Towards new models for the construction of interactive electroacoustic music discourse*

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The advance of technology brings about modifications of style, performing techniques, music listening, and brings to us new relationships between creation, interpretation and perception. The aim of this article is to set out an approach to strategies of musical production for acoustic instruments and technological resources, describing different notions of interaction where the electroacoustic textural complexity coexists with the live processing of the instrumental source and where a goal is to work within the frame of an open and easy-to-carry-out performance structure which is friendly to the musicians, clear as a discourse and attractive to the audience.

1. INTRODUCTION: ON THE NEED TO CONSTRUCT NEW MODELS OF SOUND DISCOURSE

We frequently read about strategies concerning fusion and contrast of instruments and electroacoustic sounds, a subject contributed to by researchers and composers. The incorporation of new technology has changed ways of thinking about, performing and perceiving music, and the way performers relate to electroacoustic sounds has become a key concern for composers and researchers.

With this in mind, we may search for new models that allow both an extended use of instrumental sources and a broad concept of interaction with new technologies or at least more efficient employment of the existing resources, where the textural complexity of electroacoustic music and the live processing of the instrumental sound might coexist within the frame of an open performance structure which is at the same time technologically elegant and interesting to be performed and to be listened to.

From my perspective, the history of Western music shows a very narrow connection between the evolution of instrumental musical sources and the unfolding of musical style. This has always been a constant and so, for example, we identify immediately medieval instruments with the musical style of their time; the unmistakable shape of the viol's family is clearly related to the Renaissance, the sound of the 'basso continuo' instruments unmistakably baroque and the 'grand piano' carries the stamp of romanticism. Every time has its own sound, every sound has to do with the technological development of the moment and, therefore, the evolution of style.

The first years of the twentieth century showed a tendency to avoid the inclusion of new technologies in music – with rare exceptions. The 'sound' of that period was the big symphony orchestra, whose evolution climaxed with the last post-romantics and impressionists. Just after that, musical style reflected a strong struggle between the neoclassical step 'backwards' and the ideas of Schoenberg and his followers which were not based on new instruments but on the search for a new syntax.

The appearance of radio broadcasting and the recording industry modified musical listening, facilitating the need to continue enjoyment of compositions of the past and thus contributing to the marginalisation of efforts to introduce new instruments or new formal ideas, discouraging the public from listening to new ways of conceiving and realising musical ideas.

By the end of the first half of the last century, with the appearance of 'musique concrète' calling for a new way of composing and listening, musical style witnessed substantial changes, confirming the rule: new 'instrumental' sources modified style as deeply as they had always done in the past. Electroacoustic music is a clear example. Acousmatic art discloses a new universe filled with sounds whose origin is not revealed, or is placed out of context, and new paradigms of musical analysis have been established in accord with such ideas.

Musical discourse has always been attached to the temporal axis. This dependency articulates a noticeable difference between music and plastic arts where in the latter the concept of time relates to the observer's *own* time and perspective. At a first stage, the inclusion of acoustic instruments in electroacoustic works did not involve great changes to musical discourse because the

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instruments adapted their performing behaviour to follow the temporal inflexibility of electroacoustic music. But the continuous appearance of new tools and resources suitable for musical creation acted as a permanent catalyst for the construction of new models of musical discourse, particularly during the last two decades of the twentieth century. This has given a new profile to the relationship and interaction between traditional instruments and electroacoustic sound sources and media, providing great opportunities for flexible dialogue between machines and musicians, and also helping the integration of and interaction between music and other arts.

2. TO BE, OR NOT TO BE … IN CONCERT

Just as every time has had its own style related to its own sound sources, musical discourse always adapted its shape to some kind of concert structure which has evolved with technology but always maintained in essence the notion of a relationship between the musicians and the audience. Technological advances have broadened these horizons, transforming all kinds of facilities into places suitable for performing and also made music available to almost everyone via the Internet. However, the act of composing is done mostly with the aim of a presentation in concert, which is to say music composed to be performed in front of the public in venues designed for that purpose with instrumental performers or, in the case of acousmatic music, projected from loudspeakers. In many respects our culture does not show the explicit intention to remove concerts or concert halls.

The role of the score is also a crucial issue. Up to the appearance of recorded sound, the score was essential to guarantee that a composition may survive the composer, and that it could be performed without the composer's presence. Even more, the development of serial ideas in its tireless search to probe all possible parameters led the musical written sign to the point where the score almost became an end unto itself. The experience of the second half of the last century, beginning with 'musique concrète', has brought many of these ideas into question, challenging even the nature and necessity of the existence of the written score.

The Ina-GRM has developed the 'Acousmographe' to create 'perceptual' scores as tools of analysis and aids to the projection of the sound in concert, and there are many other examples of digital tools designed for the graphical representation of sound. In recent years, the evolution of new hardware has allowed the integration of acoustic instruments and technology, in almost all cases requiring the participation of the composer whenever the work includes live processing of the instrumental sound.

The emergence of new hardware and software demands a bridge between the traditional idea of the concert and the capabilities of these new technologies to form a more expanded notion of the performative musical event, and it is therefore necessary to define some principles and methods for the inclusion of technology in musical discourse.

3. PERCEPTION AND INTERACTION

When we think about the construction of models for interactive composition, we must consider the idea of balance between the use of computer-based tools and the relationship between performers and electroacoustic sounds on stage. As a result of this, technology should not become itself an end, but a key to expand the expressiveness of musical language. Within the field of interaction, perception should become more important than technology.

With this in mind, compositional strategies which include any kind of software for interaction should avoid an excessive dependency on specific computer platforms. To that extent, we should not leave the design of the complete composition's outline to be dictated solely by the design of software. Instead, the perception of the entire construction and the management of different degrees of live control and randomness or degrees of aleatoric organisation, should remain in the composer's hands.

Also, when we talk about interactive music, we should make a distinction between the audience's and the performers' perception. In both cases the perceptive field is central, but while the audience is passive, the performers interact and their perception is an active one, which is in fact a component in the realisation of the work.

I would like to propose three main approaches or references for these ideas on discourse perception:

(1) The idea of perceptual criteria, based on the Gestalt theory, starting from Max Wertheimer's writings and followed by Marc Leman.
(2) The new approach to perception in auditory scene analysis by Albert Bregman.
(3) Pierre Schaeffer's typo-morphology in his *Traité des objets musicaux*, and Denis Smalley's spectro-morphology and structuring processes in *The Language of Electroacoustic Music*, edited by Simon Emmerson.

