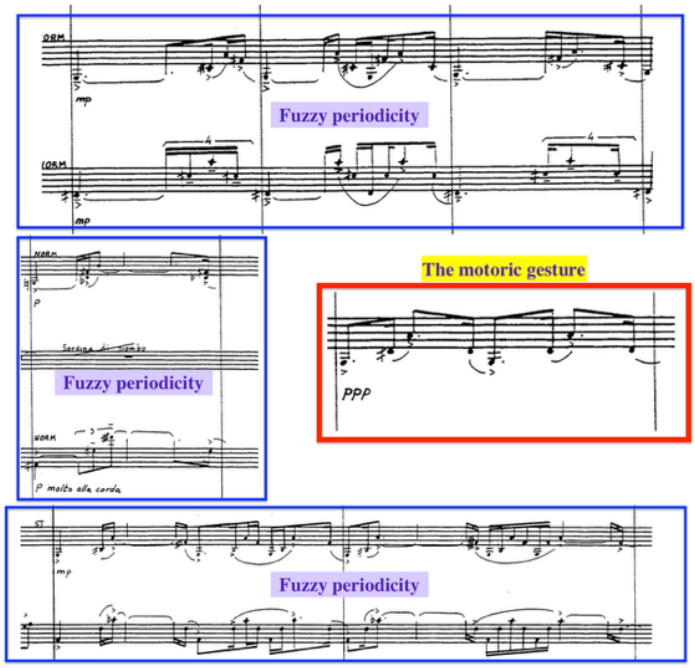


Fig. 12. Examples of fuzzy periodicity and the motoric gesture in the second section. Grisey, *Vortex* 21, 23, 24.

This relationship between recurring patterns and unexpected subtle changes leads to another concept in Grisey's writings: *preaudibility*. In *"Tempus ex Machina,"* preaudibility concerns the extent to which a listener can anticipate upcoming musical events. In the opening of this section, the limited pitch material and recurring motoric motif provide the listener with a familiar framework from which to form expectations. However, these expectations do not necessarily allow the listener to predict precisely what will happen next. In this section, the piano's unexpected attacks, together with the motoric motif's subtle changes in duration, complicate the listener's ability to anticipate the continuation of the music and the next events. Even when the motif moves into solo lines or becomes part of a more spatialized distributed gesture as around rehearsal number 64, its familiar identity and the restricted pitch material in the piano part preserve a degree of continuity. The piano frequently returns to a limited collection of pitches, including E, C-sharp, and D-half-sharp, in single-note attacks, dyads, and triads. These recurring pitch materials

reinforce familiarity, while changes in texture and the placement of attacks make the unfolding of events less predictable. Thus, the section creates a tension between the listener's ability to recognize recurring material and their ability to anticipate its continuation which reduces the section's preaudibility.

In the previous section of the first movement, Grisey shaped an overall acceleration and a sense of temporal contraction by creating jolts through the subtraction of sixteenth notes from the continuous sixteenth-note arpeggios. In contrast, in the second section, he creates a sense of temporal dilation, or a literal slowing down of the musical gesture, by imperceptibly extending the duration of certain beats within the main motoric gesture. This temporal dilation contrasts with the sustained notes played by the woodwinds in the other layer, which are followed by a large crescendo at rehearsal numbers 41, 42, and 44 (see fig. 13).

