FILTERING AND SYNTHESIS: IT-BASED APPROACH IN THE COMPOSITIVE PROCESS OF GIOVANNI VERRANDO AND FAUSTO ROMITELLI

Luca Befera

Dipartimento di Musicologia e Beni Culturali,
Università di Pavia
luca.befera01@universitadipavia.it

Luca Guidarini

Dipartimento di Musicologia e Beni Culturali,
Università di Pavia
luca.guidarini01@universitadipavia.it

ABSTRACT

To investigate the influences that information technology has brought to musical writing and compositional process, the cases of Giovanni Verrando and Fausto Romitelli – Italian post-spectral composers of the 1960s generation – will be examined. After their studies at IRCAM in Paris, they integrated tools of digital sound treatment and musical form management into their notation, opportunely mediated by software and informatics tools. Two fundamental aspects of their language will be investigated: the cyclical organization of the form, and timbral generation techniques as filtering for Verrando and synthesis for Romitelli. It will be demonstrated how the principles indicated, deriving from specific methods of digital treatment of sound, are applied to the creation of complex timbres reproduced by the orchestra or by the ensemble. In both cases, the results are a writing process, compositional way of thinking and sound outcome hybrid between acoustic and electronic, determining a formal management mediated by sound data and according to a prominently IT-based approach.

1. INTRODUCTION

During the 20th century, technology became an integral part of the sociocultural environment, determining significant changes in various fields of human activity according to a technomorphic process.[1] This reflected a different conception of the cultural objects, considered as data of a heterogeneous nature. The proliferation of software, the web, personal computers or, more generally, digital devices in everyday life, has invested an expanding catchment area, manifesting itself in a different way of conceiving reality [2, 3, 4]. In the theoretical field, this has evolved from studies in the area of information theory and, in parallel, to computer science [5, 6]. The binary code revolution caused a progressive substitution of the digital perspective over the analogue one, towards a widening of the communicative possibilities mediated by virtual platforms [7, 8]. Therefore, cultural objects have also acquired the value of data, which can be managed with the help of computers and which, in an equal and opposite reaction, are influenced by digital language.

The use of informatics or, more generally, electronic devices as a tool to support or expand creative and performing possibilities affected also the musical domain. Starting from the pioneering studies done in the '50s and '60s in well-known centers such as Club d'Essay in Paris, WDR Studios in Cologne, Bell Laboratories in New York and Studi di Fonologia Musicale Rai in Milan [9], the experimentation on music software became a focal point of some institutions' research during the '70s, among which IRCAM held a central role. There, the spectral composers found an ideal place to develop their timbral research: composing "the sound" and not "with sound" [10, 11] became one of the key principles of their studies by means of software for sound analysis and production, or, namely, for the management of the spectral content. At the same time, some synthesis models were used to manage the pitches organization, to reproduce complex sounds by orchestral rendering or generate sequences of sonic events according to algorithms or abstract criteria. Therefore, the mediation of informatic procedures and software such as Max/MSP, PatchWork, OpenMusic, Audiosculpt, and Csound assumed the dual function of

[1] The term, applied by Eric Maestri in the musicological field, was derived from the science and technology scholar Linda Caporael, who defines 'technomorphism' as "the attribution of technological characteristics to humans" [1]. The concept was discussed by the former author regarding the sound parameter in the speech Timbre is a technomorphic thing: A comparative analysis of three case studies, held during the conference Timbre is a Many-Splendored Thing on 4-7 July 2018 at McGill University in Montreal.

means for sound production and tool to manage the formal organization [12].

Within this paper, these dynamics will be investigated in the production of Giovanni Verrando and Fausto Romitelli, Italian composers of the ‘60s generation who studied at IRCAM and integrated into their compositional approach elements derived from informatics and electronic practice on the basis of what already done by the spectral authors of the previous generation. The parallel formation path of the two composers started from the education at the Conservatory of Milan and the courses of Donatoni at the Civica Scuola di Musica and Accademia Chigiana, then proceeded in the *Cursus de composition et informatique* at IRCAM – Romitelli from 1990 to 1991, then remaining in the Parisian institution as Compositeur en recherche from 1993 to 1996, and Verrando from 1993 to 1997 [13, 14]. The ways of managing sound and form were therefore influenced by common roots, although each one of them would have then developed his specific means of expression.[2]

The cases of the filtering in Verrando’s *Filtering* – first movement of *Triptych* (2005-2006) for large orchestra and electronics – and the synthesis in Romitelli’s *Hellucination I – Drowningirl* – third movement of *An Index of Metals* (2003) for soprano, ensemble, electronics and video – will be investigated, since these pieces, identifying the stylistic evolution of each author, exemplify the influences of information technology (IT) in their compositional approach. The cases presented in the paper are the results of a research that focuses on the precompositive material analysis, both by a sonic and formal point of view. The analysis of the IT derived sketches and preparatory materials underlines a close relation between their compositional practice, especially in the macro-formal and sonic construction domains. In both the pieces analyzed, the form is conceived in a cyclical way, but with different purposes: in *Filtering*, the sounds are organized as discretized and clearly perceptible units; in *Hellucination I – Drowningirl* the modular construction is conceived in a way that sonically avoids the perception of the cycle. Therefore, each author manifests a compositional approach based on modules, to construct a likewise segmented form or to generate a continuous process where the modules are not even recognizable. Moreover, the sonic perspectives are complementary: in the first case, filtering is a useful process to manage the spectral content while synthesis is a means for sounds production; in the second, filtering is an informatics and symbolic tool while synthesis is a model through which the spectral content is oriented. The specific dynamics within which filtering, and synthesis become part of the compositional process and formal structuring with the help of informatics tools will be further analyzed.