I would like to apply these ideas about perception to the performers' experience during a real-time interactive session. From this point we may ask, for instance:

- *Which line of action should be suggested to bring out different notions of integration around the idea of perception and performance?*

- *What aspects of the way the work is specified and structured should be clearly determined and which should be only suggested or left to final decisions in the composer's and performers' hands?*

3.1. Perceptual criteria based on the Gestalt theory

Gestalt theory was introduced in 1910 by Max Wertheimer, Kurt Koffka and Wolfgang Köhler. According to Gestalt, we perceive naturally the idea of the whole as something different to the sum of its parts. So, everyone has the natural ability to discern the outline of a global discourse and the idea of completeness and unity remains in our consciousness even if afterwards we do not retain some details. The Gestalists identified a series of Principles or Laws of Perceptual Organisation, which are present to the extent that considerable effort is required to soften their influence:

- *Balance – Focal Point – Figure-Ground – Praegnanz or Good Figure*
- *Isomorphic Correspondence – Simplicity*
- *Proximity (or Connectedness) – Similarity (or Familiarity)*
- *Good Continuation (or Direction) – Common Fate – Closure – Unity/Harmony*

Balance

A psychological sense of equilibrium, or balance, is usually achieved when visual 'weight' is placed evenly on each side of an axis. Of course central for visual arts but also present in music, Balance is present in the perception of forms.

Focal Point

This is a clear visual characteristic, but we may also understand it in our field. The Focal Point is the centre of interest, it is a main subject taking part in the sonic dialogue.

Figure-Ground

Our minds try to perceive what is in foreground and what in background, which is a natural feature of the perception of texture. According to this, our perceptive process mechanism makes us focus our attention on an element or certain group of elements distinguishing them from the rest.

Pregnance (Praegnanz or Good Figure)

Praegnanz (or Pregnance) has to do with the more essential elements of sound objects, which is to say what we perceive at a glance. Gestaltists also call this the 'law of the Good Figure' and according to this principle we always look for the simplest or most consistent form, avoiding ambiguities. In a musical phrase it is like a stamp, a definite peculiarity, such as a trill located in the midst of other sounds.

Isomorphic Correspondence

This probably has to do with a different discussion completely devoted to acousmatic music but relates to our tendency to look for sound sources or for the 'meaning' of sound. Instinctively we try to find the evocative side of each sound whose source is not revealed. Pierre Schaeffer's notion of reduced listening tries to avoid this natural tendency of human perception.

Simplicity

As in visual arts, the audience has an unconscious effort to simplify what is perceived into what they are able to decode. Extremely complicated structures or overweighted textures discourage the audience and tend to be rejected. This is one of the main disadvantages of serial music.

Proximity (or Connectedness)

We naturally organise closer elements into coherent groups, and spaced elements are perceived as unrelated. This contributes to the comprehension of structure.

Similarity (or Familiarity)

We retain information on similar elements which may be considered as equivalents. Then similar elements located together are perceived as belonging to the same section or group, and when placed in different parts of a work may be considered as references despite not being exactly the same. The effect of combining Similarity and Balance is a core component in the articulation of structure.

Good Continuation (or Direction)

This is the natural action of following the organisation of speech and relates to the tendency in our perception to connect elements in a way that makes them seem contiguous or flowing in a particular direction.

Common Fate

Elements moving in the same direction at the same speed or with a regular speed or amplitude change in time tend to form a group or to be considered as a 'oneness'. For instance, Risset's falling Shepard tone

effect or a slow 'crescendo'. Common Fate is more precise than Continuity.

Closure

The natural tendency to perceive a whole even if some details have not been sufficiently well understood or well received. The audience's minds will tend to close gaps and complete forms.

Unity/Harmony

Close to the law of Closure, Unity has much to do with perception of congruence. All elements seem to belong to the same cause. They are not the same but have in common some kind of connection.

A live performance is always affected by these principles, and when we design some kind of interaction, as soon as the performers are asked to make choices they begin to connect what to listen to and what to play, discovering the underlying relationships among the elements they produce and perceive. Some of these principles appear more powerful than others inside the structure of an interactive composition. Particularly *Figure-Ground* and *Focal Point* have to do with the perception of texture while performing, and *Pregnance* and *Common Fate* have to do with choice within a frame of *controlled randomness*. I always use the term randomness as a synonym of aleatory, with the idea of having chance and freedom to choose at the same time. Further on I will develop the concept of *controlled randomness* in the analysis of different alternatives for the construction of models of discourse through interaction.

In his book *Music, Gestalt, and Computing: Studies in Cognitive and Systematic Musicology*, Marc Leman introduces models that connect musical signal processing to music analysis and computational psychoacoustics where interaction becomes a central concern. He affirms that perception cannot be understood statically, without temporal evolution, but as an evolving interaction between an organism and a stimulus. In that sense, listening to a piece of music is a very different experience to reading the score, as our level of analysis is quite different. The analysis of written music allows us to go back and forth, while in listening, our perception does the work relating similar or different elements.

3.2. Auditory scene analysis

The second main reference is to Albert Bregman's *auditory scene analysis*, also founded in Gestalt theory. Bregman writes about the following principles:

- *Proximity*
- *Similarity*
- *Good Continuation*
- *Closure*
- *Common Fate*

These ideas are extended into the 'neo-Gestalt' analysis according to which there are two levels or stages of perceptual processes:

- *Automatic instinctive and effortless*
- *Voluntary learned and effortful*

3.3. Spectro-morphology

The third main reference is Denis Smalley's **spectro-morphology** and structuring processes which, in terms of my argument may be considered as a final evidence for Pierre Schaeffer's typo-morphology concepts relating to the perception of the Sound Object. I would like to focus particularly on Smalley's concepts of *Level and Focus* and *Texture and Gesture* investigating their relationship to live processing and the interactive dialogue between instruments and electroacoustic sounds.

