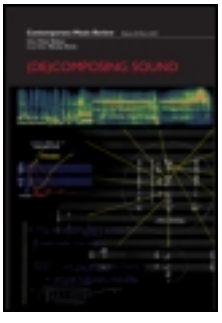
This article was downloaded by: [Ircam]
On: 11 February 2013, At: 09:25
Publisher: Routledge
Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Contemporary Music Review
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gcmr20

The Creative Process in Traiettoria: An Account of the Genesis of Marco Stroppa's Musical Thought

Vincent Tiffon & Noémie Sprenger-Ohana

Version of record first published: 20 Apr 2012.

To cite this article: Vincent Tiffon & Noémie Sprenger-Ohana (2011): The Creative Process in Traiettoria: An Account of the Genesis of Marco Stroppa's Musical Thought, Contemporary Music Review, 30:5, 377-409

To link to this article: http://dx.doi.org/10.1080/07494467.2011.665580

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: http://www.tandfonline.com/page/terms-and-conditions

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae, and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand, or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

Contemporary Music Review
Vol. 30, No. 5, October 2011, pp. 377–409

Routledge
Taylor & Francis Group

The Creative Process in *Traiettoria*: An Account of the Genesis of Marco Stroppa's Musical Thought

Vincent Tiffon and Noémie Sprenger-Ohana

Downloaded by [Ircam] at 09:25 11 February 2013

This paper aims to explore Marco Stroppa's compositional workshop through the emblematic work Traiettoria *to demonstrate how an underlying trend of spectral thought was present in the composer's mind during the gestation of the work but did not determine his aesthetic orientation. From the study of common filiations and difference between Marco Stroppa and the spectral composers, we intend to show how his years of intensive training in various disciplines crystallise into* Traiettoria*, giving rise to personal and long-lasting key concepts.*

Keywords: Marco Stroppa; Mixed Music; Piano; Synthesis; Spectrum; Music Technology; Music Computing; Creativity; Psychoacoustics; Computer Science; Music Cognition; Sketches Studies

The composition of Marco Stroppa's *Traiettoria* for piano and synthetic sounds (recorded on tape[1]) between 1982 and 1985 coincided with the apogee of the spectral movement (1975–85). When hearing the piece for the first time, it would be easy to identify a common aesthetic between Marco Stroppa and the spectral composers. Indeed, Stroppa and the spectral composers share a common intellectual and scientific background (acoustic, psychoacoustic), modes of musical and technical training (notably in the domain of sound synthesis), intentions around the issue of sound (resonances, harmonic/timbre perceptual ambiguities, the continuum between the concept and the percept, etc.) and more generally the multilayered organic model used in the compositional process. The study of documents that record the genesis[2] of *Traiettoria*, on the one hand enables the reconstitution of the compositional processes for the piece and on the other hand unveils crucial components of the composer's workshop. Indeed, *Traiettoria* was Stroppa's first compositional project after he finished his musical training. This project gave form to the composer's cognitive tools and shaped the key concepts of

ISSN 0749-4467 (print)/ISSN 1477-2256 (online) © 2011 Taylor & Francis
http://dx.doi.org/10.1080/07494467.2011.665580

his thinking and the development of his language, which while largely linked with the spectral momentum is not spectral from the point of view of the compositional process. These are our hypotheses about the construction of the composer's workshop during the creation of *Traiettoria* and the link between Stroppa's aesthetic and the spectral trend.

To prove our hypotheses, we will refer to a number of pedagogical documents dated after the composition of the piece as well as direct quotations from the composer as recorded in a series of recent interviews (September 2009–November 2010). The objective is to identify the exact filiations with certain protagonists of the 'spectralisme' and the bifurcations through several major compositional decisions, by examining in detail two key concepts that underpin Stroppa's compositional thought. First, the notion of interferences that accounts for the harmony/timbre ambiguity, the work on space in sound and the play with instrumental and electronic resonances. Second, the organic model, which encompasses notably the use of the *contrast model* (Tversky, 1977) in the composition of *Traiettoria* with the aim of producing perceptual effects of fusion and fission of auditory streams (McAdams, 1984). According to Stroppa (and to the spectral composers), those effects are essential to establish the correspondence between the composer's desired conception and the listener's reception.

Downloaded by [Ircam] at 09:25 11 February 2013

Stroppa and the Spectral Composers: Common Filiations, Crucial Differences

Although it is difficult to link Marco Stroppa's works with an established aesthetic or school, he shared initially a common filiation with the spectral composers before each took distinctively different paths.

Traiettoria was composed between 1982 and 1988. In the premise of the piece, a text in Italian entitled 'Tre studi per un progetto'[3] (probably written at the end of 1982[4] as a sort of statement of intent for *Traiettoria*, which was at the time in the very first stages of composition), Stroppa says it was Messiaen who identified the particular phenomenon capable of '[...] creating a chord that is essential to his harmonic theory through the superposition of different notes [from the] first sixteen basic components of sound'.[5] He is undoubtedly referring here to the musical example called 'resonance chord' from the second volume of *The technique of my musical language* (Messiaen, 1966, p. 38; musical example no. 208; Anderson, 1988; Anderson, 2000). Indeed the chord is composed of the superposition of various superior harmonics derived from a fundamental frequency (harmonics 4–7, 9, 11, 13, 15). Stroppa's reference to Messiaen's acoustic model points to a common heritage shared by Stroppa and the spectral composers who acknowledged Messiaen as their mentor.

Another apparent filiation is that between Jean-Claude Risset and Marco Stroppa. A piece such as *Traiettoria* emerged directly from the school of thought that aims to 'compose sound itself' (Risset, 1990),[6] a compositional idea first advanced by Varèse even before Jean-Claude Risset put it into practice with

time-delay direct synthesis.[7] In addition to the facts that they were both experts in sound synthesis and trained as pianists, another parallel can be drawn between the young Jean-Claude Risset, who first 'entered composition' through the practice of the piano touch[8] and Marco Stroppa who, some 20 years later, began composing *Traiettoria* by working on piano resonances. For *Traiettoria* as for Risset's piano pieces, the composer's attention was focused, not on the spectra of piano sounds but on the more general concept of a sound spectrum. The instrument was not used, as it was by the spectral musicians, as a reservoir of piano sound spectra with characteristics that could be harnessed for composition (instrumental or sound synthesis), but rather as a tool that allowed the pianist–composer to explore the microscopic dimensions of sound (the disposition of partials, dynamic profiles, etc.) and produce sounds with broader spectral characteristics than piano sounds. Just before he quotes Messiaen, Stroppa says he was 'especially touched by the richness and vitality of the piano's sound and above all by its timbre'[9] (which is not really surprising considering the particularly inharmonic spectral layering of piano sounds). He describes how he searched inside the sound produced from the percussion of a low key not only for the frequency but also for the internal components of a note. 'Each atom, by joining to form a unit, will generate a large molecule which gives the sensation of a single pitch'.[10] He then recommends listening to 'the internal life of sound: its energy and its trajectory in time, its hidden resonances, the richness of its many combinations, deep in a living, changing kaleidoscope'. As such, in *Traiettoria* the piano is ultimately a tool in the composer's workshop in that it enabled him to explore the microscopic properties of sounds in general. The verbal metaphors, such as 'enter into sound' and 'to be inside sound', which were first used by Giacinto Scelsi (Scelsi & Kanach, 2006), whose work Stroppa seems not to have known at the time, and also by Varèse, Nono, Risset, Harvey, etc., indicate a spectral approach that is shared by several generations of musicians who endeavoured to compose with both notes and sounds.

The heritage from Messiaen and Risset displays a cognitive background shared by both Stroppa and the spectral musicians. This background is based on common references, which will be explored below, from computer music and acoustics (musical acoustics, psychoacoustics). However, a bifurcation occurred very early on, notably when the spectral musicians—so called by Hugues Dufourt in 1979[11]—joined together in 1973 to form the Ensemble Itinéraire. This instrumental ensemble aimed at the time to promote a music of sound. In contrast, for Stroppa, Risset and other musicians who used direct synthesis, instruments were not the locus for sound composition. Stroppa's cognitive models would be fashioned, indiscriminately in either sound synthesis or acoustic writing, according to an efficiency criterion. Whatever Stroppa could not solve instrumentally, he would produce synthetically and vice versa: for example, when his imagination pushed him to produce with the piano resonances that went beyond the natural capacities of the instrument, he made use of the potential in sound synthesis. Conversely,

Downloaded by [Ircam] at 09:25 11 February 2013

rhythmic percussive formulas that were difficult to produce synthetically were composed using the piano. More generally, for the spectral composers instrumental composition is the preferred medium for sound composition. For them, mixed music is an enlarged instrumental music encompassing the electronic medium and rarely, so we believe, a separate category. In contrast, Stroppa envisions the articulation piano/synthetic sound as an inseparable affiliation, part of a single and same compositional gesture.

We have briefly analysed some of the common links (Messiaen, Risset, scientific knowledge, focus on the microstructure of sound) and the conceptual differences (the spectrum as a model, the autonomy of mixed composition) between Stroppa and the spectral composers. During the genesis of *Traiettoria*, was Marco Stroppa familiar with spectral music, which had already seen a good decade of compositional activity? It seems as though the trend was unfamiliar to him because he has said several times[12] that he was not even aware of its existence while he was still in Italy and before he arrived at the IRCAM (Institut de Recherche et de Coordination Acoustique/Musique) in February 1983. However, on 1 and 2 October 1982 during the Venice Biennale, the IRCAM and the Ensemble InterContemporain (EIC) gave two concerts. The first day, the EIC played a piece by Gérard Grisey (*Solo pour deux*, for amplified clarinet and trombone) and the second day they performed in the Italian premiere of Hugues Dufourt's piece for orchestra, *Saturne*. Stroppa was present at the scientific session when 'the 4X[13] was presented and Tod Machover's piece for the 4X, *Fusione Fugace*, was heard for the first time'.[14] Indeed at Machover's request, Stroppa took part in the piece, notably by operating the 4X (the trio of performers consisted of Tod Machover, Emmanuel Favreau and Marco Stroppa). Since according to the archives of the Venice Biennale the piece was premiered on 28 September 1982, Stroppa could have attended the premiere concert (or the rehearsals) of *Solo pour deux*. The first page of Stroppa's personal notebook on *Deviata*—the oldest dated document in the composer's private archives—is dated 14 October 1982. It can therefore be assumed that spectral music was not completely unknown to Stroppa during the first ebullient moments of the conception of *Traiettoria*.

By the time *Contrasti* (the third movement) was completed, the challenges of the spectral aesthetic had clearly been assimilated, as confirmed by one of Stroppa's articles published in Italian in 1985, in which he refers to Grisey's *Modulations* (Stroppa, 1985). Marco Stroppa's reluctance to acknowledge a connection with the spectral musicians must stem from the fact that his first instincts did not come from spectral music. More specifically, his compositional processes differ from the dogma that places the spectral model at the origin of instrumental composition. The spectrograms in his private archives, from classes he took in acoustics and psychoacoustics at the CSC (*Centro di Sonologia Computazionale*), show that he was able to reproduce the spectral models through analysis-re-synthesis. The 'analysis-re-synthesis' at the time consisted of the spectral analysis of a sound followed by a non-automatic re-synthesis, that is, through the visual selection of

Downloaded by [Ircam] at 09:25 11 February 2013

certain parameters reinserted in the writing of the synthesis code. The piano spectrograms recorded in his student notebooks and kept in the composer's archives are certainly rudimentary but they describe an almost exhaustive range of spectral characteristics specific to piano sounds (slight inharmonicity, short noisy attack transients …). Similarly, there are examples of pseudo-instrumental FM sound synthesis. Nevertheless, these two examples do not constitute a model for Stroppa's composition or for his compositional process. There are no perceptible traces of the reproduction of piano or other instrumental spectra in *Traiettoria* and such a procedure remains marginal in the composer's other works using electronics.