2. GIOVANNI VERRANDO: FILTERING

2.1. Introduction

The experience in Paris was particularly relevant for Giovanni Verrando: from then on, the composer began to implement his research on sound through informatic devices. Since 2005, this aspect has been integrated by experimentation on timbral possibilities of acoustic instruments, in what he defines ‘new lutherie’ as “the stable introduction of new instruments into the ensemble and a more general openness to the evolution of lutherie” [16]. This research is closely connected with the usage of informatics tools: the new timbral possibilities are also implemented by rendering electronic sounds - often obtained through entirely digital processes - by means of the acoustical ensemble. This process involves the comparison between the acoustic and electronic spectra, conveyed towards a hybrid outcome. Moreover, this approach is mediated by the psychoacoustic science deepened during the IRCAM education, where both the extended techniques and software research became useful tools for a deeper study of timbre and syntactic management of sounds. The notation was therefore influenced by sounds generation and organization, mediated by software such as Audiosculpt for the definition of the timbral content and Max/MSP for the management of the discrete objects that contain it.[3] In the two following sections, these dynamics will be respectively investigated, taking as an example some excerpts from *Filtering*, first movement of *Tryptych* (2005-2006) for large orchestra and electronics.

2.2. Timbral content

In *Triptych*, all the synthesized - and then re-orchestrated - sounds come from 38 predetermined samples [14, 16]. The composer works with Audiosculpt to analyze or resynthesize the sounds, modelling or selecting the spectral components of samples taken from other pieces or previously generated by himself through digital synthesis: from the continuous comparison between the graphic result visible in the sonogram, the effects generated by the instruments and the relative acoustic perception, he orients the compositional process towards the desired sonic result. This process implies a close relationship between electronic and acoustic sounds. To clarify this dichotomy, Eric Maestri defines the categories of ‘endogenous movement’ (modifiable within itself) and ‘exogenous movement’ (relative to the gesture): “Electronic sound is characterized by the expansion of the envelope, and in particular of the sustain, which becomes the centre of sound evolution and the moment in which the difference between the instrument and the electronics is decisive. [It

[2] For more information about the interconnections between the two authors, see the thesis *Sincronie: Interconnessioni Formali tra Nova, Verrando, Romitelli e l’Electronic Dance Music negli Anni ’90*, which examines their collaboration in the Nuove Sincronie and Sincronie festivals and some aspects of a common compositional approach through information theory and informatics tools, especially at a syntactic level [15].

[3] The composer himself attests the usage of the software in the interview realized by Luca Befera on August 7th, 2019.

becomes fundamental] the control of the evolution of sound over time; the change of energy in the spectrum without re-attacking the sound. In this way, endogenous and exogenous movements change the hierarchy. Where in instrumental music it is the gesture-carried sound that dominates, in electronic music it is the texture-carried sound; the decisive difference between electronic and instrumental sound seems to me to be given by the different evolution of envelope maintenance" [17]. Although computer processing allows multiple gradients between these categories, as well as, in some cases, it is possible to control the envelope through the instrumentation, the categories are useful to describe macro-tendencies of the spectral content, which are expressed in a perceptual dichotomy or - if the composer himself wants to recreate electronic effects through acoustic gestures as in this case study - in hybrid sonic results.

In addition to the dialectic relationship between endogenous and exogenous movement, Verrando manages the formal structure according to the perceptive differences between inharmonic, aperiodic, harmonic and sinusoidal sounds [16]. These principles derive from the psychoacoustics studies made in the '90s by Albert Bregman and Stephen McAdams on the 'auditory scene analysis'. This theory is based on the examination of how the brain processes acoustical images of certain sounds to recognize their location and connotation. Given two simultaneous sounds, the listener will or will not split their perception depending on their sound qualities and, consequently, on the relationships that he established between them. An 'auditory stream' is defined as "our perceptual grouping of the parts of the neural spectrogram that go together" [18] or, in the definition of his proselytes Daniel Pressnitzer and Stephen McAdams, as "a sequence of events that can be considered to come from a same source" [19]. In both cases, listeners segregates the stimuli present in a sound input system through their perception, defined as 'auditory scene'. The streams are discretized according to the spectral composition of the sounds, their location within space and different rhythmic patterns. Verrando uses Audiosculpt to work precisely on the segregation of auditory streams by observing and modelling the spectral content through the software's graphical interface. In the example in Figure 1 (relative to what the composer defines as *Triptych*'s 'sound 31'[4]) it is possible to observe waving bands cancelled in the spectrum to recreate an oscillation of the inharmonic frequencies within the sound. Figure 2 shows another approach, in which Audiosculpt is used for spectral analysis only. The sonogram at the top left refers to a sample taken from Rasite, the sixteenth track of the album Aaltopiri by Pan Sonic: observing and listening, the composer works to achieve the most similar sonic result,

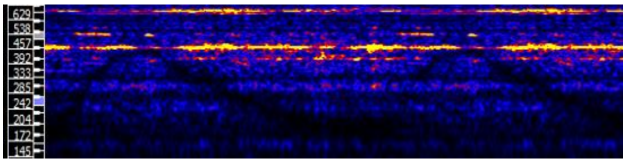


Figure 1. Inharmonicity oscillations in the 'sound 31' of *Triptych*.