3.3.1. Level and Focus – Gesture and Texture

The idea of *Level and Focus* has to do with interaction and the degree of aleatoric organisation or randomness involved. On this point Smalley writes that '… we need to be offered the possibility of varying our perceptual focus throughout a range of levels during the listening process …'. To survive repeated hearings, a work must possess this focal potential. A mixed work for instruments and electroacoustics, based on an open structure, should not rely on the listener's ability to discover the small and hidden details of the composition. The focal scanning of structural levels should allow different ways of linking the sonic materials within the same discourse.

Following Smalley's words on *Gesture and Texture*, Gesture has to do with trajectory, with the application of energy and its consequences; and is married to causality. This idea of Gesture is central to the analysis here, and the concept of causality is essential to any kind of interactive project and will provide the threads of an interactive dialogue where occurrences and consequences may exchange their roles.

Inside an electroacoustic interactive work, *Texture* and *Gesture* are in flux, one as a consequence of the other, ranging from what Denis Smalley calls *first order surrogacy* of recognisable instrumental sound, to second or *remote order surrogacies* where timbral variations related to or obliterated from the source may emerge, always according to Smalley's concepts where the higher order surrogacies refer to deeper transformations of the original sound. So we may affirm that the balance between *Texture* and *Gesture* will have a role in defining the nature of sound discourse.

4. INTERACTIVITY OR INTERACTION? QUALITIES OF AN INTERACTIVE PERFORMANCE

The first experiences of integrating acoustic instruments within electroacoustic discourse were ruled by laws coming from either the world of the purely instrumental music, or from the purely electroacoustic world. In the typical concert situation for an electroacoustic work with instruments from the 1960s to the early 1990s, performers followed a strict temporal axis, provided by a recorded part that was 'fixed', making chronometer timekeeping in concert a frequent occurrence.

This practice plots against a natural interaction between performers and electroacoustic sounds. Even in works that contemplate the possibility of diverse responses, the performers' decisions will never modify the electroacoustic part, and the observed relationship is that of a form of interactivity which we may also call responsive interactivity where, after a given stimulus, a possible response takes place. This could also apply to situations where the performer's part is fixed, and the computer produces possible responses.

Recent technological developments, however, allow us to define in real time practically all the aspects of sonic discourse, making possible an interactive relationship between instrumental and electroacoustic sound where both may change in time as a result of a two-sided stimulus-response relation that not only allows but in fact requires freeing of the diachronic axis. This concept of interaction, which we may also call co-action, is much more flexible as it allows both participants to question and answer each other in different ways during the work.

4.1. Action and reaction: Causality – Gesture Salience

We may affirm that inside an electroacoustic interactive composition the internal texture streams of the electroacoustic part favour the relations of causality. Denis Smalley defines causality as a relevant quality of acousmatic perception, close to the concept of *Gesture*. I would like to extend this concept to the internal relationships between the participants of an interactive work, where the performers as well as the audience will distinguish the principal elements of the discourse from the secondary ones. In this situation the performers, acting as subjects, will look for stimuli in the fixed part on media. We may call these elements, which permanently suggest to the instrumental performers more than one possible reaction, the *Gesture Saliencies* of the electroacoustic part.

4.2. Perceptive Pregnance

According to the Gestalt principle of Pregnance, any short instrumental fragment has its own essential element or *good figure*. For instance, a long trill followed by three staccato notes, will be perceived more as a trill than as a staccato, and a sequence of notes, each one played with increased energy, will be perceived more as a 'crescendo' than as a melody. This distinctive property of the instrumental fragments' saliencies may also correspond to the gestural character of the way it is executed or to the instrumental timbre.

In performance, when these elements work interactively with the *Gestural Salience* of the electroacoustic part, we may then talk about the *Perceptive Pregnance* of the instrumental fragments. We may think of *Pregnance* as a synonym of *Salience* so that both are near to the idea of *Gesture*. Then, the relationship between *Gestural Saliencies* and *Perceptive Pregnances* will become the conductive thread of the interactive discourse.

5. RELATING THESE IDEAS TO DIFFERENT MODELS OF CONSTRUCTION OF MUSICAL DISCOURSE

From these ideas, I would like to search for new models of construction with the aim to get, as a result:

- A free and fluid instrumental performance, freed from a rigid diachronic axis without damaging the primary importance of perception.
- A deep use of the instrumental tonal resources.
- A broad field of interaction where aleatory introduces freedom restrained by certain rules or values that should enable different approaches to the musical discourse, taking care that the composition should be perceived as the 'same work' in all performing instances.
- A high degree of complexity in the interactive process, allowing for performance of the composition on different platforms and/or operating systems without the presence of the composer.

All these ideas might allow the development of multiple composition strategies, which may use one or several performers interacting with different technological resources. As an example I will present three of the most usual strategies in this field and focus on one of these:

- *a purely electroacoustic discourse,*
- *a mixed composition without real time sound processing,*
- *a mixed composition including real time sound processing.*

5.1. First strategy

If we intend to construct an interactive, purely electroacoustic work, we should first find an answer to some questions …

- *Which kind of purely electroacoustic interaction are we talking about?*
- *Should we consider as interactive the real-time treatment of sound in the studio?*
- *Is it necessary to transfer the live processing experience into the performance itself?*

In my personal opinion, interaction is always an open experience where the general conditions are defined before the live performance and the final decisions are taken in front of the public. The use of real-time processing software in the studio is not enough to define it as an interactive composition. Following this idea, the well-known instance of the non-real-time electroacoustic work completely conceived and realised in the studio will be transformed in a new kind of sound art expression which we may call an *electroacoustic real-time sound construction*, where:

(1) all the sound materials may or may not be designed in the studio,
(2) the texture construction procedure should be decided live, and
(3) the live control of the dynamic and spectral evolution of sound may actually become the central core of the work.

For this purpose there are some pieces of software that allow complete real-time control of sound.

5.2. Second strategy

For the case of a mixed composition without real-time sound processing we must decide about the source of the electroacoustic materials. This will become a main issue and will define the character of the whole composition which will be different depending on whether the sound objects are or are not related to the instrumental sounds.