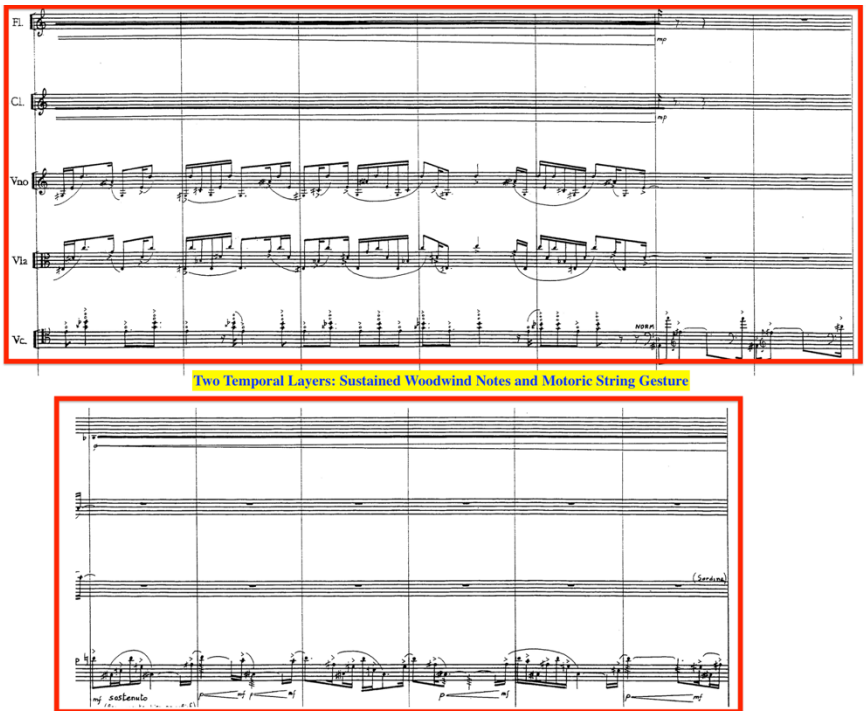


Fig. 13. Two temporal layers: sustained woodwind notes and the motoric string gesture, rehearsal numbers 41, 42, and 44. Grisey, Vortex 27, 31.

Grisey hints at the stretching of musical material in the early stages of the second section through the gradual addition of duration to certain events. Toward the end of the section, however, he stretches the motoric gesture by adding to the durations of specific beats, producing a literal slowing down of the music. This process resembles an electronic music technique in which a recorded musical phrase is time-stretched, altering its tempo while maintaining its pitch (see fig. 14).

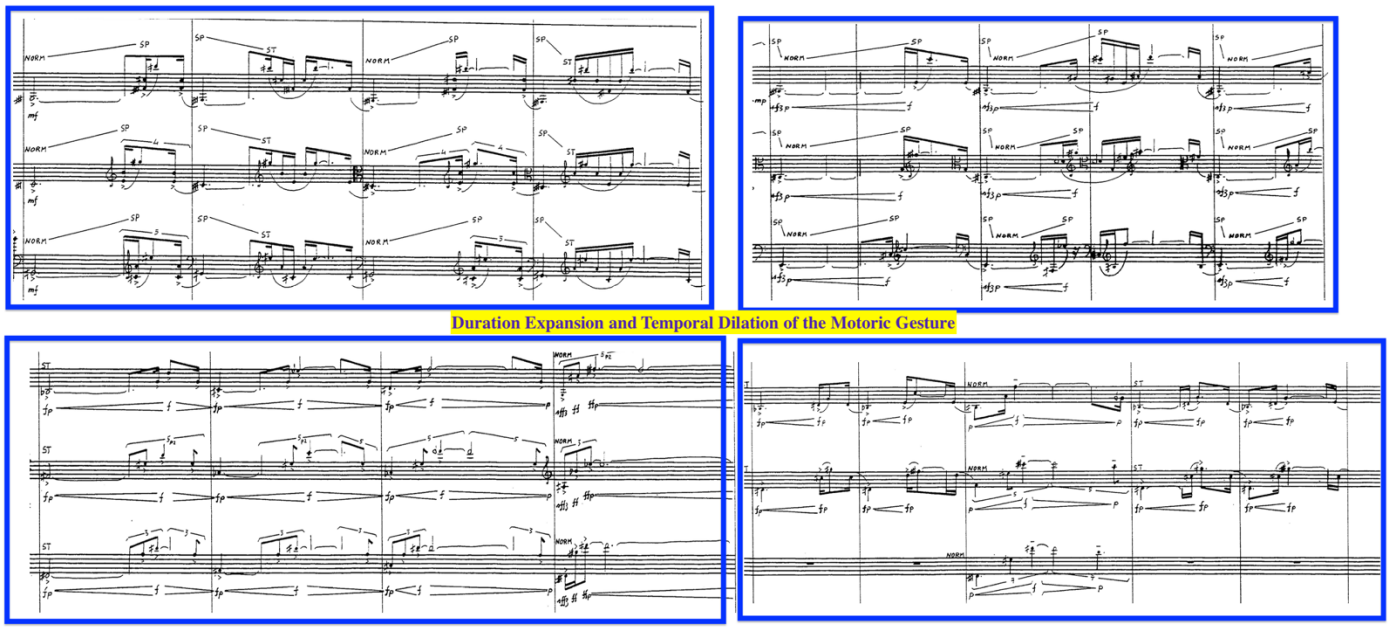


Fig. 14. Duration expansion and temporal dilation of the motoric gesture. Grisey, *Vortex* 29, 32, 36, 37.