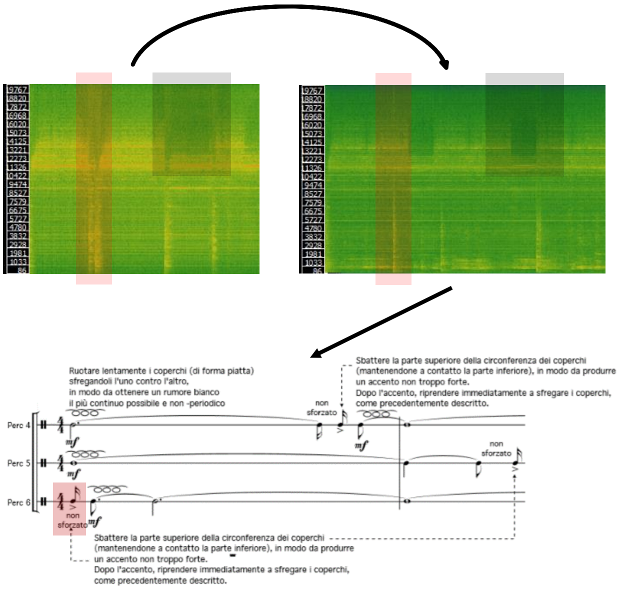


Figure 2. Comparison between Pan Sonic's *Rasite* ex-cerpt (top left) and 'sound 2' of *Triptych* (top right); the squares show the spectral affinities and the relative nota-tion.

using cymbals (top right). The resulting adiastematic notation (bottom) indicates just the durations of the percussive accents and rubbing of the cymbals, while the specific instrumental technique is explained in the word-written instructions. Figure 3 shows a further instrumental resynthesis: starting from an additive synthesis of sinusoidal sounds – loaded in the sampler (bottom-left) – the composer generates a harmonic aggregate (top-left), which is rendered through the ensemble and represented in diastematic notation (right). Therefore, these are not sinusoidal but complex timbres, whose perceptual result tends to be harmonic.

Hence, each kind of notation aims to translate a specific timbral category, through diastematic/adiastematic notation or by simple words explaining the gestures. The peculiar sonic result, focused on the spectral implications, is mainly generated by the materiality of non-conventional objects and instrumental extended techniques derived, above all, from the endogenous/electronic content at the very basis of the piece.

[4] The samples, part of which are shown in Figures 1, 2 and 3, were kindly given to me by Verrando on August 13, 2019. In the file there are four folders: the first three are related to different savings of the transcription on Finale of the orchestral score; the last one, called 'Triptych-Sampler-Max', presents the 38 samples to be used in the synthesizer and the Max/MSP patch for the application of these on the keyboard. The synthesizer reproduces either the electronic sounds that cannot be realized with the instrumentation used (e.g. sinusoidal sounds) or double the orchestral sound prerecorded in the samples. The approach highlights a retrospective assembly of discrete elements previously obtained.

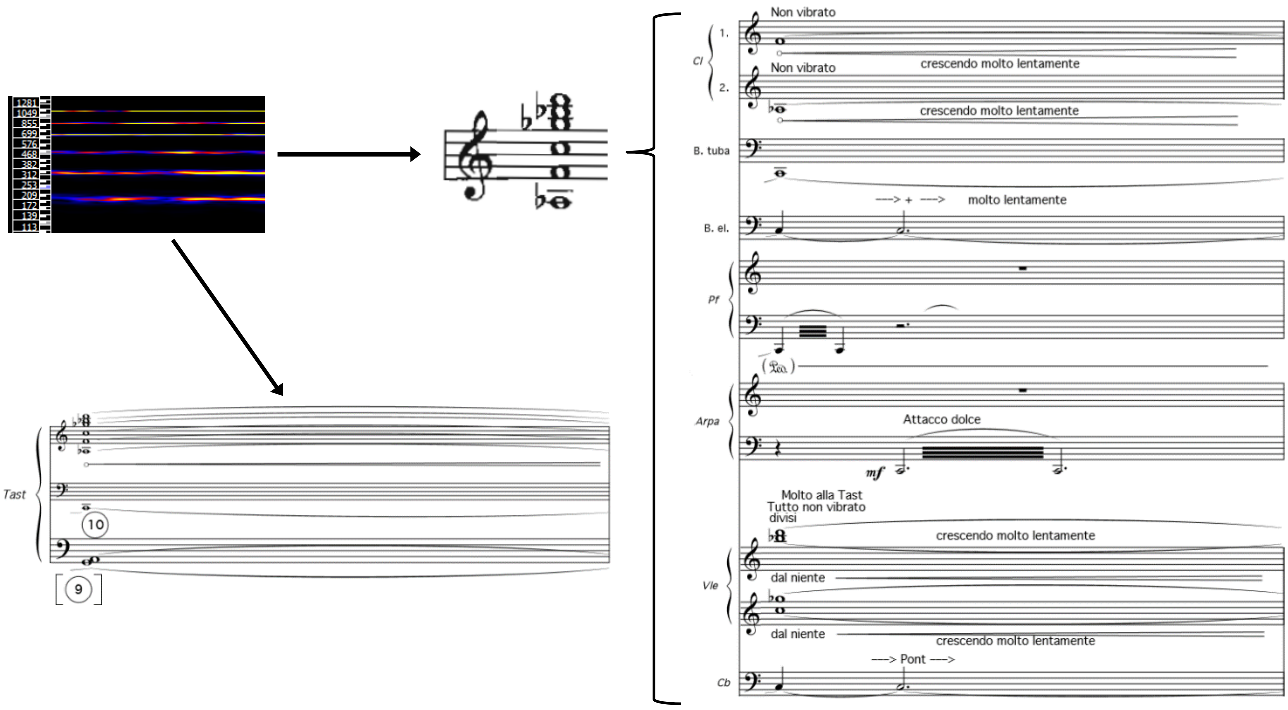


Figure 3. Transcription of the 'sound 10' (sonogram on top-left), loaded in the sampler ('Tast', bottom-left) and re-orchestrated in the score for clarinet, bass tuba, electric bass, piano, harp, viola and double bass (right). The written notes are concert pitches.