While this particular element in the spectral model does not constitute a point of convergence between Stroppa's aesthetic (at the time of *Traiettoria*) and the spectral aesthetics (at that same time), mutual references to the cognitive tools of acoustics and psychoacoustics (see below for further commentary), and concurrent musical and scientific education produced ways of thinking and practices that are common to Stroppa and the spectral composers. A precise account of these years of training shows how the few years spent in Padua (at the CSC), Venice, Verona and Milan (conservatories), and then in Paris (IRCAM) and Cambridge (MIT) were crucial in shaping Stroppa's compositional thought.

Downloaded by [Ircam] at 09:25 11 February 2013

The Years of Intensive Training

Music of Notes

Marco Stroppa studied piano,[15] choral singing and choir conducting first in Milan and in Verona, before turning quickly to music theory[16] and composition,[17] which became the focus of his intellectual inclinations. According to Stroppa learning composition as opposed to learning different styles, constitutes the fundamental difference in compositional training between Italy and France. That difference, confirmed by other composers who have trained in Italy, helps explain the divergence between the spectral aesthetic,[18] which was developed mainly in France, and Stroppa's aesthetic, as it took shape immediately following his years of training.

At that time, in Italy the composition curriculum lasted around 10 years. Harmony and counterpoint were covered in the introductory course, fugue in the intermediate course and composition *per se* in the advanced course. The aim in the first two courses was not, as in most music education institutions in France, to imitate the styles of past composers as closely as possible. It seems at the time in Italy, that students were encouraged to develop the ability to write in a language other than the one under scrutiny, all the while maintaining a certain stylistic coherence. With exposure to that type of learning, Stroppa believes looking back that at the beginning of the advanced course he had sufficiently mastered the use of the 'technical tools of the composer's workshop'[19] to develop his own musical language. Within this context, in 1982 after the piece for small orchestra *Metabolai*,[20] a composition that

marked the end of his musical training in the conservatories cited above, he was ready to compose a more personal 'second opus', a piano piece.

Music of Sounds

At the end of the 1970s, not long before completing his conservatory classical curriculum, Stroppa became interested in the latest developments in sound and music technologies. In 1980, for the first time and as a spectator at the Chigiana Academy of Sienna, he was exposed to 'real-time' technologies when Giuseppe Di Giugno presented the IRCAM's technological advances that preceded the invention of the 4X. It was then that the young composer (aged 21) decided to become involved in the domain of computer music. He signed up for the course in computer music taught by Alvise Vidolin at the CSC of Padua. The newsletters from the *Laboratorio Permanente per l'Informatica Musicale de la Biennale*[21] indicate that the courses at the CSC focused on synthesised music as well as on real time but did not include recorded sound processing. Between 1980 and 1983, Stroppa received intensive and comprehensive training (covering several levels in one year) in Verona for theory and Padua for practice. Alvise Vidolin, his '*maestro*',[22] taught him everything from the rudiments to the most specialised knowledge in signal processing (at the time called 'physical-acoustic') and sound synthesis. Within this context, Stroppa gained mastery of computer languages. At the CSC in Padua, he practised with the *Fortran* language to compose using *Music V* software. In this way he re-synthesised pre-existing electronic pieces (such as Stockhausen's *Studie 2*) and incorporated in the same manner a large number of the examples from Jean-Claude Risset's *Introductory catalogue of computer synthesized sounds* (Risset, 1995 [1969]), which he considered a veritable orchestration treatise. As part of these exercises in synthesis, he reworked certain instrumental pieces from the repertoire using sound synthesis. The idea was to practise a programming language by re-composing a widely known piece from the repertoire. Sometimes the exercise went beyond strict re-composition. For example, one of Stroppa's CSC notebooks contains a synthesised version of Bach's *Sarabande* for clavichord (from the *Suite française* no. 2 in C minor BWV 813).[23] In this case the pedagogical exercise consisted of transposing parts of, or the entire sarabande, up a fifth, adding vibrato and modifying the durations. Within that context, Stroppa developed a prodigious skill in electronic writing using *Music V*. Scrutiny of the correspondence between Stroppa and his technical assistant at the CSC, Graziano Tisato, reveals that the synthesised part in *Contrasti's* first version was completed in less than two months, proof of the composer's expertise. Stroppa explains he has not yet begun the electronic part in a letter dated 6 August 1985, that is, less than seven weeks before the premiere on 21 September 1985.[24]

After completing his training in sound synthesis, Stroppa decided to focus for *Traiettoria* on additive synthesis and frequency modulation synthesis (and more specifically the FM formant) both of which are managed by PLF subroutines. In an interview (Stroppa, 1988) conducted shortly before finishing the most polished

Downloaded by [Ircam] at 09:25 11 February 2013

version of *Traiettoria*,[25] Stroppa described that earlier period using a language that shows how fascinated he had been with computer music: 'wonderful world of computer music', 'the boundless landscapes', 'the astonishing richness and the beauty of sound synthesis'. His avowed interest for the intricacy of working with synthetic sounds, at the time generated a version of *Traiettoria* without piano and reduced to only tape, entitled *Hidinefte, ou l'autre face de Traiettoria*.[26]

While Stroppa focused his efforts on sound synthesis, which was particularly prized at the CSC, he abandoned real time. However, at the beginning of his project he was familiar with the IRCAM's 4X and the 4i, a lighter version of the latter (with less oscillators), which was about to be available at the CSC. A close reading of autograph documents about *Deviata* from Stroppa's private archives reveals that at the very start of his project, the composer had planned to use real time. Out of the two notebooks used in parallel at the beginning of work on *Deviata*, Stroppa indicates in the first one (a sort of logbook[27]) that for a short time he considered the possibility of using live electronics.[28] And on one of the first pages in the first of the notebooks labelled *Computer Jotter*,[29] dated 8 November 1982,[30] he refers to another tape-recorder used to 'process pre-recorded material', then alludes to 'pure piano sounds with minimalist signal processing: echoes, reverberations' and finally advocates 'avoiding classical analog signal processing (such as ring modulation)'. However, Stroppa quickly abandoned these different tacks,[31] which shows he was not satisfied with already existing solutions. Stroppa endeavoured to build a digital environment to match his aspirations. It is also clear that he did not adhere to the systematic logic of doubling instruments with real-time electronics (a logic upheld at the time at the IRCAM). Thus, he did not retain real time as a technical solution when he began to integrate the use of computers in his work. His opinions, already evident in the notebooks were made explicit in 1984 with the publication of an article in which he adopts an 'anti-real time' position (Stroppa, 1984). There too lies a similarity with Jean-Claude Risset (1999) who defends the same point of view.[32]

As we mentioned above, Stroppa did not attend at the CSC any classes on *musique concrète* practices. As an anecdote, the only class in *elettroacustica* he attended was on the theory of electricity. He even found *musique concrète*, which he discovered when he arrived in Paris (during the period when he was composing *Deviata*), less interesting than sound synthesis. For the composition of *Traiettoria*, Stroppa did not plan to make any sound recordings nor use pre-existing sound recordings, be it as musical material or as a rigorous model.

Synthesis was the preferred technique at the CSC for work on the control of the microscopic dimensions of sound. At the time, Stroppa was fully immersed in this type of synthesis. But he had more wide-ranging objectives:

> I did not believe in the application of classic compositional procedures to the microscopic control of sound. Nor did I want to be inspired by the internal structure of a sound to compose purely instrumental music. I was in search of something else: an artistic, poetic, intellectual and complete autonomy for sound synthesis, without any reference to pre-existing structures and materials.[33]

Downloaded by [Ircam] at 09:25 11 February 2013

However, this statement must be read with caution since it was made retrospectively. In our effort to link Stroppa's compositional processes to those of the spectral composers, we can make the following observations. In spectral music, there are two compositional models: spectral models and electroacoustic models (as for example, the transposition of FM, filtering, ring modulation etc. and more generally editing and mixing into instrumental composition). Stroppa did not use the spectral model in the strict sense for the composition of *Traiettoria*. Yet the piece bears a spectral dimension (which we will explore below). On the other hand, electroacoustic models played an important role, and it is using this second type of model that Stroppa developed a specific form of mixed composition.

Mixed Composition

In *Traiettoria*, mixed composition brings together instrumental and electronic forms of music writing in a single compositional 'gesture', which encompasses a single musical thought. The listener is invited to focus on the sounds themselves by listening to their spectral trajectories. Stroppa did not seek to make us hear, by means of electronics, the spectral model of a piano sound but rather he intended to make us hear, by means of the acoustic piano sounds and sound synthesis, spectral trajectories, a journey to the interior of sound, an aim close to those of spectral composers. Referring to the new means of analysis and sound processing, Tristan Murail wrote in 1980 (a few months before Stroppa began working on *Traiettoria*): 'The new analytic tools I mentioned above allow us, at the same time, to bring a different perspective to sounds, to journey to the interior of sounds, to observe their internal structures' (Murail, 2005, p. 122).

At this point, it is helpful to examine the chronology of the compositional process to understand exactly how Stroppa worked with the piano and its potential for sound trajectories. At the very beginning of the creative work on the first movement (intended at that point as a simple 'study'), by playing the piano and by observing the intervals, the composer decided on the notes that formed a chord, which later became a matrix. We must note that the analysis of *Traiettoria* uncovers two matrix chords: the first appears in *Deviata*[34] and the second appears for the first time in *Dialoghi*. The first chord was not formed by converting the spectrum of a piano sound into notes; it was built 'manually'[35] by selecting the intervals to keep any tonal connotations to a minimum (such as a major fifth, minor third, etc.) (Figure 1). After experimenting on the piano, the composer quickly jotted down on sheet music both the piano part and the synthesised part. It was only later that he proceeded to convert pitch into terms that the computer could read, that is, into lists of data. The pitch data consists of values found on the lines 'fq'—frequency of the fundamental tone(s)—and 'nosc'—number of oscillators for the addition of partials. It is part of the data that needs to be specified for the digital synthesis apparatus in *Fortran*.

Downloaded by [Ircam] at 09:25 11 February 2013

Contrary to what we have just observed about the first chord, the second chord has a more or less spectral layout (Figure 2). The chord is set out almost but not fully as a harmonic series, with intervals as follows: a major seventh [D–C#] instead of the octave for a harmonic series; a minor sixth [C#–A] instead of a perfect fifth; a diminished fifth [A–Eb] instead of a perfect fourth; a perfect fourth and an augmented third instead of a major third followed by a minor third; a minor third and a major second instead of an interval slightly smaller than a minor third and another one slightly larger than a major second. Thus with this second chord, the intervals become smaller and smaller in the higher registers, this is similar to a spectral layout. The second chord was formed by transforming the first chord: it was derived from the first four notes of the first chord, transposed a semitone higher [C#–A–Eb–Ab], to which were added a lower note [D] and three higher notes [C#–E–F#]. The chord was built using this simple transformation, which produced a resulting chord that resembles a spectral ordering of harmonic partials. Messiaen's influence is indirectly manifest.

