Coherence and spontaneity in *Interferências (2003)*, for cello and computer[1]

Daniel L. Barreiro

Rua Rosalino Belline, 98 - Santa Paula - 13564-050 - São Carlos - SP - Brazil

dlbarreiro@gmail.com

Abstract. *This paper presents some musical and technological aspects involved in the composition of Interferências (2003), for cello and computer (running a Max/MSP patch). It mentions the main characteristics of the work and how the Max/MSP patch contributes to generate a musical discourse that seeks both coherence and moments of spontaneity (as the result of a process of mutual influences between computer and performer).*

1. Brief outline of the composition

Interferências ('interference', in Portuguese) is a composition for cello and computer (running a Max/MSP patch) which is based on the interplay of three sonic layers based on sound materials of the following kind:

a) sounds produced by the cello live;

b) pre-recorded cello sounds that are triggered and processed in real-time by the computer according to the analysis of the audio signal produced by the cellist;

c) pre-processed electroacoustic sounds triggered by the person who controls the computer.

The sounds processed in real-time work as an intermediate level (a link, in fact) between the two other layers (the sounds of the instrument and the more heavily processed sounds of the pre-processed electroacoustic part). For this reason, they are not heavily transformed - only submitted to subtle changes regarding pitch, duration and amplitude. A 'counterpoint' is established between these three layers throughout the piece.

To a certain extent, the structure of *Interferências* can be regarded as a continuous process that incorporates some contrasting relations into its flow. The contrasts are established in such a way that does not justify the segmentation of the structure into different sections. There are, however, different 'segments', understood as moments in which the musical flow presents some fluctuations or variations. These variations are mainly related to differences in articulation and density of events (either in the instrumental or in the electroacoustic part, or even both), and to some fluctuations

1 This paper is based on some excerpts of the written component of my PhD in Musical Composition [Barreiro 2006], which was carried out between 2003 and 2007 at *The University of Birmingham* (UK) under the supervision of Professor Jonty Harrison and with a scholarship from the Brazilian Government through Capes Foundation. The Max/MSP patches discussed here were designed under the guidance of Dr Erik Oña.

in the flow of musical time. The phrases were organised to speed up the unfolding of time at certain moments and to slow it down at others, without signalling overt ‘sections’ to the listener.

Musical time was, therefore, a criterion taken into consideration for defining issues concerning the structure of the composition. Fluctuations in the overall time flow were explored through the use of different strategies derived from a research carried out during my Master’s degree [Barreiro 2000; Barreiro and Zampronha 2000a and 2000b]. These strategies include the use of variations in terms of speed and density of events, the level of contrast or similarity between sound materials and the use of unexpected events as 'impacts' that cause fluctuations in the time flow.

The work is conceived for stereo. Although one pair of loudspeakers might be considered enough for its performance, it is advisable to use at least two pairs instead of just one (especially when the work is performed in a large concert room). In this case, the placement of loudspeakers should follow the diagram presented in Figure 1, with two 'frontal' loudspeakers on the stage and two 'wide' ones on the floor – forming an arc. All the three sonic layers mentioned above are sent to the loudspeakers. The Max/MSP patch is designed in such a way that it allows independent volume control of each pair of loudspeakers. It is even possible to control the volume of the cello sounds and the volume of the two electroacoustic sonic layers independently in each pair. This allows, for example, that the cello signal be sent to the 'frontal' loudspeakers with a volume slightly higher than the 'wide' ones, consequently keeping the cello sounds mostly in the centre of the stereo image (which matches the position of the performer in the room).