2.3. Syntax

The spectral content just described is inserted in clearly defined discrete units. The 38 synthetic sounds, from which the instrumental orchestration comes from, are loaded in a sampler on Max/MSP [15]. Each one of these is marked in the score through the circled numbers (e.g. Fig. 3, sampler score on bottom-left) and reproduced in the whole play. The usage of the pre-compositive material as circumscribed informatic units reflects also the structure of the piece, organized by 'blocks' (numbered in Fig. 4) structured on data of spectral nature. The blocks content is managed by Verrando according to the oppositional categories described in the previous section (inharmonic, aperiodic, harmonic or sinusoidal sounds), which, by contrast or affinity, characterize also the blocks succession. The repetition of the same or similar elements (letters in Fig. 4) plays an important role in the macro-formal distribution, defining a cyclicity that operates on medium- and long-range.

Regarding the organization of sounds, Ingrid Pustijanac has already observed: "the materials are structured according to these two possibilities: juxtaposition or overlapping of only two harmonic planes" [14]. Beyond the simple consequentiality of the timbral blocks already discussed, this means that it is possible to identify the superimposition of multiple auditory streams within them. These streams are segregated according to the 4 spectral categories already discussed. In Table 1, a possible coding of the elements contained in the first 8 blocks is proposed, defined as follows: harmonic sounds (*a*), sinusoidal sounds (*s*), inharmonic sounds (*r* or *p* if generated by the cymbals) and impulses (*i*). The subscripts indicate different types of these categories, whereas the initial aperiodic sounds (*ap*) are recreated by playing the cymbals with the bow, generating sounds between the harmonic and metallic connotation. The sum indicates the overlapping of several elements: although there is a 'polyphony of timbres' on the whole - indicating a sort of 'global sonority' of a musical signal, which consists of several inner components [22] - by separating the internal streams it is possible to argue perceptual interconnections between different blocks. Therefore, in the last two columns, where the predominance of some elements has been inferred [15], it

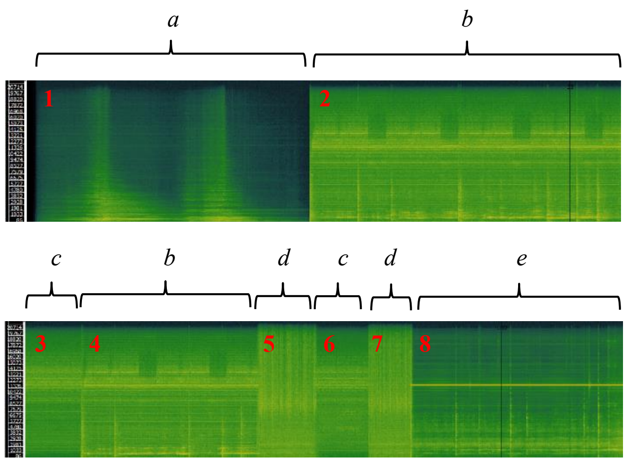


Figure 4. Formal distribution of 'blocks' over time in the beginning of the piece.

Blocks	Duration in score (in quavers)	Elements sequences	Predominant elements	
1	13	(ap_1)	$(a)(p)$	$(a)(p)$
2	20	$(s+p_2+i)$	$(s)(p_2)$	(p_2)
3	4	$(s+r_1)$	(r_1)	(r)
4	12	$(s+p_2+i)$	(p_2)	
5	4	(r_2+r_3)	(r_2)	
6	4	$(s+r_1)$	(r_1)	
7	3	(r_2+r_3)	(r_2)	
8	16	$(s+p_2+i)$	$(s)(p_2)$	(s)

Table 1. Coding of the elements contained in the first 8 blocks.

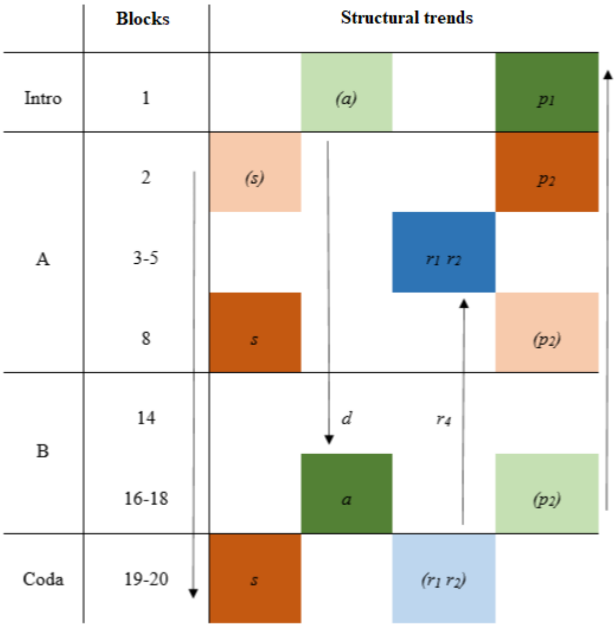


Table 2. Macro-formal distribution of the auditory streams in the first movement of *Triptych*, *Filtering*.

is possible to observe some timbral processes operating on the form as a whole: within the first 8 blocks, a progressive transformation occurs from the initial aperiodic sonority to the sinusoidal sound of block 8, passing through different types of inharmonic sounds. By extending this consideration to the macro-form (Table 2), it is possible to observe the repetition of some internal streams on a wider range. Each time, the different combinations of the same sounds generate specific polyphonies of timbres. Within these, the repeated elements maintain a parallel - though not simultaneous - flow, producing processes of internal mutation of the spectral components.