Downloaded by [Ircam] at 09:25 11 February 2013

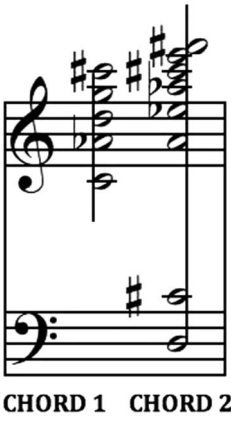


Figure 1 The two matrix chords for *Traiettoria*.

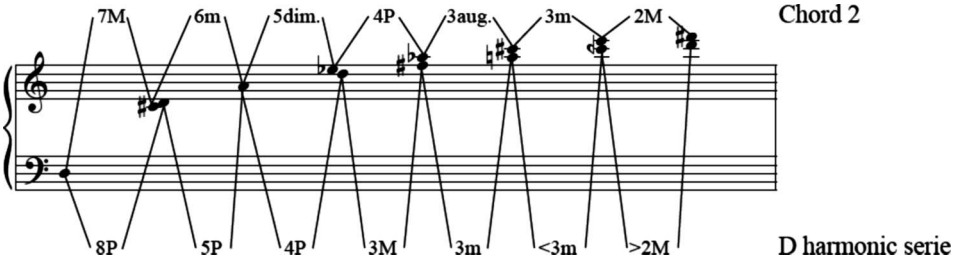


Figure 2 Comparison between the intervals of chord 2 and the intervals of the harmonic series on D.

We have seen that Stroppa did not employ the spectral model, strictly speaking, in *Traiettoria*. Nonetheless, electroacoustic techniques used as a model for composition are of great importance to Stroppa. We will focus on the examples of editing, mixing and filtering.

If mixing can be defined as a digital emulation of analogue mixings (using the ICMS software), it is more interesting to explore the manner in which Stroppa applied this model in piano writing, a practice shared with the spectral composers. For example, an analysis of the piano solo in *Contrasti* (pp. 3–15 of the score), which is shown here (Figure 3), supported by the documents related to the genesis of the work, demonstrates that beyond the writing techniques employed,[36] the superimposing and the incrustations of these piano fragments respectively pertain to mixing and editing. The listener's perception fuses or separates these short fragments, on the one hand because of the morphological qualities of each of them and on the other hand thanks to the compositional work on dynamics. This consists notably of creating dynamic equilibriums between the short fragments to highlight or conceal these perceptual entities. The combination of the techniques of editing/mixing and the concerns for the perceptual criteria of similarity and contrast were widespread issues at that time.

Still in the sphere of electroacoustic models, the instrumental transposition of the principle of filtering is also found in *Traiettoria*, of which we give a few examples.

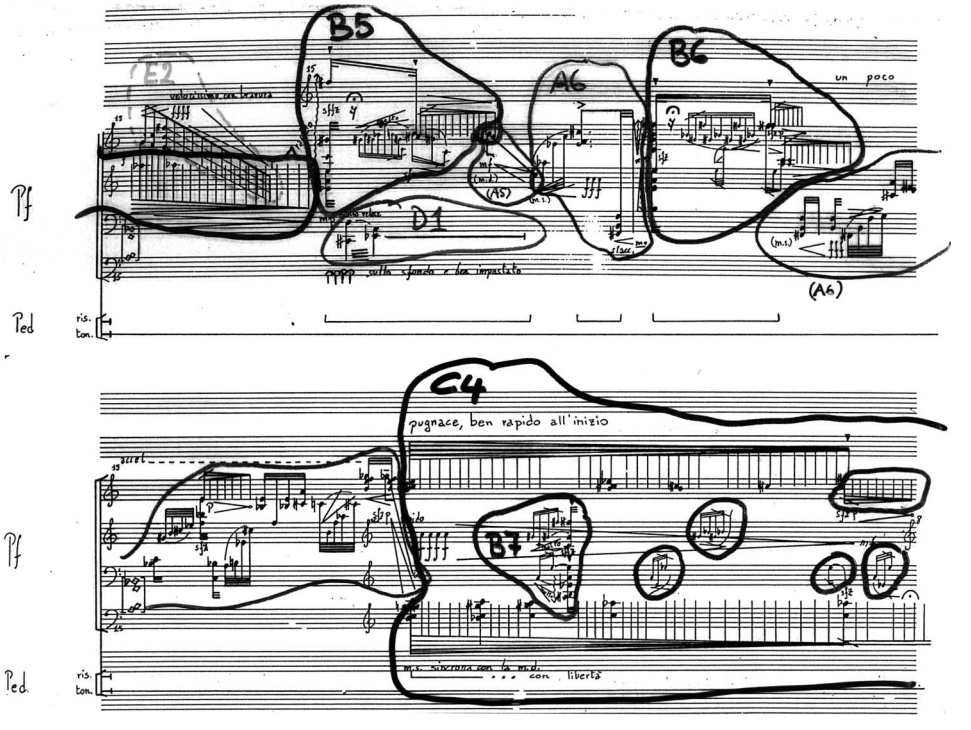


Figure 3 Stroppa's analysis of the piano solo in *Contrasti* (score, p. 6).

Downloaded by [Ircam] at 09:25 11 February 2013

First, the segmented use of the damper pedal gives priority to certain high frequencies among those produced by the piano (see Stroppa's pedagogical schema in Figure 4). An example of the use of the damper pedal as a high-pass filter can notably be found on p. 2 of the *Dialoghi* score. Second, the third pedal (*sostenuto* pedal) helps produce sympathetic resonance. Third, Stroppa used the common notation of electronic sounds to denote, during a pre-compositional phase, a piano fragment later notated using traditional notation. For instance, the following fragment (Figure 5) for the piano is directly derived from the dynamic imprint of a piano spectrum, in other words from a dynamic profile of the type attack/resonance. Such a procedure is also noticeable in the works of spectral composers, for instance at the end of Grisey's *Périodes* (1974) or at the beginning of *Partiels* (1975).

Thus, Stroppa maintained a certain distance with the use of the sound spectrum model for his compositional work. The analysis of his creative process shows that his initial idea was related to the microscopic dimension of sound. Stroppa translated this initial idea by working on piano resonances, using the instrument (with trills, tremolos or pedalling) but also using sound synthesis (with a very detailed

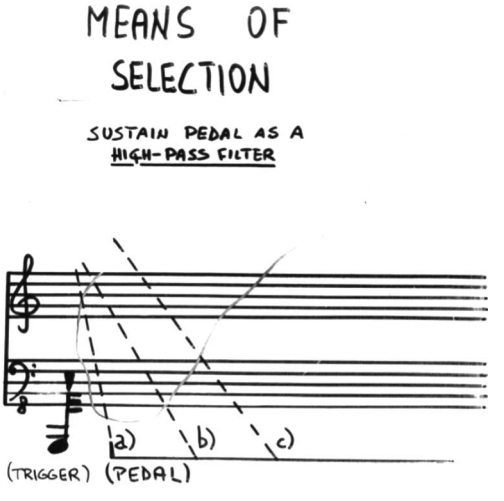


Figure 4 Stroppa's pedagogical schema on the use of the damper pedal as a high-pass filter.

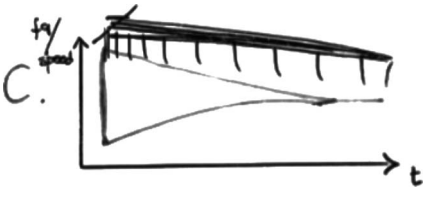


Figure 5 A piano fragment derived from its spectral outline (Stroppa's pedagogical document).

Downloaded by [Ircam] at 09:25 11 February 2013

conception of the physical characteristics of sound) and composition techniques borrowed from electroacoustics (filtering, incrustation, editing …).

From the start, Marco Stroppa imposed a strict constraint on himself: to produce music by mixing instrumental writing and direct sound synthesis (realised in time delay by means of a computer) and then broadcast with loudspeakers. In mixed music, the score is a medium common to the prescriptive writing for the instrumentalist and the descriptive writing of sound synthesis. The synthetic sounds are first sketched during the composition process using a score format, which, for *Deviata* and *Contrasti*, also contains the piano part (see for *Contrasti* the excerpt in Figure 6), and then reworked and refined in the *Computer Jotter* to be 'interpreted' (according to Stroppa) by the person in charge of writing the computer code. In this case, this person was obviously Stroppa himself, but the task can be taken up by any other person who knows the *Music V* language. Stroppa's mixed composition is not a mix of two mutually exclusive types of music writing, but the embodiment, using various formats (score and computer code) of a compositional thought which integrates together both the instrumental world and the world of sound synthesis.

Having explored the years of Stroppa's musical training and some of the implications for his approach to mixed composition, it is now time to turn to his scientific training in order to better understand how the two are intermingled.

A Versatile Scientific Background

Computer science. Computer science is omnipresent in Stroppa's thought and has therefore influenced his compositional process. While composing the last two movements of *Traiettoria*, Stroppa was studying as a graduate student at the MIT in Cambridge (Massachusetts, USA). For two years (from September 1984 to September 1986), he attended lectures mainly in computer music, cognitive psychology and artificial intelligence (Winston, 1984), notably with Barry Vercoe.[37] He witnessed the birth of the Media Laboratory in 1985. During this open course (he had the possibility to choose from all the lectures without restriction), he acquired skills in fundamental computer science: particularly in expert systems and imperative programming—notably the structured programming on which the *Fortran* language used for *Music V* is based. He read many books by his teachers on those topics, which he deems fundamental, such as *Structure and Interpretation of Computer Programs* (Abelson and Sussman, 1985) published during his stay.

Learning structured programming was of central interest to Stroppa who retained notably the idea of the decomposition of a problem into 'primitives'.[38] Stroppa adopted this principle in his compositional practice. He stated in an interview:

> From a compositional point of view, what is my primitive? Where, as a composer, do I start from to define a material (material that may be complex but that I use as a unit)? Is it a chord, a note, the spectrum of a note, a rhythm, a three-minute long process, etc.?[39]