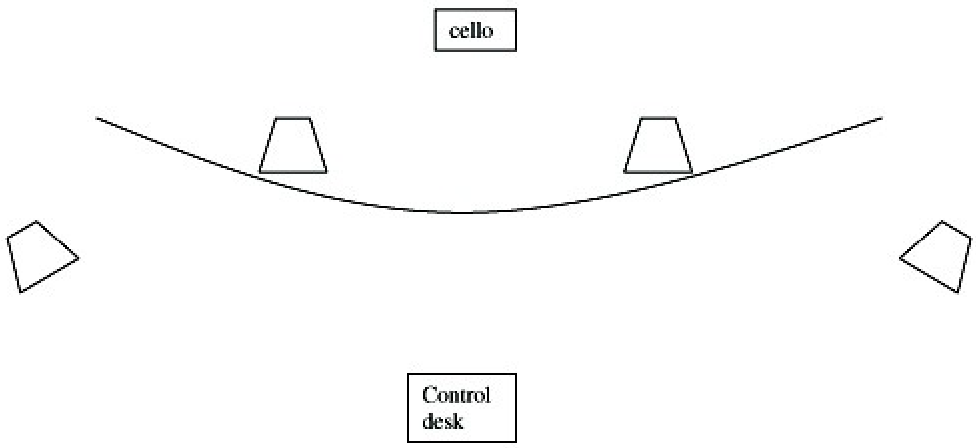

Figure 1

2. Sound material and compositional strategy

The electroacoustic part of *Interferências* (both the sonic layer generated in real-time and the layer of pre-processed sounds) is completely based on cello sounds captured in a recording session I had with the German cellist and composer Caspar Johannes Walter in 2003.

As guidance for the recording session I elaborated some charts displaying general information (in words) about the sound-types I would like to have as source material for the piece. The intention was to get a set of isolated sounds that should be as varied as possible. The charts asked for glissandos, pizzicatos, trills, tremolos, ricochets (jeté), harmonics, sounds of tapping on the body of the instrument and on the fingerboard, sounds with and without vibrato, sul ponticello, sul tasto, normal playing, notes preceded by single and double appogiatura, etc. There were indications that each kind of articulation should be played with different durations (short or long), dynamics, speeds and in different registers of the instrument. There were no indications of pitches - they should be chosen by the player.

The sounds obtained with this strategy constituted the source material that, after being processed, was used for the composition of electroacoustic segments of various lengths that are triggered at specific moments in the piece by the person who controls the computer (making up the pre-processed sonic layer mentioned above).

Some of these samples from the recording session were also stored as unprocessed source sounds and constitute the material that is triggered and processed in real-time by the computer during the performance according to the analysis of the audio signal produced by the cellist.

For the recording session mentioned above, I also wrote some short phrases on single line staves. They displayed precise information about the durations, articulations and dynamics to be used for each event, plus some vague information about register (low, medium and high). Again, I deliberately omitted details about specific pitches. The intention was to make the performer concentrate on the gestures indicated by the other parameters only. He should not worry about playing the 'right' notes - his concentration should essentially be focused on the gestures. I wanted him to improvise with the pitches within the framework set by the other parameters, so I asked him to play each phrase several times with different notes and some slight variations of tempo in each occasion.

The composition of these phrases was inspired by the concept of *Unités Semiotiques Temporelles* ('Temporal Semiotic Units'), or simply UST, developed by a group of researchers at the *Laboratoire Musique et Informatique de Marseille* - M.I.M. [Mandelbrojt 1996]. In general terms this research can be defined as a classification of musical gestures according to their temporal signification, i.e. the effects they potentially cause on listeners in terms of temporal perception. To some extent, this concept is the opposite of that of the 'sound object', since it does not target the sound for itself "in its material, its inherent texture, its own qualities and perceptual dimensions", "independently of its origins or its meanings"[2]. On the contrary, in the case of the USTs the meaning or, more precisely the 'signification' (understood not in the sense of verbal or conventional meaning, but as a temporal sensation) is the target. They are called 'units' because they are defined as coherent entities that preserve their 'signification' regardless the musical context in which they occur. Although this last concept can be polemic, I found the classification of gestures in the theory of UST quite interesting and

2 From the definition of 'sound object' presented in Chion (1983).

decided to use some of them as compositional tools for organising my musical thinking while composing *Interferências*.

Here are some of the categories that were chosen from the theory of the USTs:

1) Activity followed by glissando, with acceleration (as if something has been set in motion and suddenly fallen down);
2) Activity followed by a steady and extended sound (forces in contradiction: movement versus stability);
3) Relative stability suddenly disturbed by a gesture performing an acceleration;
4) Irregular repetition;
5) Sudden deceleration (as if a sudden resistance forbids a movement to continue);
6) Obsessive repetition;
7) Progression;
8) Presentation of a musical idea whose progression is not clear.