Summarizing, informatics spread across the whole piece and influences the very routes of the compositional process. First of all, the electronic – or electronic derived – sounds generated by software predominate and are inserted in discrete and clearly recognizable elements. Secondly, the timbral material is managed according to quantitative criteria related to the spectral content and inserted in discrete elements assembled by juxtaposition or overlapping of sounds. Finally, the identical repetition of some structural functions resembles a digital treatment of sound, whose polyphony of timbres is branched into smaller streams or spectral data. The syntactic structure, partly derived from spectral practice, corresponds in Verrando to a specific procedure, which finds in 'new lutherie' a peculiar realization. The resulting notation is related to digital processes, which are later translated into the score to ensure an easy intelligibility by acoustic instrumentalists. However, it always maintains strong informatics and electronic connotation, manifested in sonic results and formal management.

3. FAUSTO ROMITELLI: SYNTHESIS

3.1. Introduction

Since his first approach with the IRCAM cursus in 1991, Romitelli introduces computer aided composition knowledge – a topic of interest at the Institute since the 80s – in his practice. With the help of Laurent Pottier, he developed a personal PatchWork library [23], used for the pieces written in the '90s. In the 2000s, Romitelli started to work with the OpenMusic language[5], mostly to create and organize fixed harmonic fields in a personal compositional discourse. Unlike Giovanni Verrando's case, Romitelli doesn't start from a preexistent spectrum in order to resynthesize the exact auditory image, but rather from a sound-synthesis criterion that symbolically – thanks to PatchWork and OpenMusic – generates pitches aggregates of imaginary complex spectra to be orchestrated. The actual state of research doesn't permit to examine Fausto Romitelli's personal computer – preserved by the Giorgio Cini Foundation in Venice (Fondo Fausto Romitelli, FFR from now on) – but the sketches-driven analysis permits to investigate the symbolic synthesis process that allows him to create the formal and pitch organization of *Hellucination I – Drowningirl*, the third section of *An Index of Metals* (2003), video-opera for soprano, ensemble and electronics.

3.2. Sources

Currently preserved by the Giorgio Cini Foundation in Venice (Fondo Fausto Romitelli), the sources analyzed for this research were conserved in a mixed folder - that contains sources related to *An Index of Metals, Domeniche alla periferia dell'Impero* (1996/2000), *Seascape* (1994), and notes for lessons – and consist in:

[5] Personal call with Luca Guidarini, 12.06.2018. Paolo Pachini was the musical informatic and video maker that helped Romitelli in *An Index of Metals*.

A. Three pages of annotations, schemes, and tables for the control of time, density and dynamics (Figs. 5a and 5b);

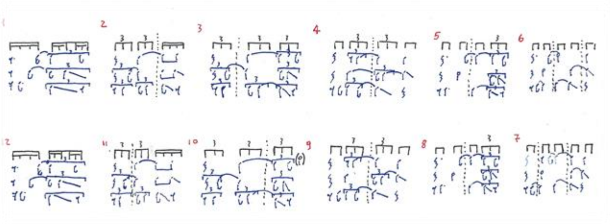


Figure 5a. First two pages of A resumed, FFR, transcription.

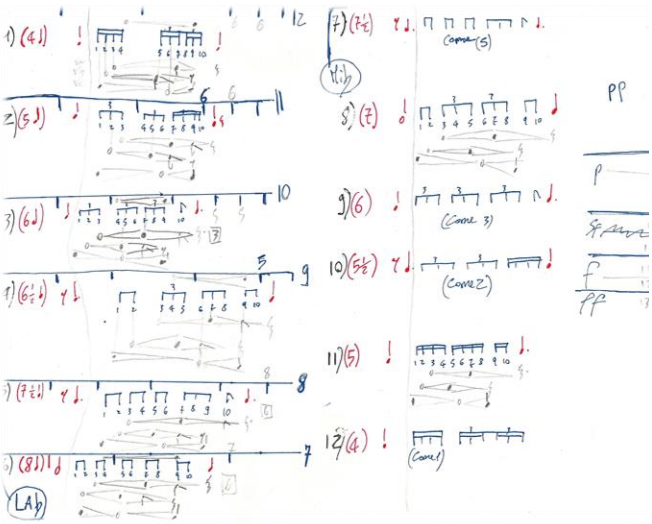
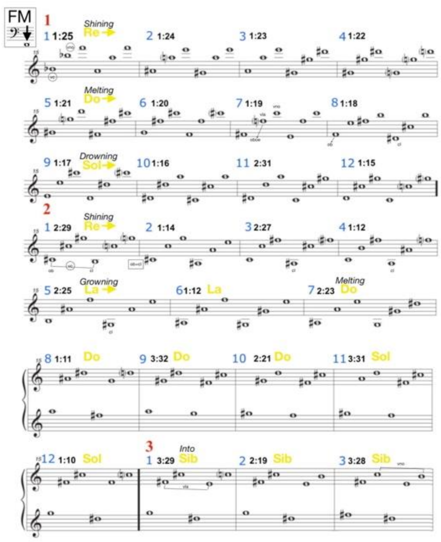