Downloaded by [Ircam] at 09:25 11 February 2013

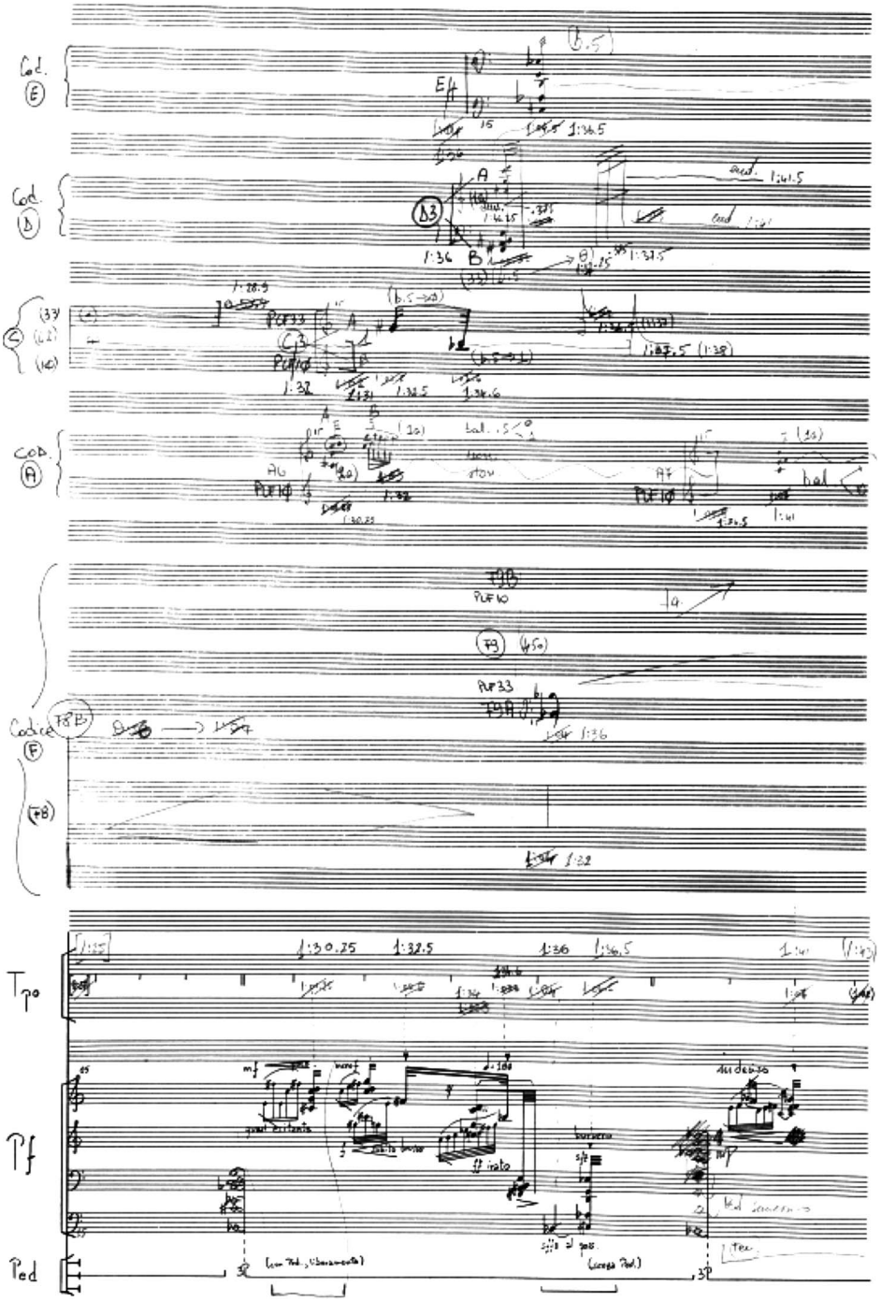


Figure 6 Working score for the mixed part of *Contrasti* (unpublished, p. 4).

Downloaded by [Ircam] at 09:25 11 February 2013

Asked about the relations between fundamental computer science and compositional processes, Stroppa said he prefers a top-down approach (from the human language to the language of the machine).

> Because this allows me to work from the top to the bottom and in a musical way. Because the top is the problem the way I envision it, not the way the machine envisions it. And this way of working, as Sussman explains very well, is imperative epistemology. This is the study of knowledge structures, not in a declarative way (that is by saying what they are) but through emphasise on how we can solve the problem. The imperative epistemology point of view—as I later found out—is exactly the type of problem we have as composers.[40]

According to Stroppa, the decomposition of problems into primitives (top-down) is a permanent endeavour. After what, the recombination of several primitives (bottom-up) into sequences of primitives[41] completes the creative process.

We must stress that as early as *Traiettoria*, Stroppa took charge of all the technical aspects of his works. He has no assistant computer programmer (today also called a 'computer music designer'). However, even with advanced expertise in information systems and their languages, today Stroppa claims to have more the mind of a physicist than that of a computer scientist. This leads us to explore another layer of his scientific background.

Cognitive science and psychoacoustics. Since the 1970s, many researchers in psychophysics have focused on psychoacoustics, a discipline defined as the study of the relationships between sounds and the way they are perceived, which has lead to many important discoveries of interest to composers (McAdams & Bregman, 1979; McAdams, 1987; Risset & Wessel, 1982; Wessel & Risset, 1979). Marco Stroppa remembers that from very early on as a student at the CSC Juan Roederer's *Introduction to the physics and psychophysics of music* (1979) was at his bedside table.[42] His notebooks from the CSC date from 1982. They contain basic but essential principles in psychoacoustics (number of partials in relation to a fundamental degree of inharmonicity of each partial according to its rank, duration of sound in relation to frequency, intensity in relation to frequency) and above all, concrete examples (notably using the piano). Browsing through his student notebooks, which are among the oldest documents he preserved, reveals that his knowledge of many aspects of cognitive science and psychoacoustics dates back to the beginning of his training in computer music at the CSC. These aspects may have played a role while he was working on *Traiettoria*. Already in 1975, Risset had underlined that 'exploiting the huge possibilities of direct synthesis requires an in-depth knowledge of sound and the science of psychoacoustics, that is, the correlations between the physical parameters of sound and its effects on the senses, a science that has yet to be uncovered' (Risset 1975, p. 58). Even today, according to Stroppa, psychoacoustics is to sound synthesis what an orchestration treatise is to orchestral composition.[43]

Downloaded by [Ircam] at 09:25 11 February 2013

In 1984–85, Stroppa and other composers then at the IRCAM (among others, Roger Reynolds, Barry Anderson, Jean-Baptiste Barrière, Jonathan Harvey, John Chowning …) made a direct use of these works. During his stay at the IRCAM, Stroppa often met with McAdams, as is incidentally revealed in a 1991 documentary film, which shows undated archive footage of the two men discussing the notion of 'auditory fusion' that Stroppa had just discovered.[44] When asked recently what concepts, in addition to the fusion/fission of the auditory streams, were important to him at that time, without hesitation Stroppa[45] cited timbral space.[46] These concepts were studied at that time and illustrated with many specific and impressive sound examples,[47] which had a deep impact on Stroppa. He even created sound excerpts[48] to illustrate the phenomenon of perceptual segregation in McAdams' thesis (completed and submitted in 1984). This constitutes further evidence of his involvement in psychoacoustic research at the IRCAM at that time.

Life sciences. Another important model for Stroppa is that of organisms (Stroppa, 1989). The issue of organisms or more precisely of the organic model (Hautbois, 2000, 2006; Orcalli, 2012) lies at the heart of spectralism.

> Spectral music lies between the forms of communication of early cybernetics, which have a scientific base in the theory of information, and those of the second cybernetics in which the world of the subject and the world of *expression* replace objective means of representation. The *organism* (the organic model) replaces the *machinism* of the Cartesian model.[49]

For Orcalli, spectral musicians who directly or indirectly received training in psychoacoustics, with the help of among others Emile Leipp, shifted to the 'organic paradigm'. The use of exploratory electronic devices often leading to sonographical representations enabled the generation of so-called spectral composers, and also Stroppa at that time, to envision sound as a living entity. According to Orcalli:

> Since as Leipp contends, musical sound is not a stable phenomenon, it should be considered less as an *object* than as a *living being* and so its unfolding requires a method of analysis that can represent the evolution and the complexity of the elements actually perceived.

In Stroppa's work, the organic nature of sound is applied not only to sound as a spectral structure but also to entities larger than sound alone. While he was composing *Traiettoria*, Stroppa used the idea of the organism, linked with his knowledge of psychoacoustics, cognitive science and computer science, to develop the original concept of Musical Information Elements (MIE), which later became Musical Information Organisms (MIO).[50] At the core of Stroppa's thought on organisms, lies the strong influence of a book co-written by one of his professors at MIT, Eleanor Rosch (Rosch & Lloyd, 1978).[51] *The teaching of thinking* by Nickerson, Perkins & Smith (1985) is also worth mentioning, since E. E. Smith was a champion of 'categorisation' and also one of Stroppa's professors at MIT. During the creative

Downloaded by [Ircam] at 09:25 11 February 2013

process that resulted in *Traiettoria*, Stroppa gradually developed and theorised his thought on organisms, which he later delineated in a publication (Stroppa, 1989).

Other readings and meetings (Changeux, 1983; Monod 1970) nurtured Stroppa's interest in the natural sciences and prompted him to increase the use of metaphors that bring together the musical world and the living world.

Thus, apart from his already established knowhow in the strictly musical domain, non-musical knowledge—shared in part with the spectral composers—was decisive in the creative process for *Traiettoria*.

Key Concepts

Stroppa's compositional workshop is the result of the crossing between artistic and scientific disciplines. Musical and non-musical learning combined with the elaboration of personal concepts, coalesced into the creative project that led to *Traiettoria*. Delving into the origins of the work, its genetic traces and the scientific environment in which it evolved, we can understand how Stroppa's own compositional concepts emerged (Stroppa, 1991).

Downloaded by [Ircam] at 09:25 11 February 2013

Interferences

Stroppa's harmony–timbre ambiguity. The first thoughts at the origin of *Traiettoria* came as notes jotted down in a private notebook, which we have already called the *Deviata* logbook. These notes confirm that the composition project was initially intended as a single piece for piano solo of fixed duration at around 20–25 minutes.

These notes jotted down by the composer illustrate that he was first interested in studying 'interferences': the entry for 3 November 1982 (on the first page of the *Computer Jotter* no. 1) shows that the title for the work in progress is *Interferenze*. For Stroppa, these 'interferences' that he wished to explore then refer to interactions between harmony and timbre.[52] Stroppa was familiar with this notion from works such as Jean-Claude Risset's *Mutations* (1969). The introductory sounds of *Mutations* unfold three continuous moments: a five-note melody, a chord/timbre—the famous perceptual ambiguity—composed of the first five harmonics of each of the five notes; and a pseudo gong derived from the first five harmonics of the chord/timbre. This series is now emblematic of the way perception can alternate between listening to a harmonic chord and listening to a spectrum. Stroppa had this kind of perceptual ambiguity in mind when he started his preparatory work.[53] This idea conveyed with the expression 'Pitch/Harmony/Spectrum Continuum' and reformulated as 'Musical Ideas: Sound/Harmony unity' would be mentioned later in numerous pedagogical writings related to *Traiettoria*.[54] Stroppa kept the idea of harmony–timbre interferences in the successive development of his compositional project. Nonetheless, the title and the range of the project evolved. During the first stages of the work, one of Stroppa's composition teachers at the Milan conservatoire,

Azio Corghi, encouraged him to take a commission from the Italian radio (RAI).[55] The project evolved into an undefined number of shorter pieces. Stroppa choose three studies that could be autonomous to better suit the requirement of a radio broadcast. The original title for the studies was *Studie per interferenze*,[56] which then become *Tre studi per un progetto*[57] and later the generic title *Traiettoria* (a title derived from the first movement entitled *Traiettoria … deviata*).[58]

The idea of interference is related to the liminal thought advanced by Grisey as early as 1980, in a letter to Hugues Dufourt dated 5 July (Grisey, 2008, pp. 281–282). With this term, the latter hoped to avoid the restrictions of the word 'spectral' when defining the eponym aesthetic movement. Grisey tells us that our perception is confronted by thresholds and limitations that bring different musical parameters into play, for instance when our listening shifts from chord to timbre. Stroppa's view on interferences shares this idea. It seems that interference lies at the core of other key concepts employed by Stroppa, such as resonance, space in sound, *contrast model* or again the opposition fusion/fission. The concept of resonance derives from the phenomenon of acoustic resonance, which as we know is central to 20th century spectral aesthetics.