The musical phrases recorded by Caspar Johannes Walter as a result of this process were not used for the composition of the electroacoustic part of the work whatsoever. They were just used as a guide during the composition of the instrumental part. During the compositional process I had other recording sessions (this time with the British cellist Ellen Fallowfield, who premiered *Interferências* in November 2003) in which I could try new phrases, revise previous ones, try new combinations of phrases, etc. until I finished the composition of the instrumental part.

The phrases from the recording sessions were therefore treated in an ‘acousmatic’ way. The compositional work consisted in identifying their salient features, cutting, selecting and re-arranging their segments into larger phrases, and combining them with new segments in order to generate a continuous musical argument for the instrumental part. This empirical process was guided by the aural judgement of the results obtained and had the aim to explore fluctuations in the flow of musical time, based on the USTs mentioned above.

3. The score and the Max/MSP patch

The result of this compositional process is a score that indicates duration, articulation and dynamics of the musical events to be played by the cellist. The choice of pitches is left for the performer - the score only gives general indications of register (see Figure 2). The pitch contour (indicated in terms of register) is more important than the specific pitches themselves. As a consequence, the performer is encouraged to concentrate on the gestures, i.e. on the articulations, the contour and the amount of energy he or she delivers while playing the piece, rather than the choice of pitches.

The computer, running a Max/MSP patch, analyses the following three parameters:

a) the time elapsed between the onsets of subsequent events played by the cellist;

b) the duration of each event;

c) the amplitude of each event.

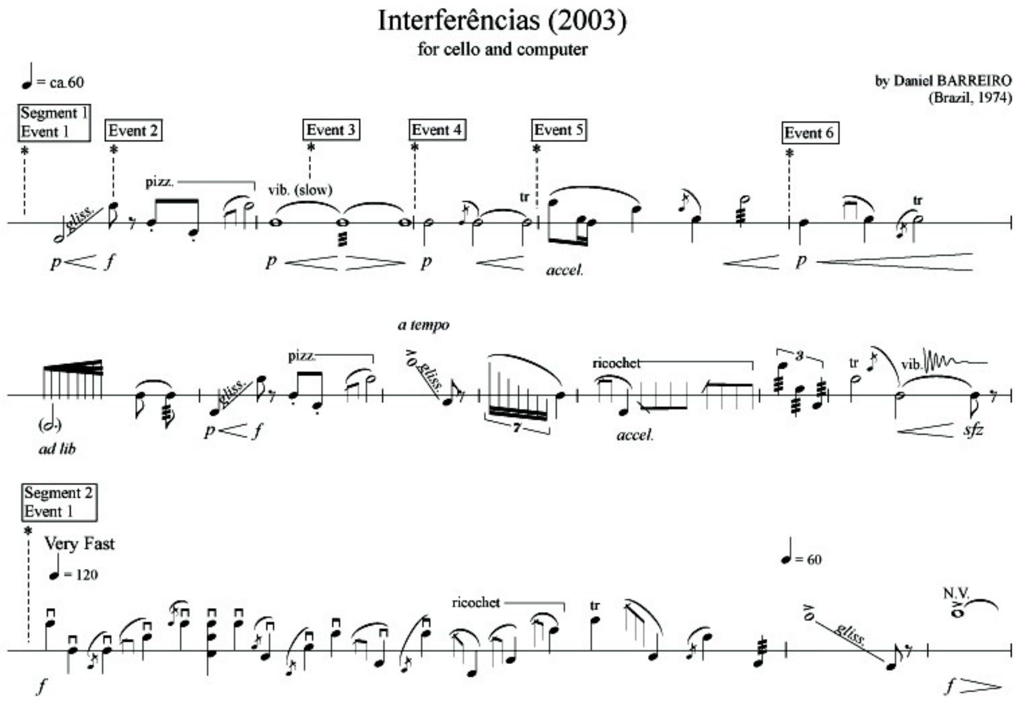

Figure 2

Based on the data obtained, it triggers and processes the pre-recorded cello sounds in real-time. Another person (not the cellist) follows the cues displayed on the score in order to trigger the playback of the pre-processed electroacoustic sounds and to change the settings that are used by the Max/MSP patch at specific moments in the piece.

