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States of Balance and Turbulence

György Ligeti's Pièce électronique nr. 3 *in Concept and Realization*

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In 1957 György Ligeti had recently immigrated to Cologne and was learning about the developments of the avant-garde while working in the electronic music studio of the WDR. His output from this period includes an unfinished work, *Pièce électronique nr. 3*, a fascinating, yet virtually unknown composition, originally conceived as *Atmosphères* – the title later used for his orchestral composition of 1961. *Pièce électronique nr. 3* looks forward to the innovative texture-driven orchestral compositions for which Ligeti became famous, but also reflects the influence of serialism as practiced by Karlheinz Stockhausen. The serial electronic music composed at the WDR in the 1950s offers a unique perspective on stages of theoretical planning and their relationships to audible realizations; the extensive sketches for this piece are no exception. The piece uses a consistent series of odd numbers to generate durations and pitch material for both small and large scale structures; it also uses sine tones as the predominant type of material, arranged in a way reminiscent of Stockhausen's structure-group-forms. Shortly after this composition, Ligeti criticized aspects of serial practice, including duration rows and serialized dynamics, and moved away from this theoretical model. Along with comments in interviews, Ligeti's approach to dynamics in this piece illustrates a significant difference in the artistic ends which Ligeti and Stockhausen sought. The use of such non-serialized parameters as determinants of large-scale form becomes increasingly characteristic in Ligeti's style in *Apparitions* and *Atmosphères*; moreover, the basic shape of *Pièce électronique nr. 3* closely resembles the form of the first movement of *Apparitions*. Thus elements discovered through serial pre-planning in the electronic medium were ultimately realized in non-serial orchestral works.

In 1957 György Ligeti had recently immigrated to Cologne and was learning about the developments of the avant-garde while working in the electronic music studio of the WDR. There he completed two pieces, *Glissandi* (1957) and *Artikulation* (1958), the latter of which has become relatively well known; Ligeti began a third work, yet left it unfinished: *Pièce électronique nr. 3* (1957–58) is a fascinating, but virtually unknown composition.[1] Originally conceived under the title *Atmosphères* it was then renamed after this title was taken by his landmark orchestral composition of 1961. *Pièce électronique nr. 3* looks forward to the innovative texture-driven orchestral compositions for which Ligeti became famous, but also reflects the influence of serialism as practiced by many leading composers in the 1950s, and thus provides an intriguing window

1 Information about this piece provided in this article is derived from Ligeti's sketches held in Basel, Switzerland at the Paul Sacher Foundation's György Ligeti Collection, and were examined by the author in June 2004. Ligeti completed a score including all of the frequencies and durations, the spatial organisation, and rough notes for the dynamics, but he never brought it to completion on tape. *Pièce électronique nr. 3* has since been realized by Kees Tazelaar, using CSound and working with Johann van Kreij and Paul Berg at the Institute of Sonology in the Netherlands. This realization presents the pitches and durations, but does not interpret the less specific dynamic indications; it was completed in 1996 and is available on the CD set *His Master's Noise*, BVHAAST CD 06/0701.

into Ligeti's compositional thought – both his aesthetic goals and the compositional methods he employed to achieve them. This essay explores serial aspects of this work, including several similarities with Karlheinz Stockhausen's early electronic pieces, and then goes on to address some of the non-serial features which may shed light on the different compositional paths that Ligeti and Stockhausen would ultimately take and the different concepts of the musical work that these paths reflect.