From working on piano resonances to the 'little treatise on resonance'. To broach the issue of piano resonances, Stroppa began exhaustive work on pedalling which aimed to unveil hitherto unexpected spectral profusion. This work, carried out in the 1980s within the framework of the first drafts of *Traiettoria*, led in the 2000s to what the composer called 'a mini-treatise on piano resonance' (Interview no. 2). This small 15-page treatise was conceived of as an introduction to the revised edition of the *Miniature estrose* series (1st book).[59] Evoking the complex resonance phenomena at play in the *Miniature estrose*, Stroppa uses the expression 'per pianoforte d'amore', a reference to the *viola d'amore*, which possesses a second set of sympathetic strings. In this small treatise, Stroppa exhaustively describes the possibilities offered by pedalling. He advocates progressive and segmented pedalling, a practice already in use in *Traiettoria*. For instance, if the soft pedal is down, the progressive use of the other pedals strengthens the modification of the timbre of the sounds. In fact, a piano is tuned so that the frequency of the two or three parallel strings associated with the same note in the medium and high registers is slightly different. This produces a 'chorus effect', that is to say a spectral halo around the desired note thus animated by a very slow beat. The progressive use of the soft pedal gradually, and not brutally, modifies the timbre.[60]

Similar to the segmented use of the damper pedal is the example quoted above (figure 4) of a high-pass filter used by Stroppa as an electroacoustic model for the composition of the instrumental part of *Traiettoria*. Stroppa consciously employed this procedure, as confirmed in the introductory text for *Deviata*.[61] In interviews, he explained that he uses the damper pedal to filter part of the sound. Filtering by acoustic means is notably apparent in the introductory piano solo of *Deviata*, for instance with an explicit reference to the phenomenon on p. 2 (systems

Downloaded by [Ircam] at 09:25 11 February 2013

1 and 2) and on p. 3 (system 2). In reality, more than a rigorous filtering, the segmented use of the damper pedal favours the resonance of high frequencies, compensating their natural rapid decay (compared to that of the low frequencies). Finally, playing with the third pedal (or sostenuto pedal)[62] acts as a real comb filter. The spectral components of a chord (latent chord) selected when the pedal is pressed, resound by sympathy when notes are played 'freely' in accordance with the indications given in the score. Stroppa determined the choice of the latent chord and its neighbouring notes according to spectral criteria.[63] The aim was to measure out the spectral balance or 'spectral thickness' (Stroppa, 2009) that is to say the 'space in sound'.

During a first exploratory phase centred on playing directly on the instrument, the composer made great use of his technical and musical expertise in piano playing. As has already be shown, the logbook for the first movement confirms that Stroppa soon faced an impasse that he now sees as a theoretical dead-end (Interview no. 1): the natural decrease in the piano's amplitude envelope precludes sustaining the sound for a length of time. The piano offers several solutions to this problem (trills, closely repeated notes, tremolos, pedalling). For instance, in the first page of his logbook, Stroppa refers to playing with the double escapement action as a means to obtain a very soft sound, between resonance and percussion, even when played pianissimo.[64] With the close repetition of a single note (two successive sounds that appear to be tied together) we reach a discrimination threshold and the distinction between the two sounds is no longer possible.[65] The resulting effect is an acoustic blur, a temporal fusion that Stroppa used extensively in *Dialoghi* (notably at the beginning and at the end of the piece).

The solutions devised to compensate the unavoidable decrease of piano resonance derive from Stroppa's almost systematic exploration of the slightest possibilities for resonance in the instrument. The impact of these explorations on *Traiettoria* has been evoked above. For Stroppa, these solutions did not quite match the needs of his project based on harmony-timbre interferences. Thus, when he chose to use computers[66] it was above all because he hoped to open up the resonance potential of the instrumental spectrum. As a result, Stroppa built his compositional method from within the sound spectrum. For instance, he distinguished between the different temporal phases of the acoustic sound (attack, decay, sustain, release) and he assigned them indiscriminately to the piano or to the tape. An emblematic example of such a procedure reduced to the form attack/resonance is found when the first synthetic sounds of *Deviata* appear: the attack of the piano chord (the matrix chord no. 1 mentioned above) marks the passage to the development of a resonance, this time entirely created with the help of synthetic sounds. By mixing the two worlds, the composer intuitively intended to provide the morphology of tape sounds with a rendering as natural as that of the instrumental sounds. To do so, Stroppa, tried constantly to animate the synthetic sounds, to give them a more organic nature (in the sense of the 'organic model' mentioned above). The aim was to avoid the perfect finish produced by the computer.

Downloaded by [Ircam] at 09:25 11 February 2013

In his preliminary work, Stroppa faced another dead-end: how to imbue piano sounds with a strongly inharmonic spectral quality. To tackle this challenge in the preparatory piano try-outs for the second study, he envisioned the possibility of working manually on the strings inside the piano and of placing an object inside the piano to prepare it, in a similar way to John Cage. Page 2 of the logbook reads: 'plastic plectrum, drum stick, knitting needle'. In the end, he renounced these expedients and decided to work only with traditional means, i.e. the keyboard and pedals. He also renounced any form of staging, which diverts the listening process from the sound itself. These dead-ends led Stroppa to resort to sound synthesis rather than solely use the piano in order to fashion resonances and space in sound.

Electronics as a resonance generator. With regard to electronic resonance, Stroppa employed different means to make sounds more 'alive', as if they were naturally resounding before being broadcast on loudspeakers. Here again, it is a matter of the composition of a sound space rather than the exploitation of a sound projected into a space—which was not entirely rejected by the composer but was not central to his method. In addition to a preferred usage of tremolos, which help give a more 'natural' dimension to sounds,[67] here are three examples illustrating such a practice. First, a technique endorsed by Stroppa himself (Stroppa 1989), which involves *defocusing* a chord (or a set of frequency components) by adding clusters around the chord (or around frequency components). To avoid producing stereotypical synthetic sounds with this technique Stroppa used several control parameters: the number of clusters, the position of the clusters around the main note (frequency bandwidth) and finally a random principle preventing similarities. This technique tended to yield more inharmonic chords than harmonic chords and could even generate a beat feeling if some frequencies were very close to one another (the minimum density unit for a cluster being here the semitone, a feeling of saturation is quickly reached).[68] Second, random data are introduced within the programme codes. On one page of a *Computer jotter* (Figure 7), the division mark '÷' shows a value that is not fixed but within two limits. Such a conception of composition leaves certain values unfixed, allowing ever-different interpolations and as a result, a more 'natural' sound. This constitutes a procedural phenomenon where the values relative to one another are more important than the absolute fixed values as such. Third is a manual imitation of the *flanger* technique. The procedure (less distinctive because shared by a community of composers at the time *Traiettoria* was being composed) consists in superimposing one or several copies of a sound onto itself but with a very slight delay (determined with a precise calculation in milliseconds),[69] imperceptible to the ear but which causes certain targeted frequencies to be highlighted. Stroppa voluntarily used such a mix to emphasise the notes from the two key chords of the whole cycle. By embracing this procedure to compose the last movement *Contrasti*, Stroppa gave a new life to the most static sounds,[70] even if they acquired a slightly more whiny tone colour.

Downloaded by [Ircam] at 09:25 11 February 2013

Figure 7 Page from the *Computer Jotter* to generate the A6 sound.

Finally, in a mixed configuration, projecting synthetic sounds with a loudspeaker positioned, according to the composer's instructions, under the piano's soundboard, can also create sympathetic resonance. The piano is therefore turned into a

Downloaded by [Ircam] at 09:25 11 February 2013

resonating filter. Conversely, the natural resonance of the piano can be captured (with a microphone) and projected on loudspeakers (if possible with an acousmonium rigged according the composer's instructions). In a mixed concert situation, the sound reinforcement of the instruments is crucial to avoid any discrepancy between the mode of propagation of acoustic sounds and that of electroacoustic sounds. In this precise case, the challenge is also to amplify the natural resonance of the piano, to immerse the listener within the sound.

The 'Organic Paradigm'

In addition to the concept of resonance, common to both spectral thought and Stroppa's thinking for his compositional project *Traiettoria*, they also share the 'organic model'. The 'organic model' in composition refers to sound conceived of not as an object but rather as a living being (Hautbois, 2000, 2006; Orcalli, 2012). This is why Orcalli speaks of a new 'organic paradigm' (Orcalli, 2012), mirroring the technical, intellectual and institutional ecosystem shared by the composers of the decade between 1975 and 1985. For Stroppa, those years favoured the development of what he calls the MIOs in his compositional process. It is important to demonstrate here how much his thinking on organisms depended on his knowledge of cognitive science and psychoacoustics. Reconstructing the genesis of the three movements of *Traiettoria* helps understand how Stroppa's thought on organisms became more and more prominent in his compositional process.

The birth of Musical Information Organisms. We have already seen that, at the beginning of the project, Stroppa had no knowledge of spectral ideas. His work essentially focused on the study of piano resonances and then on means of achieving this electronically. When he started working on the electronic part for *Deviata*, Stroppa in fact intended to make the piano resonances last longer. He considered three types of synthetic sounds (A, B and C), identifiable thanks to specific musical characteristics (Figure 8): glissando, attack/resonance and a resonant cluster. Incidentally, as it is shown in the *Computer Jotter* for *Deviata*, these three types correspond (though not systematically) to three different kinds of sound synthesis:[71]

- type A (glissandi) is produced using what is nowadays called granular synthesis with the PLF20 and the PLF21 in *Music V*;
- type B (attack/resonance type sounds or more broadly all complex sustained sounds) is produced using FM synthesis with the PLF33;
- type C (resonant clusters) is produced using additive synthesis with the PLF10.

At that point, Stroppa was not yet thinking in terms of organisms. His aim was to make the piano sounds last longer with the help of electronic resonance. However, he was already thinking in terms of perceptually identifiable types. In other words,

Downloaded by [Ircam] at 09:25 11 February 2013

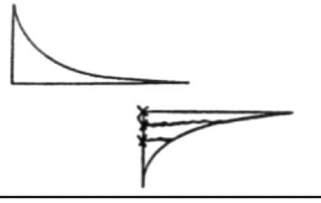
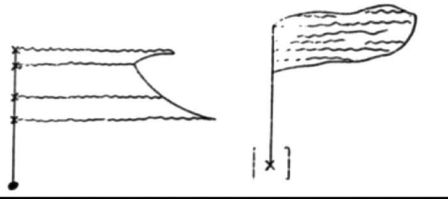
	Feature	Score notation
Sound type A	Glissando (from smooth to granular)	
Sound type B	Attack/resonance	
Sound type C	Resonant cluster (with or without perceptible fundamental)	

Figure 8 Features and score notation of the three sound types in *Deviata*.

Stroppa made use of the notions of similarity and contrast in the perceptual selection process without being conscious of their exact scientific underpinnings.

The genesis of *Dialoghi*, the second movement, which he began slightly before the premiere of *Deviata*, was contemporary with Stroppa's stay in Paris. He then discovered spectral compositions and, more importantly, met researchers in psychoacoustics (such as Wessel and McAdams).

> Perceptual judgments tend to be relative in nature. With few exceptions, we tend to judge an object in terms of the relationships it has with other objects. Relational judgments are of great interest in music, because music involves patterns composed of a variety of sounds, and it is the relational structure within and between the patterns that is of primary importance. Judgments of the extent of perceptual similarity or dissimilarity between two sounds can be made in a very intuitive fashion. One can say that sound A is more similar to sound B than to sound C without having to name or otherwise identify explicitly the attributes that were involved in the judgment. Research groups at IRCAM, at Michigan State University, and at the Stanford Center for Research in Music and Acoustics have been using perceptual dissimilarity judgments in a variety of musical and otherwise audio-related contexts. (Wessel, 1979, p. 47)

The documents related to the genesis of this second movement contain several annotations by Stroppa that seem to confirm that his preference for broaching the perceptive issue from perspective of Wessel and McAdams. The transversal notion of

Downloaded by [Ircam] at 09:25 11 February 2013

fusion/fission used to describe musical entities also appears in these documents. Such musical entities are described in terms of similarity, and in terms of their degrees of fusion or fission. Stroppa became aware of that procedure whereas it had still been intuitive in *Deviata*.