Then, we will be able to use one or more instruments to construct the mixed work and the electroacoustic part will be completely fixed on media. The traditional mixed composition from the 1960s and 1970s showed the performers more attached to the chronometer than ready to listen to the electroacoustic sounds and simply play along with them. To avoid this situation, we should provide the instrumental performers with more than one alternative to dialogue with the electroacoustic part. This situation will almost inevitably cause us to break the time axis and force the performers into a dialogue. The basic difference between the second and the third strategy will be the inclusion of real-time processing, so I will refer to this opening to freedom of choice and natural dialogue inside the *third strategy*.

5.3. Third strategy

For the case of a mixed composition including real-time processing I would like to propose a model of construction for interactive music discourse which aims to provide a structure as open as possible, but where the final outline of the whole composition remains in the hands of the composer and the performer/s instead of being defined by the nature of the software involved.

This model or strategy should allow the consolidation of some of the principal targets: to get a fluid performance, to be free of the diachronic axis, to get a large field of interaction and to design different interfaces for performance. For that purpose, the introduction and management of randomness or aleatory limited by perceptual rules is crucial.

5.3.1. Controlled or restrained randomness

Any real-time construction embodies some grade of randomness, and a fundamental question in the process of composition is to define how much randomness we will allow. Also, if we have the aim of reaching an understandable sound discourse, which is to say a clear discursive thread that may be friendly to the musicians and followable by the public, we will need to focus on how deeply we should allow change in the ordering of elements on the time axis. There may be different procedures which should simultaneously allow the existence of an open structure without risking damage to a sense of unity within the discourse. For instance, a work divided into several sections, each one with a recognisable character, all of them including aleatoric elements, but keeping always the same ordering of the sections, may show similar and different occurrences on each performance. But as long as the episodic order of the sections never changes, and aleatoric processes occur inside each section, the listener will perceive variations of the same central idea.

Gestalt principles will impose limits on performers so that their broadened perception, thanks to the multiplicity of possible approximations, should constrain a sense of randomness at the point where they may begin to lose contact with the work's unity due to excessivly aleatoric processes.

6. A PARTICULAR CASE: FLAX

From my perspective, the best way to present this third strategy is through the analysis of an interactive composition that follows these guidelines. The work's title is *FlaX*, which I composed in 2002 for real-time processed flute and electroacoustic sounds recorded on digital media. The title of the work comes from *flauta* which is the Spanish word for flute and X as an indication of the presence of sound processing.

6.1. First step

The first step in the composition of the piece was the creation of the instrumental part. The goal was to make

it as natural as possible to the performer. He should play it as naturally as a work for solo flute. So, at this first stage, the work took the form of a purely instrumental composition consisting of thirty-two short fragments or modules. Each one of the fragments has a strong gestural nature that allows multiple orderings, so that they should behave as modules inside the piece, and their existence should not be restricted to the electroacoustic treatment. This in fact allows multiple associations based on the performers' Gestalt. The thirty-two segments were set out in the score in one of their possible orderings, just as in a solo flute piece. The intention was that if the the modules integrate well as a self-sufficient work for flute, then that integration should provide a strong basis for the interactive composition, helping to deepen the relation between the performer and the instrumental part. As for the second step, it was necessary to record the flute modules, in a particular arrangement given to the performer as a standalone work for flute whose title was *FLA*.

6.2. Second step

The second step was to record the instrumental segments and use them as raw material for the composition of the electroacoustic part. This was done in the studio using different pieces of software, principally GRM Tools by Ina-GRM. The deeper transformations of the flute sound (*remote surrogacies* according to Denis Smalley's classification) are then used in the electroacoustic part moving constantly back and forth from second-order to remote surrogacy providing the instrumental performer with different stimuli for interaction.

The less drastic transformations are left for real-time performance. Since one goal is that the performer should play naturally, he needs to recognise his own sound and dialogue with the recorded and live electroacoustic ones, so that *gesture* becomes a main subject. Hence, the real-time processing of the acoustic instrument has to retain something of the stamp of the original timbre.

6.3. Third step

The third step was the grouping of the instrumental fragments. This was done according to criteria I call *perceptive pregnance*, emphasising the principal element of every fragment, which is to say pointing out on each segment its more clearly perceptible outstanding element *for the performer*. I refer specifically to the instrumental performer because he has a deeper focal approach than the audience.

The thirty-two short segments were grouped into seven perceptive categories:

- Frullati
- Impulses
- Crescendi
- Iterations
- Long Notes
- Phrases
- Rough sounds

These categories correspond to criteria of *perceptive pregnance*, emphasising the principal feature of every fragment, in other words pointing out on each segment its more clearly perceptible defining element for the performer.

Of course, each fragment may have different characteristics, but the idea is to consider the most outstanding one for interaction. This might also not be the same for different performers, so when the composer defines these categories he must relate them to the character of the sound objects being played and the texture over which these instrumental fragments should be applied. For this reason, the instrumental fragments' categorisation and assignment to different episodes or sections is up to the composer and not the performer.

Figure 1 gives details of all the instrumental fragments classified in accordance with these criteria, showing their placement in the score. Since these are perceptually defined, this might not be the only possible classification. The chart will help to identify the different instrumental modules inside the score (see Figures 2 to 5).

6.4. Fourth step

The fourth step corresponds to the composition of the interactive piece. *FlaX* was thought up as an interactive work 'a tre' with an instrumental part for flute, an electroacoustic part on media and a real-time (live) processing part for the flute sound. While the electroacoustic part on media is completely composed in the studio, the other two parts interact within the limits of which I called *Controlled randomness* (Section 5.3.1). The flute part is divided into sections and inside each section the flutist may choose the ordering of the instrumental segments. Following this idea, the real-time processing part is done by a second performer who also has different processing alternatives inside each section, and may also change the ordering of those. So both performers interact deciding how to dialogue. The flutist and the electroacoustic real-time performer have to listen to each other and also to the third non-real-time part on fixed media.