This is the first point in the movement at which Grisey appears to manipulate the literal tempo in this way through the additive process of extending durations. At *rehearsal 64*, which we discussed earlier in relation to its spatialized effect, Grisey temporarily suspends the sense of temporal continuity by fragmenting the main motoric gesture. The sustained, resonant pitches in the woodwinds, together with an abrupt dynamic shift to *p*, create a contrasting temporal experience, while the strings continue to represent the gesture through separated attacks. Rather

than allowing the motoric gesture to unfold continuously, Grisey disperses it across these isolated attacks, momentarily interrupting its established sense of motion (see fig. 14b.).

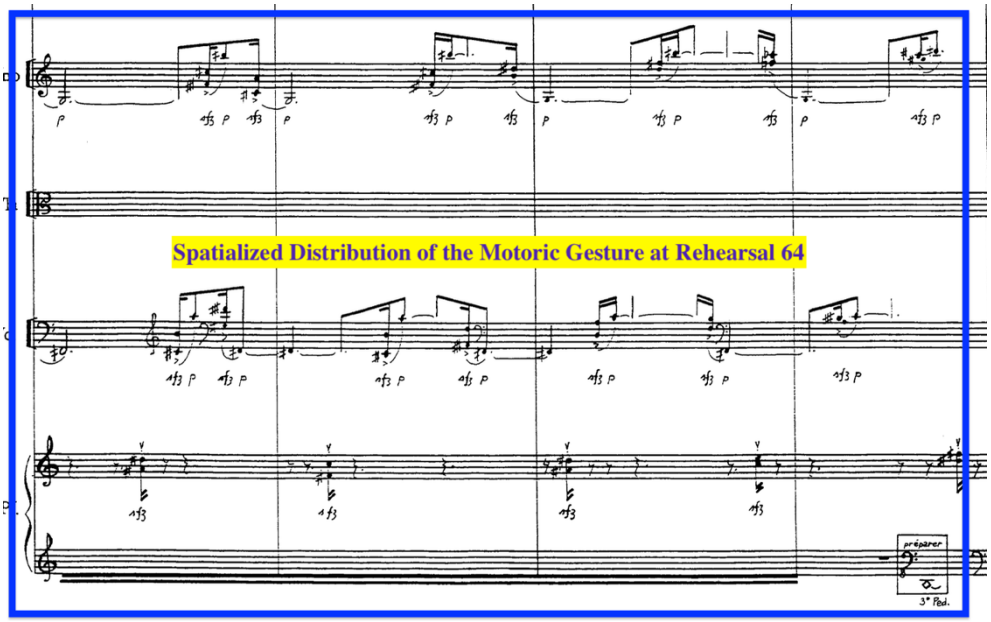


Fig. 14b. Spatialized distribution of the motoric gesture at rehearsal 64. Grisey, *Vortex* 40.

Looking at the *Fig. 13,* we can see that the role of the sustained notes by woodwinds like clarinet is to carry over the decay of the piano's attack synthetically by sustaining it and starting from zero loudness to other dynamics sometimes *mp* or even *ff.* But in listening practice we are facing two different timeframes created by this long-sustained note by clarinet and the motoric, continuous gesture played by strings. This effect goes beyond the fact of facing multiple timeframes and the psychological effect of this long-sustained notes with an extensive increase in volume leads the listener to expect a sort of change or a new event or a cadential moment or a transition, but Grisey surprises us by going back to the motoric gesture with subtle changes.

Jonathan D. Kramer, in his book *The Time of Music*, devotes considerable attention to the concepts of linearity and nonlinearity in music, examining their manifestations across different

musical styles and cultures. From Kramer's perspective, linearity can be understood as the determination of musical events through implications arising from earlier events in the piece. In this process, previous events influence the listener's expectations for what comes next, establishing a musical progression in which later events might satisfy, postpone, or disrupt these expectations. Alternatively, this can be described as a narrative line in which event A leads to event B.

Based on this understanding of linearity in musical time, we can draw a connection to the way Grisey combines two different temporal layers in this section: the motoric gesture and the long, sustained, resonant notes played by the woodwinds. The long-sustained notes played by the clarinet or flute often end with a gradual crescendo, which can lead the listener to expect a new musical event or some kind of textural, harmonic, or other types of resolution, as the crescendo creates a sense of tension. In this respect, the passage exhibits qualities of linear musical time. However, we cannot describe the section as being firmly rooted in linear musical time. As mentioned earlier, the tension does not usually resolve into a new and contrasting musical state. Instead, the music returns to the motoric gesture, continuing to develop through subtle changes in duration, timbre, and harmonic spectrum while maintaining its sense of fuzzy periodicity. This recurring process creates a sense of a musical vortex, in which the music seems to move forward but repeatedly returns to familiar material. I would describe this quality as a kind of *false linearity*.