The next step, with the third piece *Contrasti* consisted in refining the method, systematising the procedure and optimising the compositional work (*Constrati* is the longest piece written in the shortest amount of time). At MIT, Stroppa deepened his scientific knowledge of the 'contrast model', which in turn helped him organise his thinking in a rational way. The *Constrati* logbook contains the word 'organism' and sketches of the MIO.[72]

First, at the beginning of the logbook,[73] Stroppa defined the distinguishing characteristics of six sound types (1, 2, 3, 4, 5, 6) called MIE. These six elements were reordered and became six organisms A, B, C, D, E, X[74] (the first is from *Deviata* and the last from *Dialoghi*), which constitute the piano solo in *Contrasti*. Each type possesses a unique morphological identity recognisable by perception. Note that each MIO is composed of sound objects (not in Schaeffer's sense of the word), i.e. even smaller sound entities. This is again a top-down conception that Stroppa employed a lot in computer music. Second, Stroppa documented a variety of slightly different occurrences for each sound type (A1, A2 …, B1, B2, etc.). Each occurrence thus obtained (through complex compositional procedures described notably in Stroppa, 1989) is similar enough to the 'prototype' of each sound type (as noted in the initial logbook) to be perceptively equated to a specific type. At that point, the similarity criterion in the *contrast model* (see below) was applied. Third, Stroppa began editing and mixing (as seen in Figure 3) the various occurrences of MIOs, here again playing with the proximity or lack of proximity (fusion/fission) between one occurrence and another.

Fusion/fission and the contrast model. Stroppa, like the spectral composers at that time, was very interested in the notion of a threshold between fusion and fission. Such ambivalence was intentionally induced during composition, as indicated by the recurring terms 'combination', 'selection' and occasionally 'separation' in the logbooks. If we turn to the documents related to the genesis of the piece, an article entitled *Tre studie per un progetto*[75] (unrelated to the homonym text quoted earlier) and written in English by Stroppa refers to the notion of fusion to broach the issue of the relationships between acoustic and synthetic sounds:

> I think that one of the most interesting uses of electronic devices in musical composition is the possibility to unify some musical parameters so as to pass from one to another with no interruption: Stockhausen for instance, in his interesting analysis of *Kontakte*, wrote about the unification of rhythm and frequency.
>
> Well, my main musical idea was to find a continuous transition between a vertical sound structure (once called 'harmony') and its corresponding timbre, i.e. between a set of musical images to their fusion into a sole image. […]

Downloaded by [Ircam] at 09:25 11 February 2013

> So, the ratio between piano and synthetic sounds is not dialectical, the two instruments talk to and look for one another continuously. Sometimes the former is just an amplification of some of the possibilities of the latter. Sometimes (like at the end of the first studio) they are so fused that it's almost impossible to separate their timbre.[76]

While working on *Traiettoria*, Stroppa consciously borrowed the liminal relationship between fusion and fission derived from the psychoacoustics of that time. This relationship is also symptomatic of Stroppa's persistent concern for perfecting the correspondence between what the composer creates and what the listener perceives. Concept and percept are conceived of as a continuum. Here too is a point in common between Stroppa and the spectral composers of that time.

To understand how Stroppa closely linked the duality fusion/fission to Tversky's *contrast model*,[77] one may recall—the remarks above in the example of the synthetic sounds in *Deviata* touch on this issue—that in his compositional work, he carried out a classification of the MIOs or more precisely a classification of sound objects (the smallest entity within a MIO). These objects are in practice classified according to similarity criteria. Tversky's *contrast model* comes into play in this effort to assess of the degree of similarity between two sound objects (Figure 9). The model associates three terms equipped with weighting factors. These three terms are: (1) the common characteristics—specific features common to both objects; (2) the characteristics specific to the first object; (3) the characteristics specific to the second object. If we

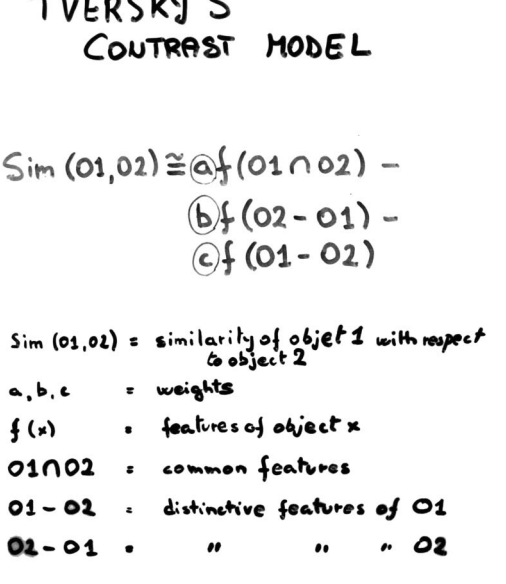


Figure 9 Tversky's *contrast model* as noted down by Stroppa (pedagogical document).

Downloaded by [Ircam] at 09:25 11 February 2013

are confronted for instance with a MIO composed of two superimposed sounds, there are two possibilities:

(1) A fission phenomenon occurs when the similarity index is low: the two sounds are discriminated. For instance the MIO C quoted above (in Figure 5) and extensively used in *Contrasti* in fact derives from a fission phenomenon that was applied to a chord during the composition of the piano part of *Dialoghi* (Figure 10). The identity of this organism is founded on a process that moves from a homogeneous chord to its fission into two distinct sound entities.

(2) In contrast, the fusion phenomenon occurs when the similarity index is high: the two sounds are indistinguishable. It is the case for certain MIOs in *Contrasti*, which are perceived as single sound entities despite the fact that they were built by superimposing two sounds, each produced by a specific type of synthesis. The most frequent case consists of a higher part created by additive synthesis and a lower part by FM synthesis, as illustrated in the *Computer Jotter* or in the mixed score of *Contrasti* (see D3A and D3B in Figure 6). In this large mixed score used by Stroppa as a working document to compose the mixed passages for *Contrasti*, one can survey in detail the synthesis part. Each sound type (denoted with a letter) appears as an occurrence in a numbered order that

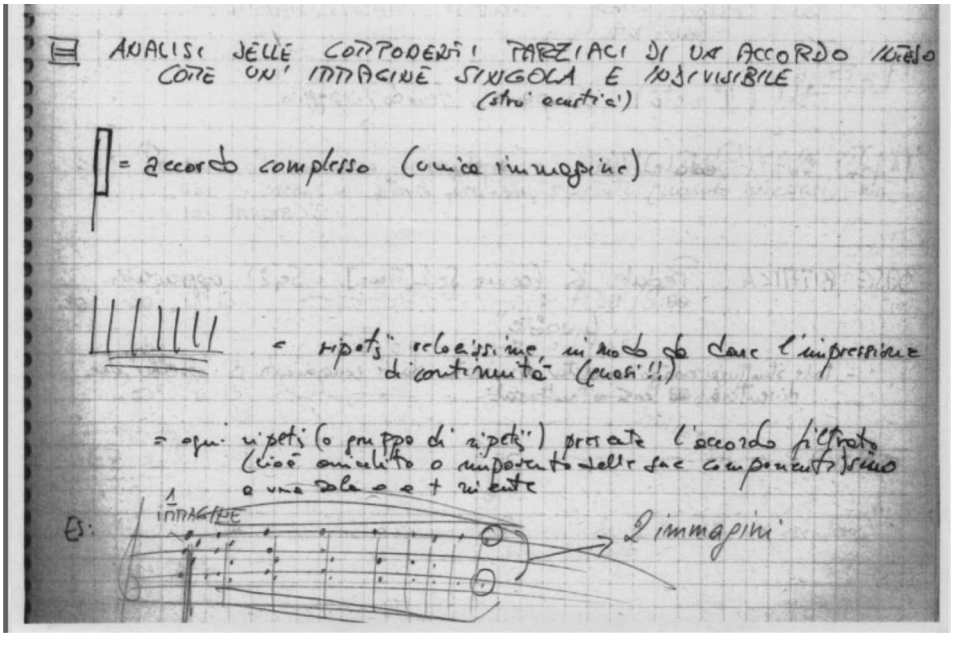


Figure 10 The fission phenomenon as described by Stroppa in the *Dialoghi* logbook (p. 15, 23 July 1983).

Downloaded by [Ircam] at 09:25 11 February 2013

can be split into two parts (A and B) created with the PLF 10 and the PLF 33 (in this case the sounds C3, D3 and F9). The fusion process acts upon the synthetic sounds. In this mixed passage, the fusion also occurs between the MIO of synthetic sounds and the corresponding MIO of the piano. For instance in Figure 6 the harmonic content of the cluster D3A (the synthetic sound at 1:36.25) comes directly from the piano chord at 1:34, and similarly for the cluster D3B played on the piano shortly before 1:36.25. Thus, in this passage doubling the piano with the electronics (synchronously or with a slight delay) induces the global perception of an organism regardless of whether it has an instrumental or an electronic origin.

From this, we see that Tversky's model was of great help for Stroppa's aural judgement. While this was done consciously in *Contrasti*, it was done more or less the same way but intuitively in *Deviata* and above all in *Dialoghi*. We also see that a MIO was not a pre-existing acoustic structure in the compositional process and the composer was not necessarily conscious of it as a musical idea. The ultimate goal in the composer's mind, always striving for the correspondence between concept and percept, is to create sound entities that are autonomous and identifiable by the listener.

Downloaded by [Ircam] at 09:25 11 February 2013

Conclusion

During the years 1980–85, i.e. right in the middle of the spectral momentum (1975–85), Stroppa elaborated his compositional toolbox with *Traiettoria*, combining scientific knowledge (shared for the most part with the spectral composers), with an expert application of digital sound synthesis. The study of all the remaining vestiges of the genesis of his work *Traiettoria* reveals that simultaneous training in music and sciences at the beginning of the 1980s (notably in acoustics, psychoacoustics and cognitive science that he shared with the spectral musicians) led Stroppa to develop an aptitude for music analysis and an inner ear for synthetic sounds, as well as an interest in a music based on sound 'interferences' (the work with resonance, the ambiguities harmony/timbre, the liminal work on sound fusion and fission, the selection of sound entities according to similarity criteria—all concepts often found in the works of spectral composers). Nonetheless, Stroppa's musical aesthetic cannot be reduced to spectral aesthetic. The spectrum is never used as a model to create an instrumental or mixed sequence. With *Traiettoria*, which constituted his first real composition, Stroppa fashioned a unique compositional workshop, which gave rise to writing processes still at work today in his most recent pieces.

Acknowledgements

This work was supported by the Agence Nationale de la Recherche in France [grant ANR-08-CREA-066]. Special thanks to Nicolas Donin, François-Xavier Féron and Romain Bricout for their astute reading of this article. Thanks to Angelo Orcalli for very enriching scientific discussions during the development of this article. Thanks to

Gilles Rico for the translation. We warmly thank above all Marco Stroppa for his ever continuous availability. Reproduction of genetic documents kindly authorized by Marco Stroppa.

Notes

[1] A tape was used for the premiere of the piece. In concerts nowadays, the magnetic tapes are replaced by digital sounds stored on an electronic device.

The complete version of *Traiettoria* consists of the following three movements:

- *Traiettoria … Deviata*: composed in Verona (Italy) from the end of 1982; premiered 2 August 1983 in Verona (Ente Lirico Arena di Verona, Auditorium S. Franceso Al Corso);
- *Dialoghi*: composed in Paris (France) between 1983 and 1984; premiered 16 April 1984 in Paris (IRCAM);
- *Contrasti*: composed in Cambridge, Massachusetts (USA) in 1985; first version premiered 21 September 1985 in Venice (Biennale di Venezia); complete version premiered 12 February 1989 in Amsterdam (De Ljsbreker Centre).