When Ligeti arrived in Cologne, he was already somewhat established as a composer and theorist in Hungary, and perhaps because of this his relation to serial practice was quite complex. He quickly developed a cautious but interested attitude towards the type of total serialism seen in pieces like Pierre Boulez's *Structures I* (1952), clearly finding some aspects of this compositional method appealing and other aspects problematic. Along with his analytical essay *Pierre Boulez: Decision and Automism in Structure Ia* (1958), *Pièce électronique nr. 3* belongs to this time period in which Ligeti's attitudes on serialism find their first mature expression. The piece cannot be called serial in the same sense that similar works by Boulez and Stockhausen are, yet it clearly shows signs of »serial thinking« – a term that Stockhausen himself has used in discussing the expansion of the serial idea to parameters beyond pitch and rhythm.[2] Ligeti speaks similarly in a self-critical description of his work *Glissandi*, saying:

> It has a primitive, almost schematic form. There is a succession of sections up to a middle point and from there out, the material of the piece is doubled – there is then a way of thinking in terms of row manipulation, ›a la mode‹. Here there aren't really any rows, but from the middle to the end the piece goes once backwards in retrograde, and simultaneously the original shape repeats once again.[3]

While in this quote Ligeti seems to be thinking, as he says, of *row* manipulation, rather than *serial* manipulation, there is evidence that *Pièce électronique nr. 3*, which he began composing immediately after *Glissandi*, is an attempt to engage serial thinking at a deeper and more thoroughgoing level, beyond the mere presence of events and their retrogrades.

In numerous articles and lectures Stockhausen has chronicled the early days of the Cologne Studio and the conception of serial electronic music that was developing at that time.[4] He stresses the importance of treating the parameters of musical material separately yet with equal importance and using similar methods for ordering values within each parameter. Stockhausen also emphasizes the importance of connections between the large-scale and small-scale (even microscopically small-scale) use of the series as a unifying element giving the work its character.[5] In handling many of these same concerns, Ligeti's *Pièce électronique nr. 3* shows signs of being a

2 See Wörner, *Stockhausen*, p. 82.

3 Quoted in Koenig, *Ligeti und die Elektronische Musik*, p. 19, »Es hat eine primitive, fast schematische Form. Es gibt eine Sukzession von Abschnitten bis zu einem Mittelpunkt, und von hier ab wird das Material des Stückes verdoppelt: also damals war sozusagen die Denkweise in Reihenmanipulationen à la mode; hier gibt es zwar keine Reihen, aber von der Mitte bis zum Ende geht das Stück einmal rückläufig im Krebs, und gleichzeitig wird auch noch einmal die Originalgestalt wiederholt.« (Translation by the author.)

4 See for example Stockhausen, *The Concept of Unity in Electronic Music* or *Four Criteria of Electronic Music*.

5 See Wörner, *Stockhausen*, p. 84.

serially conceived work; it shows Stockhausen's influence in choice of material, it shows some parallels between the treatment of rhythm and pitch and it uses a consistent arrangement of odd numbers to determine both large- and small-scale rhythmic structures.

Most noticeably related to Stockhausen's electronic *Studien* (1953/54) is Ligeti's use of predominantly sine tones as material – this is, in fact, the only of Ligeti's three tape pieces to use sine tones so extensively, and in his assembly of tones into »Groups« and Groups into larger »Structures«, Ligeti even reflects the terminology of established serial composers. While sine tones are not themselves strictly a mark of serial composition, many composers saw them as ideally complimentary to this musical language. In his article *What is Electronic Music?*, Herbert Eimert discusses how electronic music has progressed beyond even the developments in serial technique seen in Anton Webern's celebrated instrumental music. He declares:

> Only in electronic music has the real sense of these developments been realized [...]. The relationship of note to row is only known as a principle of fixed constellation in twelve-note music. In electronic-serial music, on the other hand, everything, to the last element of the single note, is subjected to serial permutation, resulting in a completely new way of composing sound – the poetics of sound, as the medieval theorist would have called it. Examination of material inevitably leads one to serially ordered composition; no choice exists but the ordering of sinus-tones within a note, and this cannot be done without the determination of the triple unit of the note. A note may be said to »exist« where elements of time, pitch, and intensity meet; this fundamental process repeats itself at every level of the serial network which organizes the other partials related to it.[6]

Thus sine tones offered the most precise control for devising the microstructures that Eimert and Stockhausen would use as the foundation of their serial networks. They could be used to construct artificial overtones and thus novel timbres, all serially determined and permuted – and unified through derivation from the same series. Moreover, this sense of unity would extend organically from the smallest elements of waveforms to the large-scale form of the composition itself. It is in this context that Stockhausen's *Studie I* (1953) and *Studie II* (1954) were composed, and in this spirit that Ligeti begins his *Pièce électronique nr. 3*.