The electroacoustic (non-real-time) part is divided into different sections. At every boundary point between two sections, there is a clearly recognisable sonic reference for the instrumental performer which also appears in the score (at 0′00″, 0′26″, 1′45″, 1′59″, 2′11″,

FlaX **Instrumental segments' placement in the score**

(fragments which may be freely ordered by the performer are indicated as "Module" those that remain fixed in time as indicated as "Segment")

(page / reference / module or segment nº and any extra reference)

7 Phrases : 1/0'26" == 1/ Gestos1/Module1 == 2/Gestos2/Module3 == 3/Gestos3/Module1 Line1
3/Gestos3/Module1 Line4 == 3/Gestos3/Module2 Line4 == 4/Gestos5/Module4

4 Long Notes : 1/RTP0/Segment1 == 2/Gestos2/Module1 == 3/Gestos3/Module2 Line1 == 3/Gestos3/Module3 Line1

4 Crescendi : 1/Gestos1/Module2 == 1/Gestos1/Module4 == 4/Gestos4/Module1 == 3/Gestos3/Module2 Line3

5 Impulses : 3/Gestos3/Module1 Line2 == 3/Gestos3/Module2 Line2 == 3/Gestos3/Module1 Line3
4/Gestos4/Module3 == 4/Gestos5/Module3

2 Rugous sounds : 3/Gestos3/Module3 Line2 == 4/6'01"

3 Frullatti : 1/RTP0/Segment2 == 3/Gestos3/Module3 Line3 == 4/Epilogue

7 Iterations: 1/Gestos1/Module3 == 2/1´45" == 2/Gestos2/Module2 == 2/Gestos2/Module4
4/Gestos4/Module2 == 4/Gestos5/Module1 == 4/Gestos5/Module2

Figure 1. Instrumental segments' placement in the score.

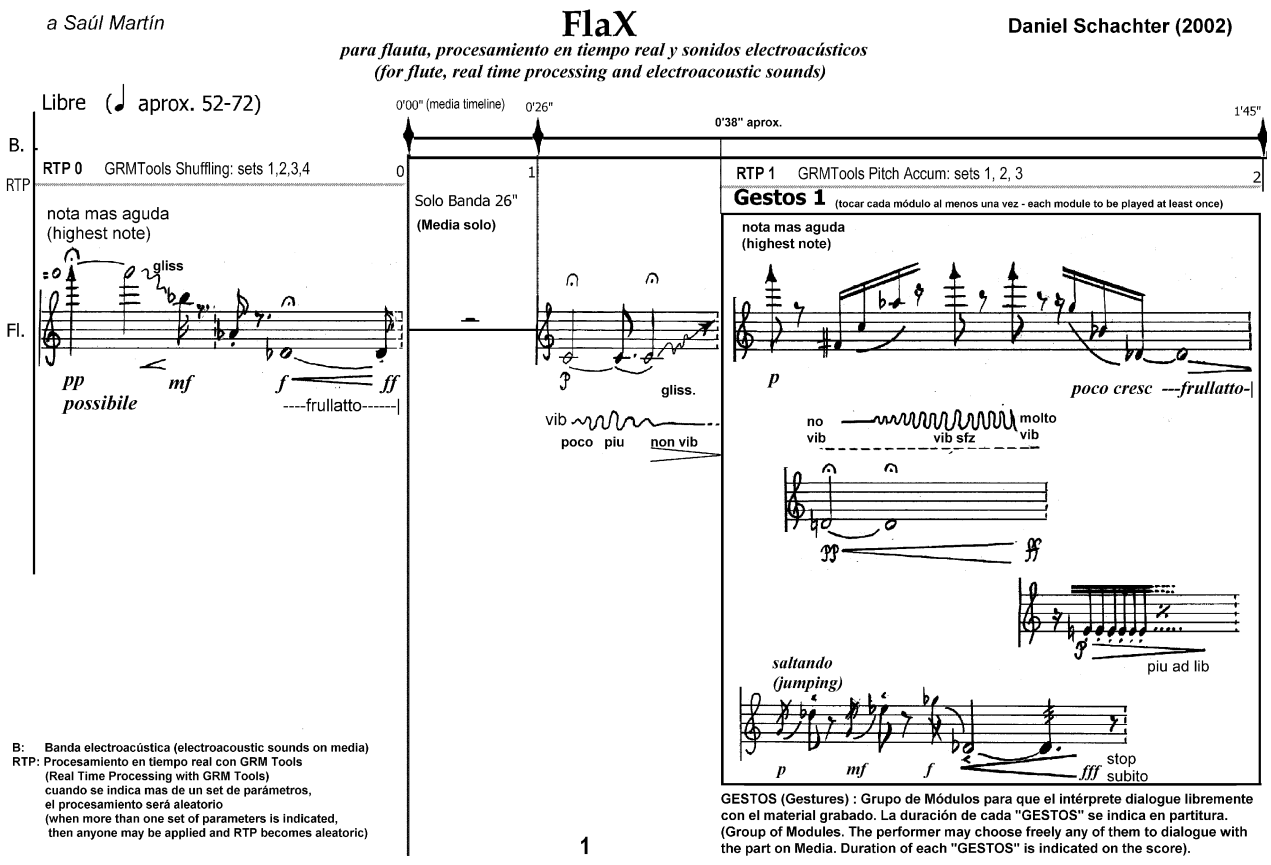

Figure 2. The score (part 1).