The pre-recorded cello sounds (which are processed in real-time by the computer) are chosen according to a two-stage process. First, a category of sounds (based on the articulation they present) is chosen according to a list of probabilities that defines which categories are more likely to happen in each segment of the piece. Then, one specific sound file within that category is chosen randomly. Since the list of probabilities is changed from one segment of the piece to another, there are some subtle differences between the segments with regard to the characteristics presented by the sonic layer generated in real-time.

The definition of the density of events to be used in this sonic layer and the way the sounds are processed derive from data collected through the analysis of the cello signal. The analysis parameters mentioned above (interval between subsequent onsets, duration of the events and amplitude) are used to control three processing parameters (density of events to be triggered, transposition and amplitude). The way the analysis and the processing parameters relate to each other changes from one segment of the piece to another. Therefore, at a given moment it may happen that the amplitude of the cello sounds determines the amplitude of the pre-recorded sounds, for example. At another moment, the duration of the cello sounds (and no longer the amplitude) may determine the amplitude of the pre-recorded sounds. These variations avoid the interaction between cello and the sonic layer generated in real-time becoming predictable and derive from the compositional intention of avoiding direct and constant mappings between parameters of analysis and parameters of processing.

The decision for generating this sonic layer in real-time and for using probabilistic and random processes was guided by the intention to incorporate the spontaneity and the surprises created by such a process in the composition.

Since the sounds that are triggered and processed in real-time are pre-recorded cello sounds, there are some connections between this layer and the cello sounds played live, especially when there are coincidences in terms of articulation. This kind of connection sometimes also happens between the cello and the pre-processed electroacoustic sounds, creating imitative relationships between the two.

The recapitulation of materials, especially of some kinds of articulations, happens in different moments in the piece, linking the musical events and consequently contributing to generate the sense of coherence throughout the work.

4. A closer look at the Max/MSP patch

In *Interferências* - as usually happens with Max/MSP programming - the sound analysis and processing operations are carried out by several modules (Max/MSP subpatches) embedded in the main patch.

One of the main controlling tools displayed on the main patch itself (not in a subpatch) is a pair of two-dimensional volume controllers (see Figure 3) that enable the user to set and change the volumes of the four different audio signals independently: the signal of the cello live, the signal that comes out of the reverb unit (embedded in the patch), the sonic layer generated in real-time and the layer of pre-processed electroacoustic sounds.

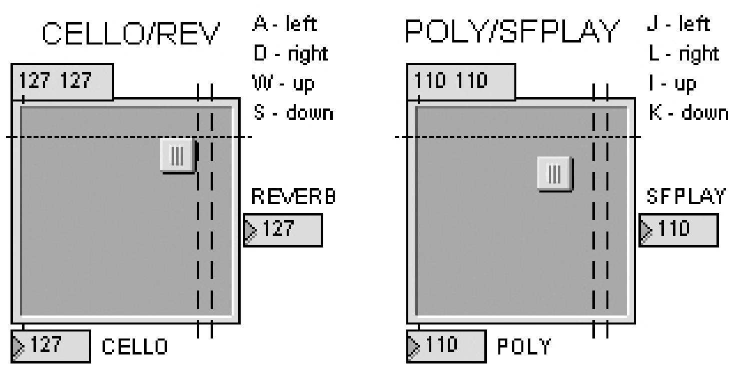

Figure 3

The volumes are controlled by pressing keys on the computer keyboard (A, D, W, S, J, L, I and K) which were programmed to guide the movements of the faders inside the squares (see Figure 3). Some other faders positioned after these controllers in the signal chain allow the control of the general volume that is sent to the loudspeakers. As a consequence, the patch works as a mixing desk.

The analysis of the time elapsed between subsequent onsets presented in the cello signal (which relates to tempo in broad terms) is carried out by the "TempoEstimation" subpatch shown in Figure 4.