For his *Studie II* Stockhausen composed a large network of note-mixtures, or collections of sine tones. These are determined by a scale where the twenty fifth-root of five ($\sqrt[25]{5}$) or a ratio of approximately 1:1.066 exists between each successive step, as shown in Figure 1 (left). Everything in this piece is based on fives, so along this scale there are mixtures with five different spacings and since each note-complex is fixed at containing five elements, this results in five different widths. Similarly, Ligeti worked out pages upon pages of pitch material for his composition. Instead of using a constant ratio between pitches, however, Ligeti used constant differences, calculated in Hertz, to generate harmonic series. He also inverted the resulting ratios to create subharmonic series, some representative examples of which are given in Figure 1 (right).

6 Eimert, *What is Electronic Music?*, p. 8.

ratio	hertz	difference
	2060	
	1930	130
	1810	120
constant	1700	110
of 1.066	1590	110
($\sqrt[5]{25}$)	1490	100
	1400	90
	1310	90
	1230	80
	1150	80
	1080	70
	1010	70
	952	58

Harmonic			Subharmonic		
ratio	hertz (cps)	difference	ratio	hertz (cps)	difference
	2000			2000	
32/31	1937.5	62.5	17/16	1882.35	117.65
31/30	1875	62.5	18/17	1777.77	104.58
30/29	1812.5	62.5	19/18	1684.22	93.55
29/28	1750	62.5	20/19	1600	84.22
28/27	1687.5	62.5	21/20	1523.81	76.19
27/26	1625	62.5	22/21	1454.55	69.26
26/25	1562.5	62.5	23/22	1391.3	63.25
25/24	1500	62.5	24/23	1333.33	57.97
24/23	1437.5	62.5	25/24	1280	53.33
23/22	1375	62.5	26/25	1230.77	49.23
22/21	1312.5	62.5	27/26	1185.19	45.58
21/20	1250	62.5	28/27	1142.86	42.33
20/19	1187.5	62.5	29/28	1103.45	39.41
19/18	1125	62.5	30/29	1066.66	36.79
18/17	1062.5	62.5	31/30	1032.26	34.4
17/16	1000	62.5	32/31	1000	32.26

Figure 1: *left*: typical pitch material found in Stockhausen's *Studie II; right*: typical pitch material found in Ligeti's *Pièce électronique nr. 3*.

Thus each of the five octaves used in this piece, from 250 Hz to 8000 Hz, could be subdivided into scales with different numbers of elements, and either a harmonic or subharmonic arrangement of these elements. Two octaves occur in the opening structure, shown in Figure 2[7], one with a harmonic arrangement extending up from 1000 Hz to 1937 Hz (stopping just short of 2000 Hz, which, as shown in Figure 1, would be the next step in this harmonic arrangement), one with a subharmonic one, extending from 1000 Hz, down to 516 Hz (stopping just short of 500). In each case, tones are rounded down to the nearest whole number, and the series are cut off one step short of the octave.

The rhythmic sculpting of these sine tones bears a resemblance to another aspect of Stockhausen's practice. In his electronic *Studien*, Stockhausen uses schematic entrance and exit patterns for each of his tone mixtures – something that Richard Toop has referred to as »mode« in his examination of Stockhausen's sketches.[8] In Stockhausen's integrally serial *Studie I*, based on a series of 6 numbers (4, 5, 3, 6, 2, 1), just as *Studie II* is based on 5, as well as in other sketches from the period, the composer developed modes such as the six shown in Example 3a, each assigned a number and serialized. Ligeti's schemes for exits and entrances seem roughly balanced, but are not strictly serialized. Nevertheless, the similarities between Ligeti's schemas and Stockhausen's are evident from the spectrographs shown in Figure 3b.