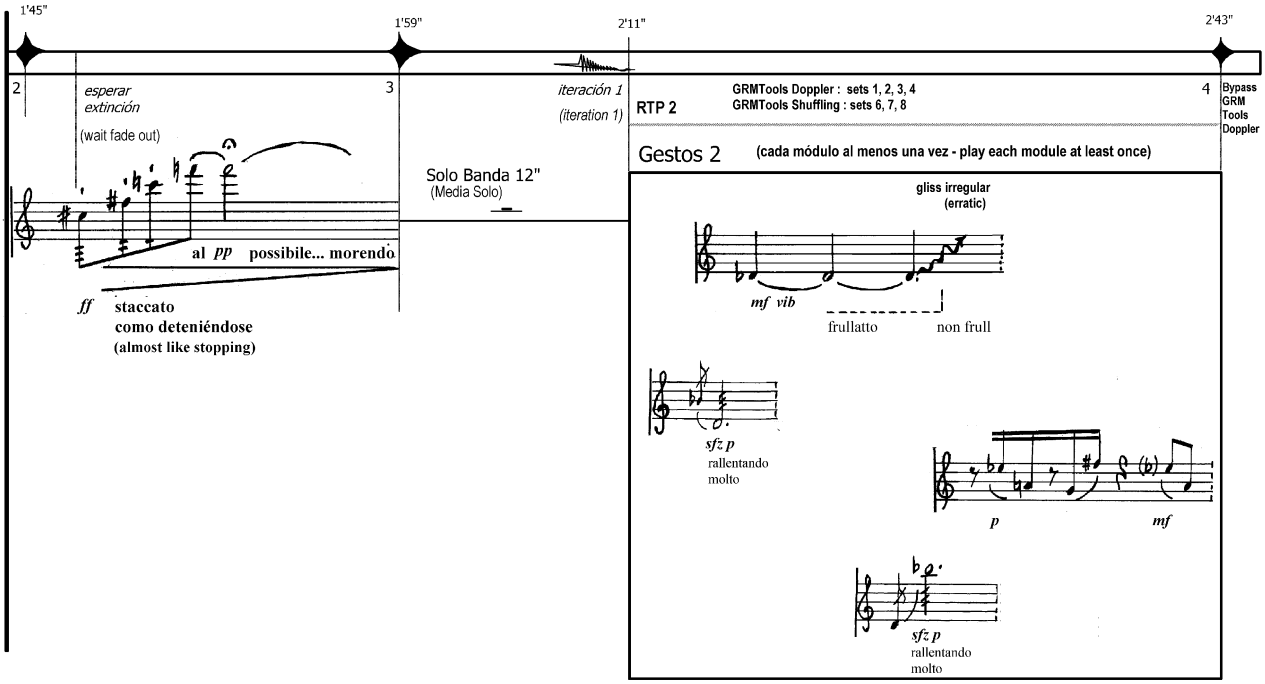

Figure 3. The score (part 2).

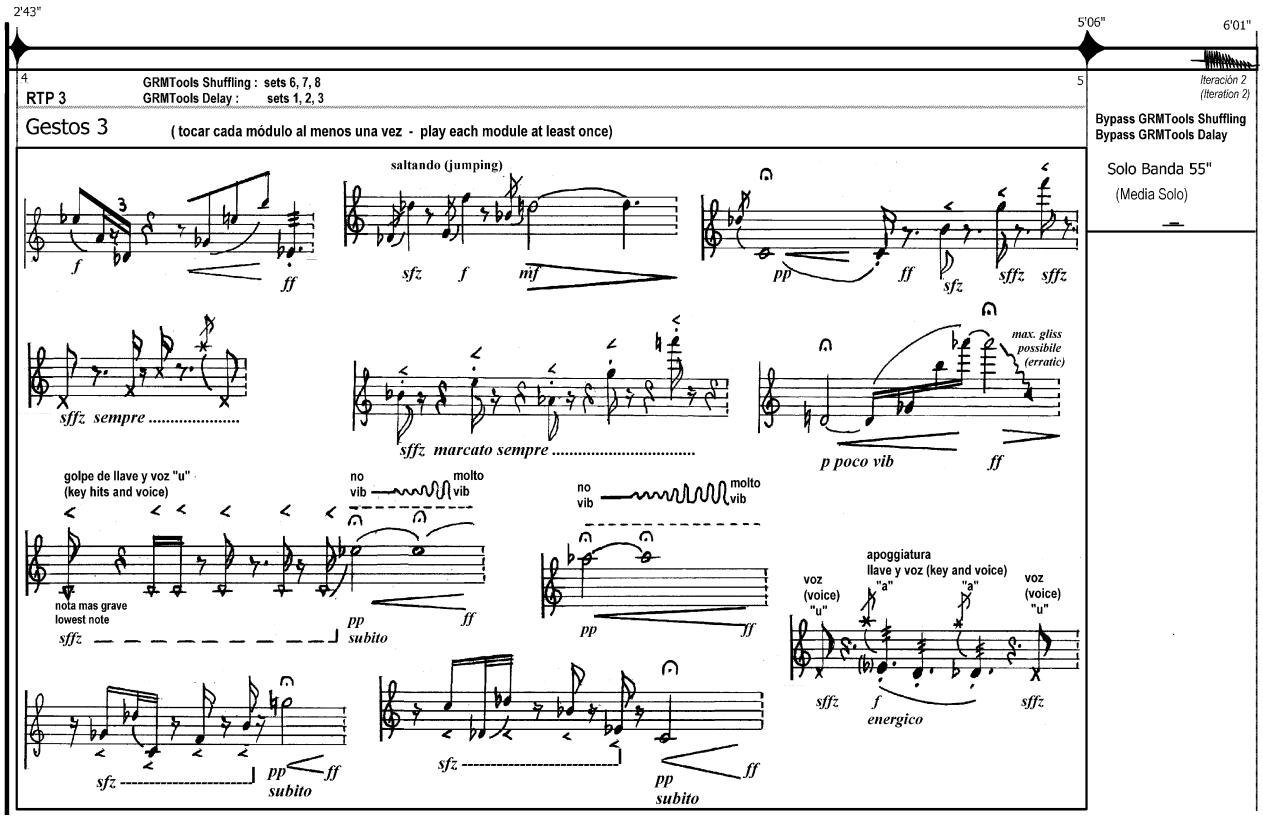

Figure 4. The score (part 3).