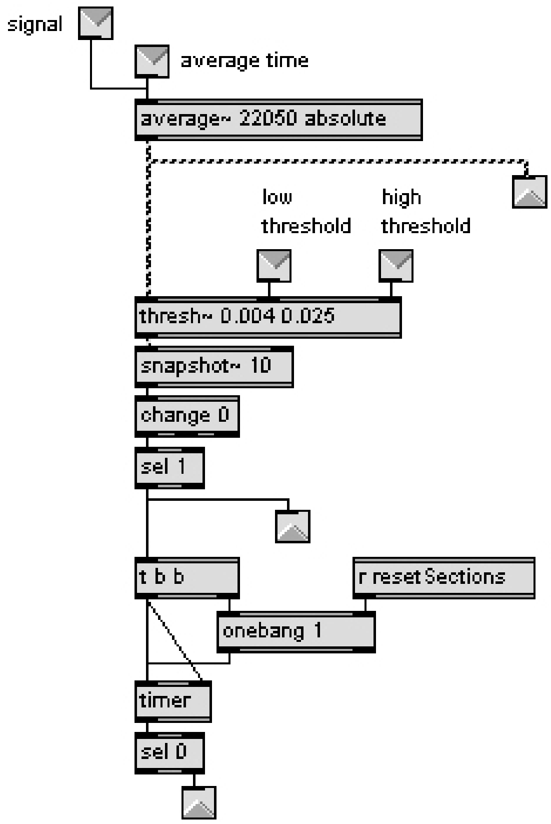

Figure 4

Whenever the amplitude of the signal goes above the high threshold (set in the 'thresh~' object), the 'timer' object receives a 'bang' that ends the previous count (reporting the time elapsed since the previous 'bang' in miliseconds) and starts a new one (which will be reported when the next onset is identified). A new onset is only identified by the 'thresh~' object after the amplitude of the signal goes below the low threshold and up again. A similar (but slightly different) subpatch, called "DurEstimation", is used for identying the duration of events played by the cellist (and no longer the time spans between subsequent onsets). The amplitude of the cello signal is also continuosly analysed by another module.

Data from these three analysis parameters (amplitude of the cello signal, duration of the events and time spans between subsequent onsets) are associated with the processing parameters (density of events, amplitude and transposition) in three subpatches that run in parallel throughout the performance of the piece. Each one of them is responsible for associating the three analysis parameters with one specific processing parameter. Therefore, based on data from each one of the three analysis parameters, the "PolifControlMachines" subpatch generates data to control the number of pre-recorded soundfiles that are triggered at a time. The "TransControlMachines" subpatch associates data from the three analysis parameters with data that control the speed of playback (and therefore the transposition) of the pre-recorded soundfiles. The "AmpControlMachines" subpatch performs the same kind of job in regard to the amplitude of the pre-recorded soundfiles that are triggered in real-time. Figure 5 and Figure 6 show two different modules that illustrate some of the approaches adopted to generate processing parameters from the analysis parameters.