7 Figure 2 is an annotated spectrograph created from Tazelaar's realization of the piece (BVHAAST CD 06/0701), using the computer programme SpectraPLUS FFT Spectral Analysis System (Campbell, CA: Sound Technology, 1998). Figures 3b and 6 were created in the same way.

8 Toop, *Stockhausen's Electronic Works*. This discussion of mode also relates to the analyses of *Klavierstücke I–IV* in Robin Maconie's *The Works of Karlheinz Stockhausen* and to what Stockhausen himself refers to as *Struktur-Gruppenformen* in his own analysis of *Studie I*, found in *Texte zur Musik*, vol. 2, pp. 23–36. The diagrams shown in Figure 3a are based on sketches for what Toop refers to as an unpublished »intermediate« study (*Stockhausen's Electronic Works*, pp. 155f.).

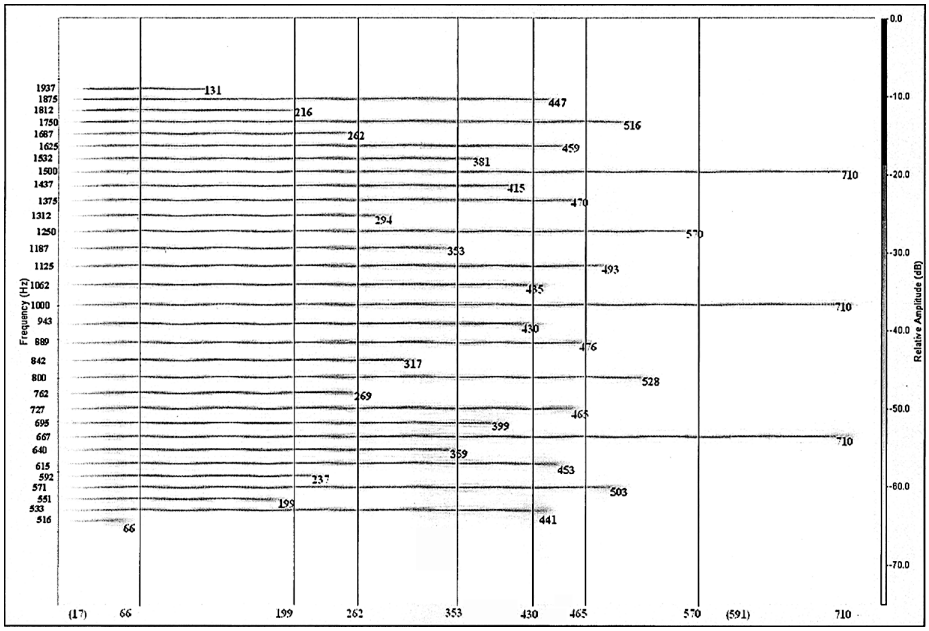
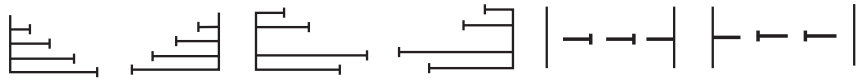


Figure 2: Structure 2 of Ligeti's *Pièce électronique nr. 3*; Spectrograph with frequencies and durations (in cm of tape at 76 cm/sec), with vertical gridlines showing time points determined by the series.

a.



Mode 1 Mode 2 Mode 3 Mode 4 Mode 5 Mode 6

b.