Figure 5b. Third page of A, FFR, transcription

B. Three double-sided pages of sketches, with references to a and c. (see Fig. 6);



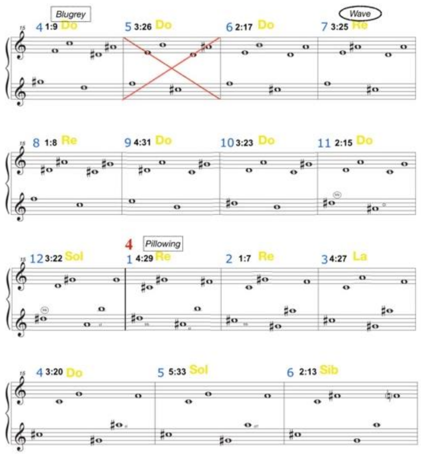


Figure 6. First two pages of B, FFR, transcription.

C. One glossed page of B. Truax, "Organizational Techniques for C:M Ratios in Frequency Modulation" [24].

0:1	1:32	1:31	1:30	1:29	1:28	1:27	1:26
1:25	1:24	1:23	1:22	1:21	1:20	1:19	1:18
1:17	1:16	2:31	1:15	2:29	1:14	2:27	1:13
2:25	1:12	2:23	1:11	3:32	2:21	3:31	1:10
3:29	2:19	3:28	1:9	3:26	2:17	3:25	1:8
4:31	3:23	2:15	3:22	4:29	1:7	4:27	3:20
5:33	2:13	5:32	3:19	4:25	5:31	1:6	5:29
4:23	3:17	5:28	2:11	5:27	3:16	4:21	5:26
6:31	1:5	6:29	5:24	4:19	3:14	5:23	7:32
2:9	7:31	5:22	3:13	7:30	4:17	5:21	6:25
7:29	1:4	8:31	7:27	6:23	5:19	4:15	7:26
3:11	8:29	5:18	7:25	9:32	2:7	9:31	7:24
5:17	8:27	3:10	7:23	4:13	9:29	5:16	6:19
7:22	8:25	9:28	10:31	1:3	11:32	10:29	9:26
8:23	7:20	6:17	11:31	5:14	9:25	4:11	11:30
7:19	10:27	3:8	11:29	8:21	5:13	12:31	7:18
9:23	11:28	2:5	13:32	11:27	9:22	7:17	12:29
5:12	13:31	8:19	11:26	3:7	13:30	10:23	7:16
11:25	4:9	13:29	9:20	14:31	5:11	11:24	6:13
13:28	7:15	15:32	8:17	9:19	10:21	11:23	12:25
13:27	14:29	15:31	1:2				

Figure 7. C:M ratio series of order 32, table from B. Truax [24].

3.3 Control of time and cyclical organization

The first two pages of A contain twelve 3-voices modules (Fig. 5a). A rhythmic figure, which structures the glissato gesture of the strings over time and controls its duration (for a total of 42 quarter notes) in a progressive way, can be seen on the top of each module. The modules mirror around an axis represented by the 6th and 7th modules. They express the cyclical nature of the formal organization: the twelve-module cycle is repeated eleven times during *Hellucination I – Drowningirl*; the last repetition of the cycle is interrupted at the moment of its maximum length (at the 6th module). An ordinate series of numbers (1-13) expresses the formal scheme of cyclical repetition (see Fig. 5b, right side). Every cycle introduces elements that increase the global density in the formal process that expresses a general crescendo, both in the strings and winds/brass. The internal organization of the modules, with the help of the glissato gesture on the strings and of the electronic sounds is conceived in a way that avoids the perception of the cycles that construct the section.

Three gestures (Figs. 8 to 10) that produce a gradual complexity of sonic material are assigned to the winds/brass instruments, and their use depends on the density condition:

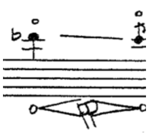


Figure 8. Gesture 1.

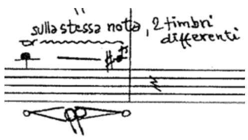


Figure 9. Gesture 2

Figure 10. Gesture 3.

The remainder of the third page of annotations (Fig. 5b) is occupied by a scheme that seems to be useful to organize dynamics peaks over time. Romitelli, for that, uses the same temporal modules of the other two pages.

3.4 Pitch organization and FM synthesis

The source B consists of a double-sided bifolio and a single double-sided page (Fig. 6). It contains a scheme with 150 bars of pitch aggregates, with numerical references to A and C, some orchestration indication, textual references to the soprano part and harmonic references to the guitar, bass and keyboard parts. The genetic criteria of those aggregates are explained by two details of the sketch: a box with the indication "FM D1[notated]" and the ratios written above every aggregate. 'D1' indicates the nominal – and hidden through the process – frequency of a Frequency Modulation, whose ratios are expressed over every aggregate. C is a glossed page of Truax, Barry [24] and contains an organizational table representing the C:M ratio series of order 32 (Fig. 7). Truax used the first half of a Farey sequence of order 32 due to creating a gradual descending of the modulator frequency from 1:32 to the harmonic ratio 1:2 that divides symmetrically the whole series.