[2] The genesis file is composed of different elements: manuscripts such as notebooks (with many sketches and a few drafts), the correspondence between composer and technician (among others); documents such as computer listings; recordings including among others the rough sound files before the mix.

[3] *Tre studi per un progetto*, four-page typescript in Italian, written in the first person, undated, from the composer's personal archives.

[4] No specific date is mentioned but Stroppa indicates that the project he is working on will be completed during the first months of 1983. The approximate date for the text is confirmed by the fact that Stroppa mentions using *Music 360* for the project, which was his original plan before he quickly discarded that version of the software (at the very end of 1982) in favour of the *Music V* version.

[5] The original text reads: 'Messiaen aveva percepito questo fenomeno con tale intensita da creare un accordo importante per la sue teoria armonica proprio dalla sovrapposizione delle note diverse tra le prime sedici componenti elementary del suono'. Ibid., p.2.

[6] An expression Jean-Claude Risset used regularly, well before he wrote the article in which he gives an overview of his career as a composer (Risset, 1990).

[7] Produced with the *Bell Laboratories* software series *Music*.

[8] See the speech Jean-Claude Risset gave when he accepted the CNRS 1999 Gold Medal, retrieved 2 August 2011, from http://www.cnrs.fr/cw/fr/pres/compress/risset2.htm. Risset's piano teacher Robert Trimaille was himself a student of Alfred Cortot who was known for his great interest in the 'toucher du piano'.

[9] *Tre studi per un progetto*, op. cit., p. 2.

[10] Ibid.

[11] 'Spectral Music': first published in March 1979 by Radio-France and then in *Conséquences*, 718, Autumn 1985–Spring 1986, pp. 111–115; reprinted in Dufourt (1991).

[12] As in our interviews with Stroppa between September 2009 and November 2010.

[13] The 4X is a numerical sound processor created in 1976 (notably by Giuseppe Di Giugno) and inaugurated in 1981 with Pierre Boulez's *Répons*.

[14] Annual report, IRCAM 1982, IRCAM Archives.

[15] Until 1980 with Laura Palmieri, piano teacher at the Verona Conservatory.

[16] With Guido Begal in Verona (music theory), Renato Ionisi in Milan (music theory including Bach's counterpoint, Renaissance double choir, late romantic style).

Downloaded by [Ircam] at 09:25 11 February 2013

[17] With Azio Corghi in Milan for the last course in composition, which he completed in one year.

[18] Insofar as the spectral aesthetics is univocal, which was by and large the case in the 1970s.

[19] Interview of Marco Stroppa by Noémie Sprenger-Ohana and Vincent Tiffon, IRCAM, 28 September 2009.

[20] Composed in 1982 at the end of his training, this 10-minute long piece was premiered 10 May 1983 in Florence by the Orchestra Regionale della Toscana (conducted by Maurizio Diniciacci), as part of the programme of the 46th *Maggio Musicale*. Less than three months later, 2 August 1983, *Deviata* was premiered in Venice (A. Ambrosini, piano).

[21] LIMB Bollettini, 1 (1981) to 5 (1985), La Biennale di Venezia. The CSC organised many activities when Stroppa was a student there. The CSC notably organised the ICMC Symposium in Venice, held from 27 September to 1 October 1982 as part of the Festival *Numero e suono* (27 September–8 October 1982) at the Venice Biennale (see the editorial of the LIMB 2 published in 1982).

[22] Stroppa paid tribute to the man he called 'master' in Stroppa (2009).

[23] Lecture notes from the CSC no. 3, year 1980–81, Stroppa's private archives.

[24] The first version of *Contrasti* premiered at the Venice Biennale on 21 September 1985, with Adriano Ambrosini on piano and Marco Stroppa on sound projection. 22 September 1985, the date often cited in documents about this piece, is incorrect.

[25] This version, which Pierre-Laurent Aimard premiered 12 February 1989 in Amsterdam (at the De Ljsbreker Center), includes the electronic solo from the beginning of *Contrasti* (originally intended for the version premiered in 1985 but left unfinished).

[26] *Hidinefte, ou l'autre face de Traiettoria* (for computer-generated tape, was premiered in November 1989 at the Maderna Festival in Milan) contains the synthetic sounds from *Traiettoria*, mixed and put in a different order (with the exception of a single passage, the first electronic part of *Dialoghi*, deemed uninteresting when separated from the interaction with the piano).

[27] *Inizi 82/83*, a spiral notebook mainly filled with written annotations and dated from 14 October 1982 to now, and henceforth called '*Deviata* logbook'.

[28] The expression 'real electronics' is mentioned in the '*Deviata* logbook' with the date 1 November 1982.

[29] The *Computer Jotters* are notebooks filled with technical data: three for the first movement and nine for the last. Out of these 12 *Computer Jotters*, only the first *Deviata* notebook contains a section with written notes (more than 60 pages). Aside from that exception, all the notebooks are filled with pencil annotations following the same procedure and they constitute a sort of computer score. In these notebooks the sounds are recorded one by one (one to two pages per sound) and type after type. For example if the sound types are called A, B, C etc., the pages follow one another: A1, A2, A3 … An, B1, B2, B3 … Bn, C1, etc (cf. Marcato, 2001).

[30] *Computer Jotter* no. 1, p. 3.

[31] The last date recorded in the *Computer Jotter* no. 1 notebook related to *Deviata* is 21 December 1982. Then, after the first 60 pages, the second part of the notebook, which contains no dates, is purely technical.

[32] Risset advocates the following view: 'The possibility of real-time performance in computer music systems is not necessarily a progress for electronic music composition' (Risset, 1999, p. 31).

[33] Interview with Stroppa conducted by Cohen-Levinas (1992, p. 7).

[34] *Computer Jotter* no. 1, p. 17, 21 November 1982; then *Deviata* logbook, p. 6, 29 November 1982.

[35] This type of calculation was then formalised and made accessible on computer using Francis Courtot's CAC Carla software (a system of *Composition Assistée par Representation Logique et*

Downloaded by [Ircam] at 09:25 11 February 2013

Apprentissage), written in Prolog2 language (Courtot, 1992). Stroppa used it, notably for *Elet ... fogytiglan*, to implement clusters using a VPS form (Vertical Pitch Structure, a concept he had first developed in 1987–88 during the compositional process for *Spiral*). This prompted the formation of the harmonic base following constraint programming. Other composers, such as Marc-André Dalbavie, Philippe Hurel and Magnus Lindberg, who were linked with the spectral aesthetic, used Carla for other applications. We are therefore tempted to think that this procedure for generating chords, which was also used by some of the spectral composers, provides further proof of affinity between spectral ideas and Marco Stroppa's ways of thinking, specifically in *Traiettoria*.

[36] Stroppa describes his writing techniques in his article (Stroppa, 1989) and calls them (among others) structural 'magnets', 'enzymes', 'distributive functions', 'moulds' ...

[37] Founder of *Music 360* (1973) and *Music 11* (1978) from the software series *Music*, Barry Vercoe established the *Media Laboratory* at the MIT and created the *Csound* language the same year, in 1985.

[38] A term denoting instructions that are directly intelligible by a computer.

[39] Interview no. 1 with Marco Stroppa by Noémie Sprenger-Ohana and Vincent Tiffon, 28 September 2009, the IRCAM.

[40] Interview no. 2 with Marco Stroppa by Noémie Sprenger-Ohana and Vincent Tiffon, 8 January 2010, the IRCAM.

[41] Called 'abstractions' in software such as Max/MSP.

[42] *Introduction to the Physiology of Hearing* (Pickles, 1982) is also mentioned in his notebooks.

[43] Interview no. 2 between Marco Stroppa, Noémie Sprenger-Ohana and Vincent Tiffon, 8 January 2010 at the IRCAM.

[44] Video documentary; Mille & Bourgeois (1991).

[45] Email from Stroppa, dated 2 November 2009.

[46] Risset explores the timbral space in the IRCAM Report no. 11: 'Hauteur et timbre des sons', 1978. This concept was used notably in his piece *Songes* (1979) and is described in detail in Risset (1978d).

[47] Sound examples from the composer's private archives. His archives collate examples from Wessel, McAdams and Risset, some of which were reproduced in the 'IRCAM Reports' published in 1978 and in 1985–86 (McAdams, 1985, 1986; Risset, 1978a–d; Wessel, 1978).

[48] Sound excerpts grouped under the heading 'Exemple sonore n°5' (Appendix in McAdams, 1984).

[49] In *italics* in the original text.

[50] Stroppa first used the term MIE while he was composing *Contrasti*. He later switched to MIO (logbook for *Contrasti*).

[51] See in particular the chapters by Tversky & Gati and Rosch in the book edited by Rosch & Lloyd (1978).

[52] *Deviata* logbook, p. 3.

[53] Undated and on separate sheets (concerning section II of *Dialoghi*).

[54] Stroppa used a number of examples from *Traiettoria* for pedagogical purposes in courses he gave at Szombathely (Hungary), Stuttgart, Paris and beyond.

[55] The word 'commission' appears in the *Deviata* logbook (1 November 1982, p. 2) and is found in the CSC archives and confirmed in an interview of the composer (Interview no. 2).

[56] The new title adopted by the composer, written in capital letters on p. 3 of the logbook for *Deviata* (10 November 1982).

[57] The title written on the front page of the first *Deviata Computer Jotter* dated November–December 1982 and referred to again later in several writings of the same kind.

[58] *Traiettoria ... deviata* first appeared as a title for the first movement the 29 November 1982 (logbook, p. 5) but the two words are several lines apart with (TRAIETTORIA) on the one

Downloaded by [Ircam] at 09:25 11 February 2013

hand and (DEVIATA) on the other hand: only the capitals and the parenthesis seems to imply that the two terms will be put together.

[59] Stroppa, M. (2009, last revision), *Miniature Estrose*, Ricordi no. 136804.

[60] See for instance the Ricordi score of *Deviata*, pp. 9, 10 and 11.

[61] Ibid. p. XVIII.

[62] Referred to on the first page of the *Deviata* logbook.

[63] The muted notes are especially highlighted when their harmonics are played.

[64] *Deviata* logbook, p. 1.

[65] According to the laws of psychoacoustics, the threshold under which our perception fuses two sounds successively played is 20/30 milliseconds.

[66] A note at the bottom of the page of the first logbook tells us that Stroppa decided early on to add a 'tape (computer)' to his piece, dated 14 October 1982 (or between this date and 1 November 1982, since the difference in writing indicates that the composer could have added this comment later). In fact, the tape is referred to and quoted several times in the subsequent pages.

[67] This is similar to the vibration added to synthetic sinusoidal sound waves to give the impression of a voice (see Chowning's research, 1973).

[68] The beats are not only perceived but they also actually exist for their number is given by the (positive) difference between the two frequencies.

[69] d=1/*freq* with *freq* for the frequency of the targeted note and *d* for the duration of the delay (in milliseconds).

[70] There is a second reason that motivates the use of this method: it helps produce sounds rapidly, a feature well appreciated by Stroppa with the date of the premiere of the work looming.

[71] Note that the type of synthesis used in *Contrasti* no longer directly determines the nature of the organism produced (as was the case in *Deviata*). For instance, additive synthesis and frequency modulation are used to create two sound entities that are then compiled into a single MIO.

[72] *Contrasti* logbook, p. 14.

[73] *Contrasti* logbook, pp. 5–6, 2 October 1984, Cambridge, MA.