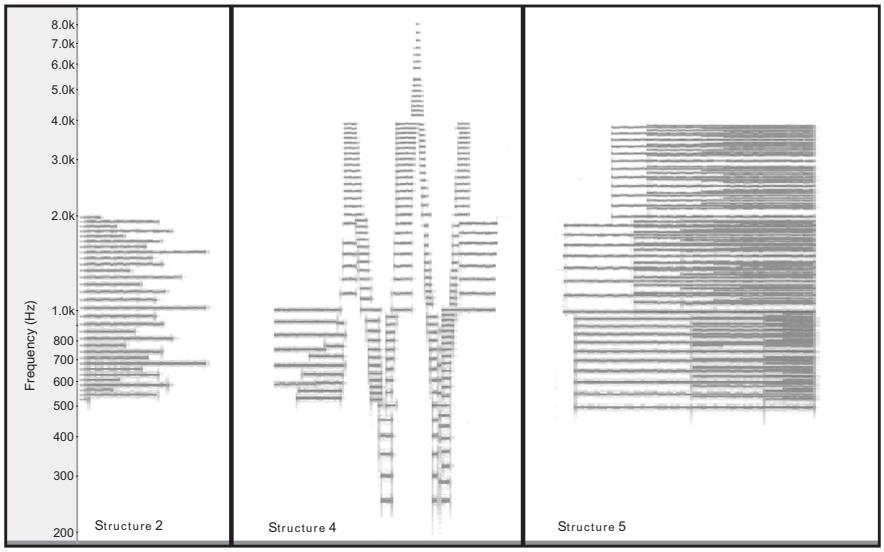


Figure 3: a: »Modes« found in Stockhausen's sketches, adapted from Toop, *Stockhausen's Electronic Works*, p. 156; b: Arrangements of sine tones found in Ligeti's *Pièce électronique nr. 3*.

Returning to the opening structure shown in Figure 2, the durations of individual sine tones depend on a series of odd numbers, which also forms a connection between the large scale and small scale rhythmic structure of the work. In his sketches Ligeti works with the number series 1, 7, 19, 9, 13, 11, 5, 15, 3, 17 – an arrangement of the first ten odd numbers. This series in its exact ordering determines the lengths of the ten »Structures« of the piece by multiplying the original series by 100 centimetres of tape (speed: 76 cm / second). These lengths are given, along with the original series, in Figure 4. Thus the opening Structure (which is actually Structure 2) lasts 700 cm, or just under 10 seconds (=760 cm).

Original Series of Odd Numbers

1	7	19	9	13	11	5	15	3	17

Lengths of the 10 Structures of Pièce électronique in cm of tape at 76 cm/sec

100	700	1900	900	1300	1100	500	1500	300	1700

Durations which determine internal divisions within Structure 2 (equal to 7 times the original series)

7	49	133	63	91	77	35	105	21	119

When these durations are placed in succession, they define the time points shown below (for reasons of tape synchronization, Ligeti begins at point 10)

17	66	199	262	353	430	465	570	591	710

Structure 5 uses time points determined by the retrograde of this series, multiplied by 13

221	260	455	520	663	832	949	1196	1287	1300

Figure 4: Lengths of the 10 Structures of *Pièce électronique nr. 3* in cm of tape at 76 cm/sec.

Within this opening structure, the same series in the same ordering is used, but is multiplied by a different constant. Seven times the original series yields the subsystem of durations also given in Figure 4. This version of the series determines several significant exit points for sine tones in the structure. When adjusted by 10 centimetres (a value Ligeti uses to account for splicing and synchronization with other tape segments), these points define a grid which determines, as one finds looking back at Figure 2, an accelerating rate of exits. Between each of these vertical gridlines an increasing number of voices exit: 0 voices between 0 and 17, 1 voice at 66; 2 voices between 66 and 199; 3 voices between 199 and 262, and so forth – the number of exits increases by exactly one until only three tones remain. Given Ligeti's concern with the »compositional design of the *process* of change«[9], articulated three years after this electronic piece, it seems that he has desgined such a process here by overlaying a linear rate of change onto an irregular timeline.