Frequency Modulation was used in the so-called instrumental synthesis since Murail's *Gondwana* (1980) [25] as a static technomorphic metaphor useful to create complex sounds; in the case of *Hellucination I – Drowningirl*, FM assumes structural relevance since the organization of the pitch aggregates is driven by the process Truax explained in his table. Starting from that and from the pitch aggregates of the source B it was possible to recreate on Max8 – using *bach* and *cage* libraries[6], especially the object *cage.fm* - the OpenMusic patch he used to create the symbolic FM, from the fundamental frequency and the ratios between the carrier and modulator frequency, with a fixed modulation index of 1 (Fig. 11).

Figure 11. Patch reconstruction on Max8, *presentation mode*.

The patch operates with an approximation of semitones, meaning that the principle behind the instrumental synthesis of Romitelli is not the aural accuracy of a timbre, but the creation of interesting-hearing, and processional driven group of fixed harmonic fields.

3.5 From sketches to score

Figure 12 shows the realization of the first formal cycle in the strings, in which the density is at its minimum point. The numbers of the formal modules correspond to those of Figure 5, the ratios are those of Figure 6.

[6] The *bach* and *cage* libraries are collections of modules to deal with Computer-aided composition in Max, developed by Andrea Agostini and Daniele Ghisi (https://www.bachproject.net/, accessed 18.04.2020).

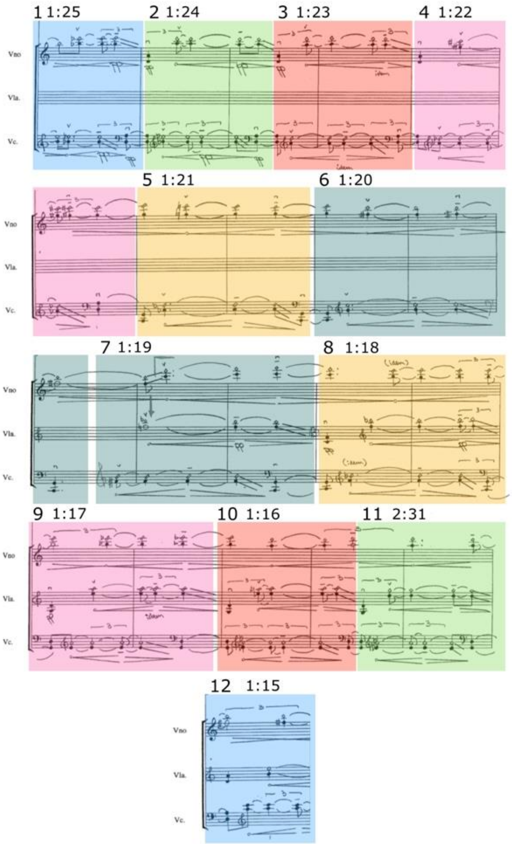


Figure 12. Pages 12-14, strings section score.

The score corresponds to the sketches within three exceptions:

1) The 3rd repetition of the cycle skips the 5th module. As a result, the text is sung without interruption in the vocal part.
2) In the 3rd module of the 7th repetition of the cycle Romitelli changes the pitch content in order to preserve the semitonal descending line of those pitches, without this correction the applications of Farey's ratio (8:31) would create an interruption of the descent.
3) The last two and a half cyclical repetitions present a different pitch organization in the winds/brass. In the previous repetitions those instruments doubled, echoing the pitches of the strings. In those last cases they become autonomous and play independent pitch aggregates from B (Fig. 6). As a result, there is a temporal compression of the process duration and an increase of the textural density.

3.6 Electronics

The 11-channels electronics of *An Index of Metals* has three functions:

1. Integration with the instruments;
2. Articulation of a single event;
3. Sampling from other's music: the *Introduzione* from Pink Floyd's *Shine on You Crazy Diamond* and the *Intermezzi* from Pan Sonic's works.

According to Paolo Pachini[7], who helped Romitelli in the realization of some electronics, *Hellucination I – Drowningirl* refers to the first function. Pachini filtered a sound of a bowed metallic tube with a CSound vocoder, then refiltered and processed it with the FM instructions Romitelli gave to him. Probably the indications were similar to the instrumental one since the pitches of every single spectrum correspond to the instrumental and the simulated ones.

3.7 Multi-layered form

Formally, the piece presents an independent harmonic line formed by the soprano, the electric guitar and bass, and the keyboard runs his own process (Table 3) alongside the instrumental synthesis.

	1(1)	2(1,5)	3(1,5)	4(2)	5(2)	6(2,5)	7(2,5)	8(2)	9(2)	10(1,5)	11(1,5)	12(1)
1	(A)D				C				G			
2	D				A		C				G	
3	Bb			C			(A')D			C		G
4	D		A	C		G	Bb			C		
5	(A'')D	C	A	G	D	A	C	G	Bb		C	
6	(B) D	G	Bb	D		G	Bb	D		G	Bb	C
7	(A'')D	C	A	G	D	A	C	G	Bb		C	
8	(C) D		Eb	F	G	Bb	D		G	Bb	C	C#
9-10	(A'')D	C	A	G	D	A	C	G	Bb		C	
11-12	(C') D		Eb	F	G	Bb	D	G	Bb	D	C	A
13	(D)G	D	A	C	G	Bb	D					

Table 3. Harmonic line of the guitar, bass, and keyboard according to the 12 cycles.