2. Conclusion

This analysis of the first movement of Gérard Grisey's *Vortex Temporum* has examined how musical time can be perceived differently from chronometric time. Grisey's distinction between the "skeleton of time" and the "flesh of time" (Grisey, "Tempus" 239–59), like Kramer's distinction between ordinary and musical time (Kramer 3–12), suggests that the measurable

framework of a piece and our experience of it are two different things. By bringing together Grisey's writings, listening, and score study, I have found connections between his ideas about time, their relationship to listening, and the numerical structures in the score. Across the three sections of the movement, which Grisey associates with the sine, square, and sawtooth waves (Grisey, "Vortex"), these connections shape how time is experienced differently in each.

In the first section, the listener experiences acceleration: time feels contracted and earlier sounds fade from memory. The periodic arpeggios, which align with the quality of a sine wave, first establish an expectation of repetition. Over the five cycles, however, the number of sixteenth notes in each phrase tends to decrease while the number of phrases increases, and the removal of sixteenth notes creates jolts. Together, these processes support Grisey's definition of acceleration (Grisey, "Tempus" 244–52), in which shorter durations and a greater density of events lead toward a temporal contraction.

In the second section, associated with the square wave, time is experienced through dilation, fuzzy periodicity (Grisey, "Tempus" 245), and false linearity. Grisey stretches the motoric gesture imperceptibly by adding to the durations of certain beats, while piano attacks at unexpected points and slight changes in duration and harmonic shift disrupt its regularity. The long-sustained woodwind notes, ending in a large crescendo, lead the listener to expect a change that usually does not arrive, since the music returns to the motoric gesture. Following Kramer's understanding of linearity, I describe this quality as a false linearity, a musical vortex in which the music seems to move forward but repeatedly returns to familiar material.

In the third section, I perceive the temporal experience as granular. The piano cadenza, associated with the sawtooth wave, weaves the arpeggio of the first section and the dotted-rhythm

gestures of the second section in and out of its own material, as if an imaginary listening cursor were moving back and forth between them.

Across the first two sections, then, the numbers in the score, such as the sixteenth-note counts and the added durations, make contraction and dilation traceable, but what they produce is not simply a matter of chronometric time. It is the "flesh of time" that we experience (Grisey, "Tempus" 239–59).

Works Cited

Allelco Limited. "Non-Sinusoidal Waveforms: Square, Rectangular and Pulsed Waveforms." *Allelco*, 27 Aug. 2024, www.allelcoelec.com/blog/non-sinusoidal-waveforms-square,rectangular-and-pulsed-waveforms.html.

Grisey, Gérard. "Tempus ex Machina: A Composer's Reflections on Musical Time." Translated by S. Welbourn, *Contemporary Music Review*, vol. 2, no. 1, 1987, pp. 239–75.

---. "Vortex Temporum I, II, III." Program note. *Festival Musica 96*, 1996. *Ressources IRCAM*, ressources.ircam.fr/en/works/work/8977. Accessed 29 Oct. 2026.

---. *Vortex Temporum I, II, III: pour piano et cinq instruments*. Ricordi, 1996.

Hasegawa, Robert. "Gérard Grisey and the 'Nature' of Harmony." *Music Analysis*, vol. 28, no. 2–3, 2009, pp. 349–71.

---. "Tone Representation and Just Intervals in Contemporary Music." *Contemporary Music Review*, vol. 25, no. 3, June 2006, pp. 263–81.

Kramer, Jonathan D. *The Time of Music: New Meanings, New Temporalities, New Listening Strategies*. Schirmer Books, 1988.

Banks, Joshua Mailman. "Process Philosophy Overcoming Itself: Modeling Grisey's *Vortex Temporum* (1994–96)." *Spectralismes: Colloque International*, IRCAM, Salle Igor-Stravinsky, 13 June 2019. *Ressources IRCAM*, ressources.ircam.fr/en/media/x439b59. Presentation. Accessed 29 Oct. 2026.

Risognanze Ensemble, and Tito Ceccherini, conductor. "Vortex temporum: I. —" *Grisey: Vortex temporum & Periodes*, by Gérard Grisey, Stradivarius, 2007. *Spotify*, open.spotify.com/track/3FP0mdP0S94HYv2OJQMmnL. Accessed 29 Oct. 2026.