This process also suggests a kind of connection between the use of pitch and the use of rhythm, since each parameter is treated in a similar manner. While Ligeti takes each octave and divides it into harmonic or subharmonic arrangements of sine tones, the subdivisions within the points on Ligeti's time grid seem to have a few similar properties. Over the first two time spans there is a harmonic arrangement of time points; the interpolated point at 131 provides a nearly exact 1:2:3 relationship leading to near-constant differences between the values 66:131:199 [instead of 66:132:198]. Between 199 and 262 the interpolated points 216 and 237 create steadily

9 Ligeti, *Metamorphosis of Musical Form*, p. 19.

increasing differences [17-21-25] resembling subharmonic arrangements. While other spans show slightly more variance, the span between 430 and 465 returns to this quasi-harmonic regularity, with constant differences of 5 and then 6 centimetres [430-435-441-447-453-459-465].

Turning back to the larger picture, we find the timeline for Structure 5 is based on the series of odd numbers, this time in retrograde and thus linking these formal calculations to serial technique, but it also introduces anomalies which will require further consideration. Just as Structure 2 used a version of the series multiplied by 7, this structure uses a version of the row multiplied by 13 to fill out the full duration of 1300 cm (see Fig. 4). Groups in each channel begin according to points in the retrograde of this series, as shown in Figure 5. Attacks occur at the beginning of the Structure and at 260 and 455 centimetres, but then cease to correspond to the multiplied retrograde – the entrance in channel 3 beginning at 700, rather than 520 or 663.

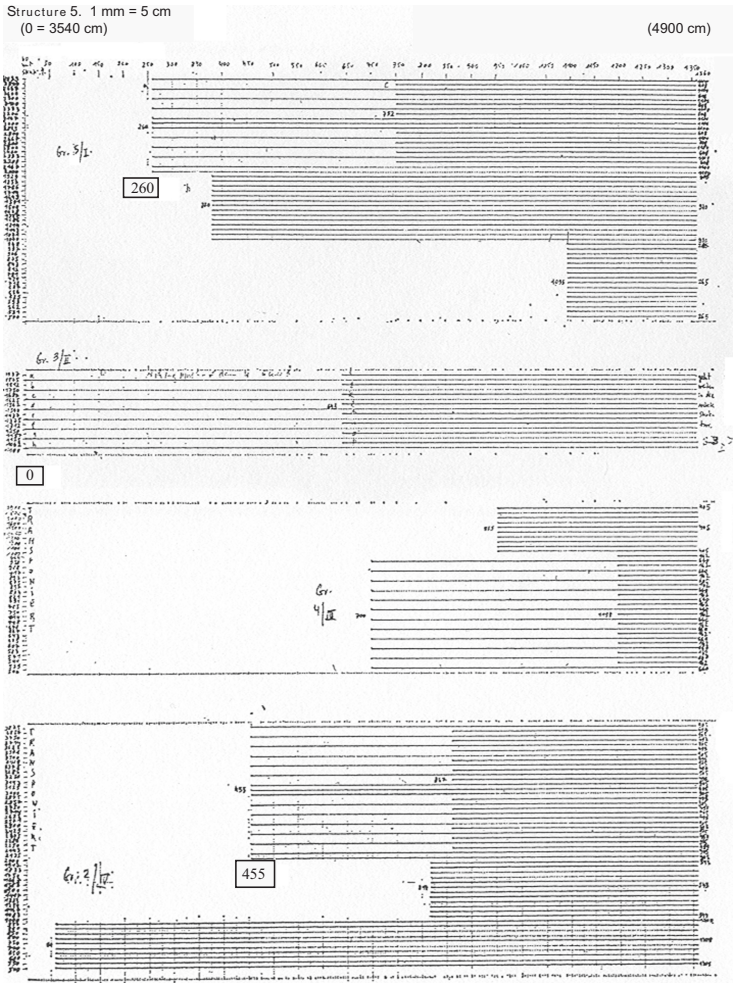


Figure 5: Ligeti, *Pièce électronique nr. 3*, Structure 5, with time points determined by the series' retrograde (adapted from Nordwall, *György Ligeti: Sketches and Unpublished Scores 1938–1958*, p. 70).