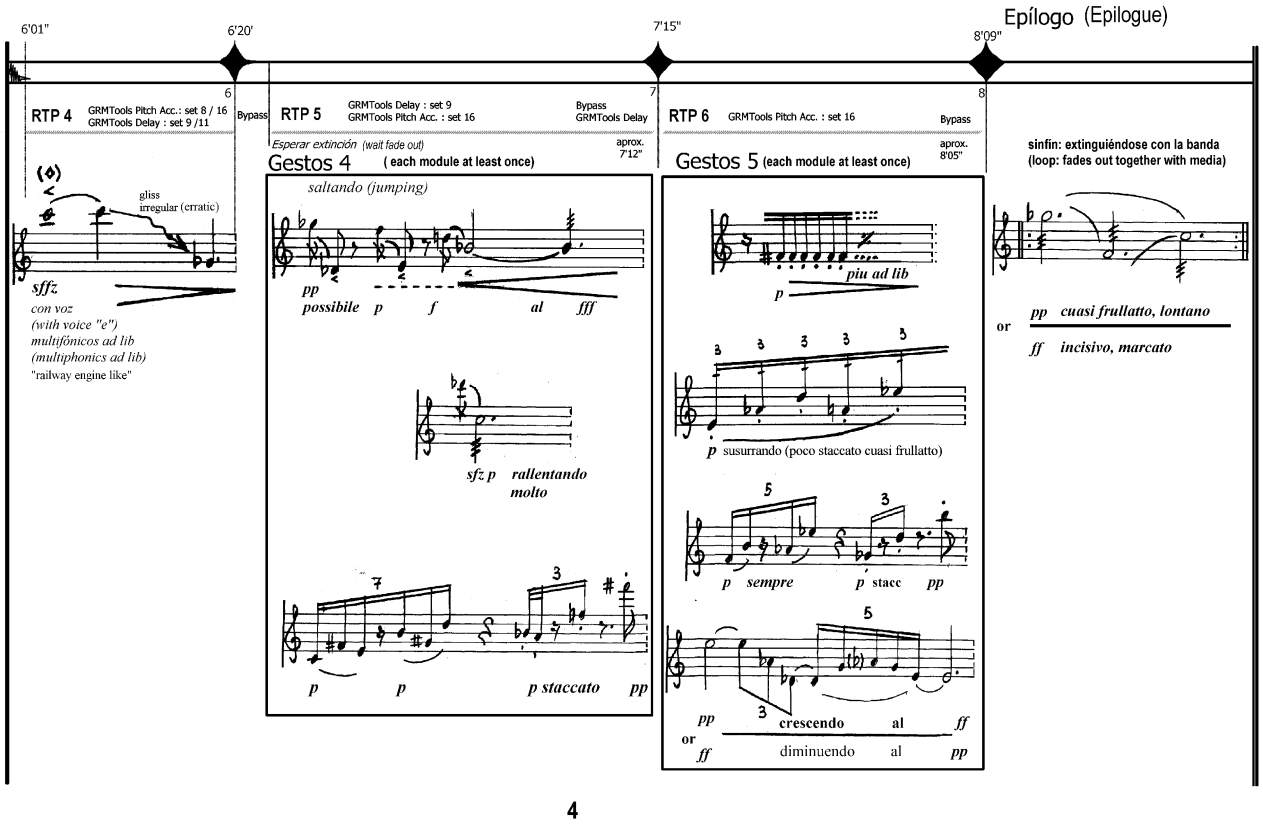

Figure 5. The score (part 4).

2′43″, 5′06″, 6′01″, 6′20″, 7′15″ and 8′09″ which corresponds to the electroacoustic recorded part). The flutist must recognise these sonic references, which are the key to a fluid dialogue because on each one he will change the instrumental fragments. Chronometric time-keeping should therefore not be necessary.

The instrumental modules are assigned to specific sections of the work. Inside each section the instrumental performer may choose how to order those fragments as if they were possible responses, and he must play each module at least once. So, the aleatoric work takes place inside each of these sections, but the sections' order remains untouched. This gives the work an episodic structure which becomes the principal axis of the musical discourse. In traditional instrumental music the concept of the 'version' of a work has to do with change in interpretation which is completely subjective. Instead, in this model the performer may change the ordering of the elements and also repeat the fragments, turning the performance into a process that is simultaneously dependent on objective and subjective criteria.

As the gestural character of the elements involved is central, each block of modules inside the different sections of the work is referred to as *Gestos* (Gestures). Then inside each *Gestos* section there are a fixed number of freely usable modules for interaction. There are three lines in the score (Figures 2 to 5):

- **B**, the 'EA band' which is the electroacoustic non-real-time part composed in the studio, also reffered to as 'recorded part' or 'electroacoustic part on media' in this work.
- **RTP**, the real-time processing of the flute part, by the real-time processing performer.
- **FL**, the flute part.

6.5. Software and hardware for real-time processing

Since one of the premises on which this work is based is that technology should not become an end in itself, any composition based on this model should not need dedicated (or expensive) hardware/software platforms. This is important to ensure the diffusion of the work almost anywhere. As such, our dependency should be limited to just one flexible, affordable and adaptable piece of software for real-time processing, that should run on different operating systems without modifying the result. The choice of real-time processing software will then also become a significant decision.

For *FlaX* I found GRM Tools VST plugins (by Ina-GRM, Paris) to be the most flexible piece of software for this purpose. These may run inside Max/MSP, on GRM Tools player, Spark FX Machine, Wave Lab, Audiomulch, Bidule, Pure Data, etc., on Macintosh,

FlaX for flute, RTP and electroacoustic sounds **© Daniel Schachter (2002)**

GRM Tools VST - Settings for RTP (flute Real Time Processing) **(= means same value as previous preset at left)**

SHUFFLING Mono or Stereo	1	2	3	4	6	7	8
gain	0 dB	=	=	=	=	=	=
mix (according to acoustics and/or mixing equipment)	50% / 70% / 100%	=	=	=	=	=	=
fragment	494ms	=	730	=	990	374	171
envelope	100%	=	=	=	88%	68%	96%
delay	129ms	=	112	=	315	991	990
initial pitch	-7	=	-7.5	=	0	=	=
final pitch	-7	=	=	-5.5	0	=	=
random pitch	0%	=	1%	0%	=	=	=
feedback	10%	54%	=	7%	22%	=	=
density	84%	=	=	=	=	=	=
mono/stereo	85%	=	=	=	100%	=	=
Interpolation can be done between settings	1, 2, 3, 4, 6, 7, 8						
transition time	free						

PITCH ACCUM Mono or Stereo	1	2	3	8	16
transpose	-6,22	-9,03	-13,4	-10	-8
delay	123ms	900	12	=	0
gain	0dB	=	=	-3	=
transpose	-5,45	-8,05	-15,46	-15,06	-13,77
delay	83ms	350	0	=	0
gain	0dB	=	=	-3	=
p.mod.frequence	0Hz	0,1	1	1,2	1,2
p.mod.amplitude	100%	13%	0	=	0%
p.mod.phase	0,50%	0%	0,50%	=	0,50%
r.mod.frequence	0Hz	=	0,03	=	0,1
r.mod.amplitude	4%	=	0%	=	0%
r.mod.smooth	72%	42%	50%	=	50%
feedback	30%	6%	0%	=	2%
mono/stereo	1,00%	=	=	=	=
direct (according to acoustics and/or mixing equipment)	-3dB / -6dB / -96dB	=	=	=	=
cross-fade	30%	10%	100%	=	100%
window	300ms	560	155	=	=
pitch detector	off	=	=	=	=
Interpolation can be done between settings	1, 2, 3, 8, 16				
transition time	free				