[74] Here after two definitions of the MIOs according to Stroppa: MIOs are 'complex events, musical concepts grasped as unique by our perception' (Stroppa, programme notes for the French premiere of *Hiranyaloka*, 17 October 1994, Radio-France, Paris); 'an organism is something active composed of several *components* and *properties* of variable complexity which maintain certain relationships between one another and yield a specific *form*. The cognitive representation of such a form constitutes its *identity*.' (Stroppa, 1989, p. 208).

[75] Undated but it is clear that this document dates from the time of the composition of the piece (most likely end of 1984) for it is written that 'the score is not yet complete and must be updated', and that 'the whole piece will be published by Ricordi'.

[76] *Tre studie per un progetto,* separate sheets, three-page manuscript, undated. The context for this document remains unsure.

[77] 'The contrast model relies on featural representation of objects, and it is used to compute the similarity between the representations of two objects. Similarity is defined as an increasing function of common features, that is features in common to the two objects, and as a decreasing function of distinctive features, that is features that apply to one object but not the other. This definition is formalised in the following equation:
$S(a,b)=\theta f(A\cap B)-\alpha f(A-B)-\beta f(B-A)$'. In Heit (1997).

References

Abelson, H. & Sussman, G. J. (1985). *Structure and interpretation of computer programs.* Cambridge, MA: MIT Press.

Anderson, J. (1988). Dans le contexte. *Revue Entretemps, 8*, 13–23.

Downloaded by [Ircam] at 09:25 11 February 2013

Anderson, J. (2000). A provisional history of spectral music. *Contemporary Music Review, 19*(2), 7–22.

Changeux, J. P. (1983). *L'homme neuronal.* Paris: Fayard. English edition (1985); *Neuronal man, the biology of mind.* New York: Pantheon Books.

Chowning, J. (1973). The synthesis of complex audio spectra by means of frequency modulation. *Journal of the Audio Engineering Society, 21*, 526–534.

Courtot, F. (1992). Carla: knowledge acquisition and induction for computer. *Interface, 1*(3–4), 191–217.

Dufourt, H. (1991). Musique spectrale. *Musique, pouvoir, écriture.* Paris: Christian Bourgeois (original work published 1979).

Grisey, G. (2008). *Écrits, ou l'invention de la musique spectrale.* G. Lelong (Ed.). Paris: Éditions MF.

Hautbois, X. (2000). L'Unité musicale sous l'angle de l'harmonique et de l'organique: recherche d'une esthétique comparée avec les sciences physiques. PhD, EHESS, M. Battier (dir.), Paris.

Hautbois, X. (2006). *L'Unité musicale sous l'angle de l'harmonique et de l'organique: recherche d'une esthétique comparée avec les sciences physiques.* Paris: L'Harmattan.

Heit, E. (1997). Features of similarity and category-based induction. *Proceedings of the Interdisciplinary Workshop on Categorization and Similarity* (pp. 115–121). University of Edinburgh. Retrieved 2 August 2011 from http://faculty.ucmerced.edu/eheit/simcat.pdf

Marcato, S. (2001). La realizzazione dei suoni sintetici in *Traiettoria* di Marco Stroppa. In *Il centro di sonologia computazionale dell'università di Padova. Vent'anni di musica elettronica.* Palermo: Centro per le iniziative musicali in Sicilia, 175–189.

McAdams, S. & Bregman, A.S. (1979). Hearing musical streams. *Computer Music Journal, 3*(4), 26–43.

McAdams, S. (1984). Spectral fusion, spectral parsing, and the formation of auditory images. PhD dissertation, CCRMA, Stanford University.

McAdams, S. (1985). L'image auditive: une métaphore pour la recherche musicale et psychologique sur l'organisation auditive. *Rapport IRCAM,* 37.

McAdams, S. (1986). Fusion spectrale et création d'images auditives. *Rapport IRCAM,* 40.

McAdams, S. (1987). Music: A science of the mind? *Contemporary Music Review, 2*(1), 1–6.

Messiaen, O. (1944, 1966). *Technique de mon langage musical.* Tome 1: texte; Tome 2: exemples musicaux. Paris: Leduc.

Mille, O. & Bourgeois, P. (1991). *Musique et sciences: Voyage au centre de l'IRCAM.* Paris: La Sept, IRCAM, CNAC, Artline Films.

Murail, T. (2005). The revolution of complex sounds. *Contemporary Music Review, 24*(2), 121–135. French edition: T. Murail (1980). La révolution des sons complexes. *Darmstädter Beiträge zur Neuen Musik* (pp. 77–92). Mainz: Schott.

Monod, J. (1970). *Le Hasard et la Nécessité. Essai sur la philosophie naturelle de la biologie modern.* Paris: Seuil.

Nickerson, R. S., Perkins, D. N. & Smith, E. E. (1985). *The teaching of thinking.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Orcalli, A. (2012). La pensée spectrale. In N. Donin & L. Feneyrou (Eds.), *Théories de la composition musicale au XXe siècle.* Lyon: Symétrie.

Pickles, J. O. (1982). *Introduction to the physiology of hearing.* London: Academic press.

Risset, J.-C. & Mathews, M. (1969). Analysis of instrument tones. *Physics Today, 22*(2), 23–40.

Risset, J.-C. (1975). Musique et informatique. In *La musique en projet.* (pp. 48–68). Paris: Gallimard.

Risset, J.-C. (1978a). Music Acoustics. *Rapport IRCAM,* 8.

Risset, J.-C. (1978b). The Development of Digital techniques. *Rapport IRCAM,* 9.

Risset, J.-C. (1978c). Paradoxes de hauteurs. *Rapport IRCAM,* 10.

Risset, J.-C. (1978d). Hauteur et timbre des sons. *Rapport IRCAM,* 11.

Downloaded by [Ircam] at 09:25 11 February 2013

Risset, J.-C. & Wessel, D. (1982). Exploration of timbre by analysis and synthesis. In D. Deutsch (Ed.), *The psychology of music.* San Diego, CA: Academic Press. French edition: Exploration du timbre par analyse et synthèse, In J.-B. Barrière (Ed.) (1991). *Le timbre, métaphore pour la composition* (pp. 102–131). Paris: Christian Bourgois/IRCAM.

Risset, J.-C. (1990). Composer le son: expériences avec l'ordinateur: 1964–1989. *Contrechamps, 11*, 107–126.

Risset, J.-C. (1995). *Introductory catalogue of computer synthesized sounds.* Reedited: Wergo Computer Music Currents no. 13, 2033-2. (original work published 1969).

Risset, J.-C. (1999). Composing in real-time? *Contemporary Music Review, 18*(3), 31–39.

Roederer, J. G. (1979). *Introduction to the physics and psychophysics of music* (2nd ed.). New York: Springer.

Rosch, E. (1978). Principles of categorization. In E. Rosch & B.B. Lloyd (Eds.), *Cognition and categorization* (pp. 27–48). Hillsdale, NJ: Lawrence Erlbaum Associates.

Rosch, E. & Lloyd, B.B. (Eds.) (1978) *Cognition and categorization*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Scelsi, G. & Kanach, S. (2006). *Les Anges sont ailleurs* .... Arles: Actes Sud.

Stroppa, M. (1984). The analysis of electronic music. *Contemporary Music Review, 1*(1), 175–180. French edition: (1984). Sur l'analyse de la musique électronique (pp. 18–93). In *L'IRCAM, une pensée musicale*. Paris: Editions des Archives Contemporaines.

Stroppa, M. (1985). L'Esplorazione e la Manipolazione del Timbro. *LIMB Bollettino, 5*, La Biennale di Venezia, 35–68.

Stroppa, M. (1988). Answers to the questionary for *Music Today Quarterly*. *Music Today Quarterly, 1*(2), Tokyo. (Private archives of the composer).

Stroppa, M. (1989). Musical Information Organisms: An approach to composition. *Contemporary Music Review*, *4*(1), 131–163. French edition (1989): Les Organismes d'Information Musicale: une approche de la composition. In S. McAdams & I. Deliège (Eds.), *La musique et les sciences cognitives* (pp. 203–234). Bruxelles: Pierre Mardaga.

Stroppa, M. (1991). Un orchestre synthétique: Remarques sur une notation personnelle. In J.-B. Barrière (Ed.), *Le timbre, métaphore pour la composition* (pp. 48–538). Paris: Bourgois/IRCAM.

Stroppa, M. & Cohen-Levinas, D. (1992). Interview with Marco Stroppa (pp. 99–117). In *Les Cahiers de l'IRCAM (Recherche et Musique)*, *Composition et Environnement informatiques*, 1, IRCAM/Centre Georges Pompidou, Automne 1992.

Stroppa M. (2009). Per Alvise Vidolin, ricordo di un incontro lontano. In P. Zavagna (Ed.), *60 dB: la scuola veneziana di musica elettronica: omaggio ad Alvise Vidolin* (pp. 139–140). Florence, Italy: Leo S. Olschki.

Tversky, A. (1977). Features of similarity. *Psychological Review, 84*, 327–352.

Tversky, A. & Gati I. (1978). Studies of similarity. In E. Rosch & B. B. Lloyd (Eds.), *Cognition and categorization* (pp. 79–98). Hillsdale, NJ: Lawrence Erlbaum Associates.

Wessel, D. (1978). Low dimensional control of musical timbre. *Rapport IRCAM,* 12.

Wessel, D. (1979). Timbre space as a musical control structure. *Computer Music Journal, 3*(2), 45–52.

Wessel, D. & Risset, J.-C. (1979). Les illusions auditives. In *Encyclopedia Universalis,* 1 (pp. 167–170; 2nd edition: 1983). Paris. M. Battier, P. Bernard & G. Charbonneau (Eds.), *Musique et ordinateur* (pp. 93–105). Les Ulis: Centre expérimental du spectacle, Université Paris-Sud.

Winston, P. H. (1984, 2nd ed.). *Artificial intelligence.* Menlo Park, CA: Addison-Wesley.

Scores

Traiettoria ... deviata, Ricordi, 1984, 133770.

Dialoghi, Ricordi, 1985, 134015.

Contrasti, Ricordi, 1985, 134261.

Miniature Estrose, Ricordi, last revision in 2009, 136804.

Downloaded by [Ircam] at 09:25 11 February 2013

Recordings

Stroppa, M., *Traiettoria*, Pierre-Laurent Aimard, piano, Marco Stroppa, sound projection, CD Wergo, 1992, WER 2030-2 [out of stock]. Reedited: Stradivarius STR 57008, 2009.

Stroppa, M., *Hidinefte, l'autre face de Traiettoria*, *extrait* (4'36''), Création IRCAM: Les Années 80, Centre Pompidou, IRCAM [out of stock].

Stroppa, M., *Miniature Estrose – Libro Primo*, Florian Hoelscher, piano, CD Stradivarius STR33713, 2005.

Stroppa, M., *Tangata Manu* (extract of Miniature Estrose, 1st Book), Pierre-Laurent Aimard, The Liszt Project – Bartók; Berg; Messiaen; Ravel; Scriabin; Stroppa; Wagner (2nd disc), Deutsche Grammophon DGG 4779439, 2011.

Unpublished interviews

A series of six interviews of Marco Stroppa was conducted by Noémie Sprenger-Ohana and Vincent Tiffon at the IRCAM (Paris):

- Interview 1: 28 September 2009
- Interview 2: 8 January 2010
- Interview 3: 26 February 2010
- Interview 4: 2 July 2010
- Interview 5: 22 October 2010
- Interview 6: 26 November 2010

Downloaded by [Ircam] at 09:25 11 February 2013