At this point in the piece deviations from the more ordered characteristics of the beginning are increasingly common, including entire reels labelled »transposed« in the score (a studio manipulation which could have effects on both pitch and rhythm), and also the introduction of filtered noise at the end of Structure 6 and impulses in Structure 7.

If Ligeti is diverging from the stricter serial arrangements shown in the opening Structure of the piece, then what logic now determines his choices? I argue that the effect of these decisions supports a global conception of form which Ligeti conceived of independently from the techniques he employed and, moreover, a formal scheme which he reuses in the first movement of his orchestral work *Apparitions* (1958/59), albeit on a greatly expanded scale. Namely, all of the decisions that deviate from the serial idea do so in order to link structures together, blurring their boundaries and individual identity, leading to a sense of dynamic transformation rather than a succession of individually contained Structures or Stockhausen-like moment forms.

Despite Eimert's celebration of intensity as an essential part of the »triple-unit« of the note, quantifiable in electronic music with an exactitude never possible in traditional media, Ligeti's dynamic markings are conspicuously non-serialized. His compositional decisions also contradict, rather than support, the boundaries provided by the serial structure in the latter part of the piece. In the beginning, the dynamic indications in the sketches give distinct shapes to the larger Structures, but later these are applied to more fragmentary and often overlapping »Groups« – so that two contradictory trajectories emerge: the Groups gain prominence by taking over the dynamic shapes previously reserved for Structures, while the structures themselves lose their prominence, resulting is a state of dissolution, in which the boundaries of Structures and Groups are subsumed into a greater polyphonic texture covering the boundaries of Structures 8–10.

Most significantly, because it represents a clear divergence from the view that serial electronic music should investigate the possibilities of microscopic sound organisation, Ligeti treats the three shortest structures of the piece in an entirely different manner. Structure 1 is described in the sketches simply as »reverberation« [»Hall«] suggesting that Structure 2 should emerge from out of this state. Structure 7 is described as »impulses« [»Impulse«] and coincides with the transformation of the pitches still remaining from Structure 6 into noise. Structure 9 is labelled in places as being an »echo« of Groups that occur in Structure 8, and which go on to blur the entrance of Structure 10. In fact the boundaries of these final structures are not at all clear from the realization score, particularly Structure 9 seems more like a development within the final polyphonic texture rather than a self-standing unit.

To summarize the form of *Pièce électronique nr. 3* (which is shown in a spectrograph in Figure 6), the work begins with balanced structures, carefully organized and showing a steady increase in motion through the first four Structures. At the end of Structure 6, the sine tones begin to diffuse into thinly filtered bands of noise and break further with the impulses of Structure 7, which seem to derail the sine tones into even wider noise bands. At this point, the low and middle registers drop out, leaving an extremely high and distorted echo of the original material.