The whole harmonic line can be represented as: A (b. 56 – 103) A' (104 -137) A'' (138 – 158) B (159 – 179) A'' (180 – 200) C (201- 221) A'' (222 – 242) C' (243-263) D (264 – 276). The first A is dilated from the start to the end of the 6th module of the 3rd cycle. A' is a variation of A, compressed in one and a half cycle.

4. CONCLUSIONS

The two analyses, although based on different assumptions, demonstrate the influence in writing and notation of an IT approach. The authors, coming from a similar background where of great importance were the practices studied at IRCAM, moved towards their specific experimentations discussed in relation to the considered pieces. The software usage, strictly connected to a spectral approach, is implemented towards specific modalities of sound generation and control of formal organization. The use of filtering and synthesis processes is emblematic of these dynamics, as practical applications of abstract informatic models. Within the macro-form, the internal processes are stratified in different ways, not explicitly perceived, but organized to generate cyclical repetition and

[7] Personal call with Luca Guidarini (see footnote 5).

continuity. Layering and modularity became two fundamental principles to manage the spectrum possibilities, generated from and structured through an IT-based approach. It is also possible to discern wider considerations through these assumptions: their compositional models belong to a technomorphic environment which, consolidated in art music context in the 70s also thanks to the Parisian institution, took specific ramifications starting from the 2000s. The musical language becomes more and more permeated by digital influences both at structural and computer-aided processes level, as fundamental elements in the authors' poetics.

5. REFERENCES

[1] L. R. Caporael, "Anthropomorphism and mechanomorphism: Two faces of the human machine," *Comput. Hum. Behav.*, vol. 2, pp. 215–234, 1986.

[2] M. Buckland, *Information and Society*. Cabridge: MIT Press, 2017.

[3] F. Webster, *Theories of the Information Society*. New York: Routledge, 2014.

[4] C. May, *Key Thinkers for the Information Society*. New York: Routledge, 2002.

[5] J. Gleick, *The information: A history, a theory, a flood*. London: Fourth Estate, 2011.

[6] D. J. C. MacKay, *Information Theory, Inference and Learning Algorithms*. Cambridge: Cambridge University Press, 2005.

[7] L. Manovich, *Software Culture*. Milano: Olivares, 2010.

[8] L. Manovich, *The Language of New Media*. Cambridge: MIT Press, 2001.

[9] P. Manning, *Electronic and computer music*. New York: Oxford University Press, 2004.

[10] G. Grisey, "Zur Entstehung des Klanges," *Darmstädter Beiträge zur Neuen Musik*, vol. 17, pp. 73–79, 1978.

[11] F. Romitelli, "Il compositore come virus," in *Il corpo elettrico: viaggio nel suono di Fausto Romitelli*, A. Arbo, Ed. Monfalcone: Teatro Comunale, 2003, pp. 81–83.

[12] G. Assayag, "Computer assisted composition today," in *Applications on contemporary music creation: Esthetic and technical aspects*, 1998.

[13] A. Arbo, Ed., *Anamorphoses: Etudes sur l'oeuvre de Fausto Romitelli*. Paris: Hermann, 2015.

[14] I. Pustijanac, "La ricezione del pensiero spettrale negli ultimi due decenni in Italia," in *Italia/Francia. Musica e cultura nella seconda metà del XX secolo. Atti del Convegno internazionale di studi*, 2009, pp. 347–372.

[15] L. Befera, "Sincronie: Interconnessioni Formali tra Nova, Verrando, Romitelli e l'Electronic Dance Music negli Anni '90," Università di Pavia, Cremona, 2019.

[16] G. Verrando and AA.VV., *La nuova liuteria: Orchestrazione, grammatica, estetica*. Milano: Suvini Zerboni, 2012.

[17] E. Maestri, "Movimento esogeno e endogeno in Professor Bad Trip I," in *Have your trip: La musica di Fausto Romitelli*, V. Santarcangelo, Ed. Milano: Auditorium, 2014, pp. 117–141.

[18] A. S. Bregman, *Auditory scene analysis: the perceptual organization of sound*. Cambridge: MIT Press, 1994.

[19] D. Pressnitzer and S. McAdams, "Acoustics, psychoacoustics and spectral music," *Acoust. psychoacoustics Spectr. Music. Contemp. Music Rev.*, vol. 19, no. 2, pp. 33–59, 2000.

[20] M. V. Mathews and J. E. Miller, *The Technology of Computer Music*. Cambridge: MIT Press, 1969.

[21] G. Castagna, *Object-oriented programming: A unified foundation*. Boston: Birkhauser, 1997.

[22] J.-J. Aucouturier, "Dix Expériences sur la Modélisation du Timbre Polyphonique," Thèse de doctorat de l'Université Paris, 2006.

[23] A. Olto, "Between spectrum and musical discourse. Computer Assisted Composition and new musical thoughts in EnTrance by Fausto Romitelli," *Sounds, Voices and Codes from the Twentieth Century. The critical editing of music at Mirage,* L. Cossentini and A. Orcalli, Ed. Udine: Mirage, 2017, pp. 419-452.

[24] B. Truax, "Organizational Techniques for C:M Ratios in Frequency Modulation," *Computer Music Journal*, Vol. 1, No. 4, pp. 39-45, 1977.

[25] F. Rose, "Introduction to the Pitch Organization of French Spectral Music". *Perspectives of New Music,* Vol. 34, No. 2, pp. 6-39, 1996.

[26] M. Spicer, "(Ac)cumulative Form in Pop-Rock Music", *Twentieth-century music,* Vol. 1, No. 1, 29-64, 2004.