DOPPLER Mono or Stereo	1	2	3	4
gain	0dB	=	=	=
mix (according to acoustics and/or mixing equipment)	50% / 70% / 100%	=	=	=
X pos	0,42	0,08	=	0,42
Y pos	0,36	1	=	0,36
amp variation	0%	=	=	=
dopp variation	33%	60%	40%	72%
following time	1,7s	0,7	=	1,5
circle amplitude	25%	69%	83%	68%
circle frequency	2,8Hz	9	17	63,7
Stereo parameter (optional) ch.separ	0,71	=	0,53	0,16
Stereo parameter (optional) phase	0	=	=	=
Interpolation can be done between settings	1, 2, 3, 4			
transition time	free			

DELAYS Mono or Stereo	1	2	3	9	11
first	3293 ms	3898	=	0	0
range	2651 ms	2046	=	173	554
gain	0	=	=	=	=
mix (not free, changes conforming the preset number)	75%	=	=	50%	50%
nr of delays	10	24	6	20	=
amp distrib	1,17	1,146	0,642	1	=
del distrib	0,79	1,309	1,645	0,5	0,903
random del	0 ms	=	=	=	=
var rate	10,8 ms	0	=	200	=
feedback	4%	0%	=	55%	100%
mono/stereo	100%	=	=	=	=
interpolation	- do not interpolate in RTP to avoid clipping				
transition time	- do not use in RTP to avoid clipping				

Figure 6. Settings for real-time processing.

Windows, or Linux platforms. Also, VST, TDM and RTAS versions have the same parameters. For the different sections of the piece, I used the following GRM Tools:

- *Shuffling*
- *Pitch Accumulation*
- *Doppler*
- *Delay*

For each one of these a specific preset file was designed. Figure 6 details the parameters for each one of the four GRM Tools plug-ins used for real-time processing.

Inside each section there are different options for real-time processing, applicable to the groups of instrumental modules. There are similarities among the different processing presets, so that the discourse may always be understood as the same, but approached from a different perspective or 'angle' of perception. While the instrumental performer decides which module to play, the real-time processing performer also decides how to process the flute. So there are two performers interacting. The goal is to obtain flexibility in the construction and clarity in the comprehension.

Each time there is real-time processing to be applied, this is shown on the score as a sequence of 'RTP' indications: RTP0, RTP1, RTP2 … Each of these RTP sections indicates on the score which of the GRM Tools have to be applied and which are the available presets that may be used to process the flute sound within that section. There are sections with only one process or with two simultaneous processes. Using the GRM Tools' interpolation feature we may find infinite points of transition between presets, so that both performers should be able to follow each other.

The tension grows from the beginning to the climax by the end of the *Gestos 3* section, just when the flute must stop playing at 5′06″. There are many elements there inside a very complex texture. Relaxation begins just before *Gestos 4* and continues up to the end. This structure may be perceived thanks to:

- The recorded part (B) which is fixed on media which follows the line between tension and relaxation.
- The instrumental and RTP parts follow the evolution of that tension-relaxation line.
- There are some places were the flutist has no aleatoric choices, at the beginning, at the end of the piece, and also others acting as articulation between sections. In my view these help the listener to perceive more clearly the structure of the piece.

As far as the construction model is concerned, all the instrumental fragments might be assigned to different sections or episodes and might be the object of an aleatoric treatment. Instead, in *FlaX* there are six of these which remain fixed in time while the other twenty-six may be freely ordered and repeated inside each of the sections to which they are assigned. This is a particular feature of this composition and assists comprehension of the discourse. The instrumental segments not used for aleatoric purposes are:

- two modules at the beginning, just before the start of the EA band (B) at 0′00″,
- one module at 0′26″ before *Gestos 1*,
- one module at 1′45″ after *Gestos 1*,
- one module at 6′01″ before *Gestos 4*,
- one module at the *Epilogue* which loops and fades out together with the EA band (B).

So these instrumental fragments, together with the electroacoustic part on media (B), become the fixed elements which act as an outline reference, over which aleatory appears inside each section.

FlaX was premiered in Buenos Aires at the Sonoimagenes International Festival in August 2002 (with Saul Martin, flute) and was also performed in June 2004 at the Sonic Arts Network Conference *Soundcircus* in Leicester (with Rob McKay, flute). In both cases, the work was performed in a Macintosh environment, running GRM Tools inside Max/MSP.

REFERENCES

Bayle, F. 1993. *Musique acousmatique, propositions, positions*. Paris: Institut National de l'Audiovisuel & Buchet/Chastel.

Behrens, R. 2002. Art, design and Gestalt theory, *Leonardo on-line*, http://leonardo.info/isast/articles/behrens.html.

Bregman, A. S. 1990. *Auditory Scene Analysis: The Perceptual Organization of Sound*. Cambridge, MA: MIT Press.

Chion, M. 1983. *Guide des objets sonores*. Paris: Institut National de l'Audiovisuel & Buchet/Chastel.

Emmerson, S. 1986. The relation of language to materials. In *The Language of Electroacoustic Music*. London: Macmillan.

Leman, M. (ed.), 1996. Music, Gestalt, and computing: studies in cognitive and systematic musicology. *Lecture Notes in Artificial Intelligence* **1,317** New York: Springer Verlag.

Rudy, P. 2003. Spectro-morphological diatonicism: unlocking style and tonality in the works of Denis Smalley through aural analysis. *Journal SEAMUS* **16**(2): 18–27.

Schaeffer, P. 1966. *Traité des objets musicaux*. Paris: Éditions du Seuil.

Smalley, D. 1986. Spectro-morphology and structuring processes. In S. Emmerson (ed.) *The Language of Electroacoustic Music*. London: Macmillan.

Wertheimer, M. 1923. Laws of organization in perceptual forms. First published as 'Untersuchungen zur Lehre von der Gestalt II' in *Psycologische Forschung* **1**: pp. 301–50.

Musical example (audio) corresponding to this article to be included on the next DVD edition: FlaX, for real time processed flute and electroacoustic sounds, by Daniel Schachter. Saul Martin, flute – Daniel Schachter, real time processing.