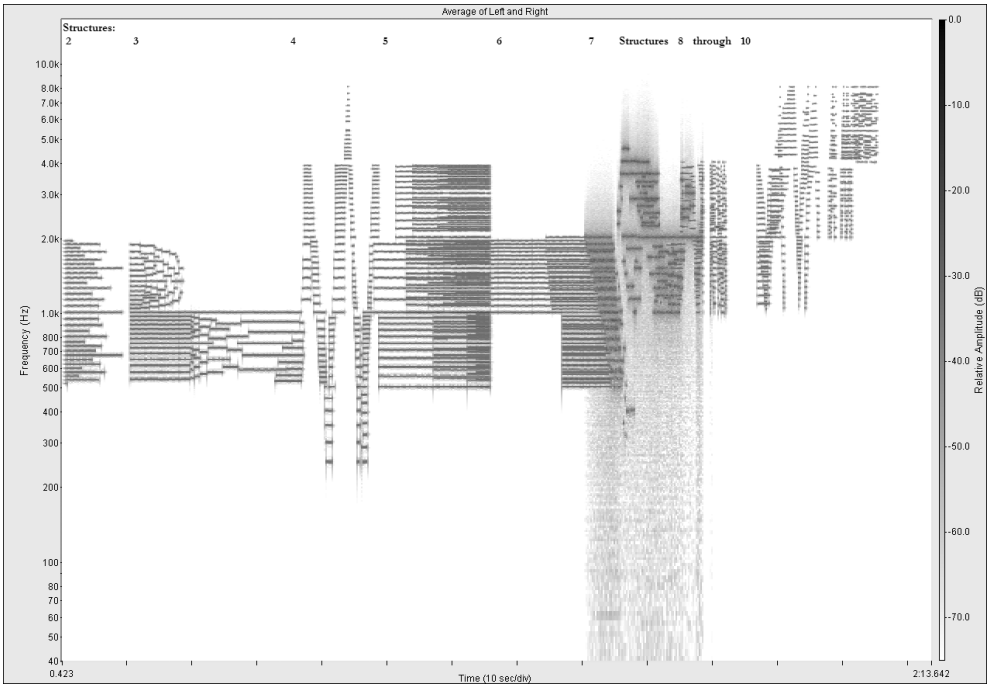


Figure 6: Ligeti, *Pièce électronique nr. 3*, Spectrograph of the entire piece.

This summary of the piece's form is quite similar to the composer's own description of his *Apparitions*, involving »delicate, resonant ›textures‹« of chromatic clusters at the beginning, which gain some degree of internal motion through the course of the initial sections of the piece. A second type of material – louder, percussive attacks – »leave[s] traces behind in the smooth noise-textures« and disrupts the opening state, which becomes more and more agitated, until, at the point of the largest attack, »the entire form is tipped over« and the register shifts dramatically from low to high.[10] Thus the general trajectory for both *Pièce électronique nr. 3* and *Apparitions* is exactly the same: a balanced state, increasing in activity, until impulsive disruptions tip the balance and ultimately shift the piece into the uppermost register. Moreover, in both pieces the sketches show Ligeti devising a rigorous formal plan for this balanced state and then diverging more and more from this plan as the piece progresses towards the tipping point. The similarities in these pieces are quite significant – not only do they group *Pièce électronique nr. 3* with a series of other known drafts of *Apparitions* (the orchestral fragments *Víziók* [*Visions*, 1956] and *Sötet és Világos* [*Dark and Light*, 1956]), but moreover they set the composer clearly apart from his contemporaries in Cologne, suggesting that, for Ligeti, compositional technique does not necessarily have an organic connection to form.

While Ligeti's use of more strict serialism to create a balanced state at the beginning of the work is meaningful, I would shun the interpretation that this is in some

10 Ligeti, *States, Events, Transformations*, pp. 166f.

way *symbolic* of Ligeti's overcoming the confines of serialism, presenting serial material at first and then exerting free-will to »escape« from it; but rather I favour the view that Ligeti considered serial structuring as one of a plurality of options – appropriate for some musical situations, textures or parameters, but perhaps not for others, a suitable starting point, but even as such, carrying little significance as a determinant for further direction. When Stockhausen and Eimert looked into the inner workings of a sound, they saw a chance to regulate and control the smallest elements of composition bringing them into a unique new kind of organic unity. Ligeti, however, saw an inherent complexity in these microscopic sounds based on opposition and plurality, which became the model for his later compositional methodology. Thus Ligeti's view of serialism is essentially non-dogmatic, and he continued to both employ and criticize aspects of serialism in the years around 1960, because he did not view serialism as an end in itself or as a language or as a fundamental organisational principle for ever-permutable moment forms, but rather simply as a tool to achieve states of balance or turbulence – or any other goal his imagination might devise.

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