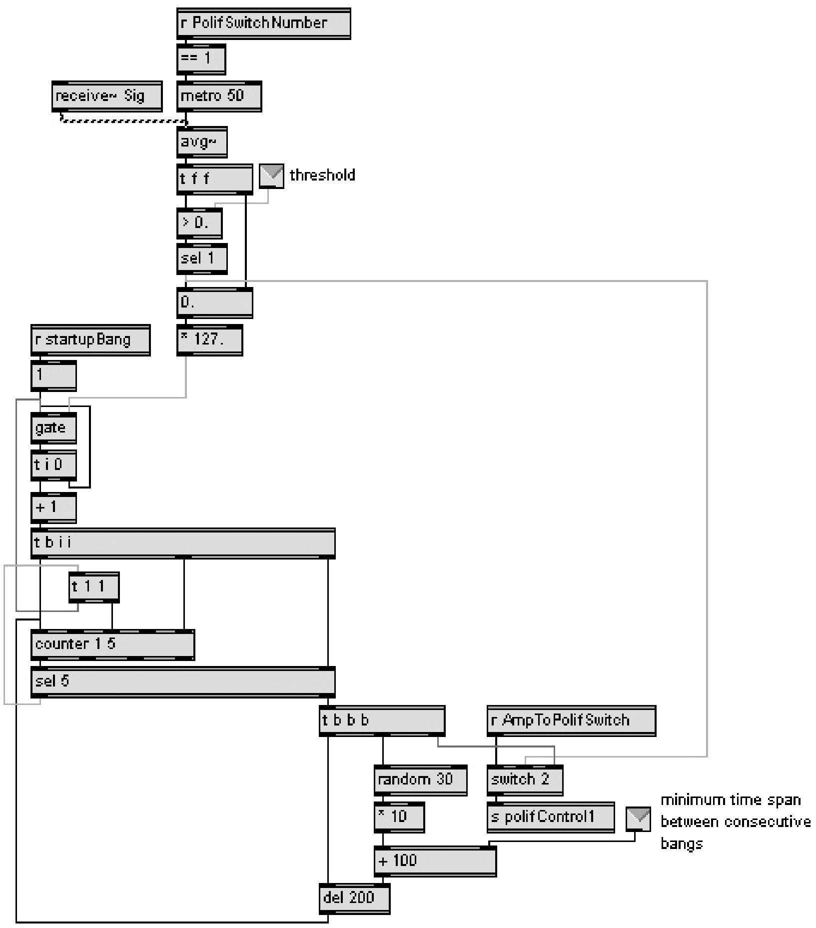

Figure 5

Figure 5 shows one of the modules that run inside the “PolifControlMachines” subpatch. This module, called 'AmpToPolifControl', transforms values of amplitude of the cello signal into data that control the density of events that are triggered in real-time. Density of events is understood here as the number of pre-recorded sound files that are triggered within a certain time span. The amplitude of the cello signal is averaged every 50 miliseconds and whenever it goes beyond a certain threshold, the subpatch sends either one single 'bang' or several 'bangs' to trigger the correspondent number of pre-recorded sound files. The choice between one or several 'bangs' is set beforehand. When the choice is for several 'bangs', the number of 'bangs' is proportional to the mean amplitude that has just been calculated by the avg~ object. The time span between consecutive 'bangs' is defined randomly within certain limits that can be changed during the performance.

Figure 6 shows the 'DurToTrans' module that runs inside the 'TransControlMachines' subpatch. This module transforms values of duration of the cello sounds into values for controlling the speed of playback (and therefore the transposition) of the sound files that are triggered in real-time.

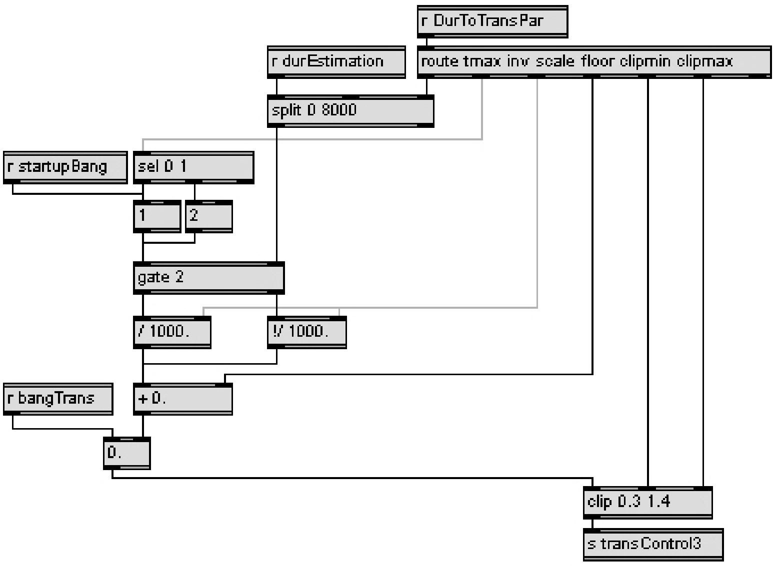

Figure 6

The values generated for speed of playback can be either proportional or inversely proportional to the duration of the cello sounds. The module also allows the user to define the range of possible values that it can output.

In total there are nine modules like the ones illustrate in Figure 5 and Figure 6 running inside the three subpatches responsible for generating processing parameters from data provided by the analysis parameters. The mappings between these two kinds of parameters are decided beforehand and set at specific moments during the performance of the piece through lists of instructions managed with the 'qlist' object. The mappings are then performed and sent to the 'poly~' object, which contains the main engine of the patch (see Figure 7) – the one responsible for playing back the soundfiles using the processing parameters that were chosen.

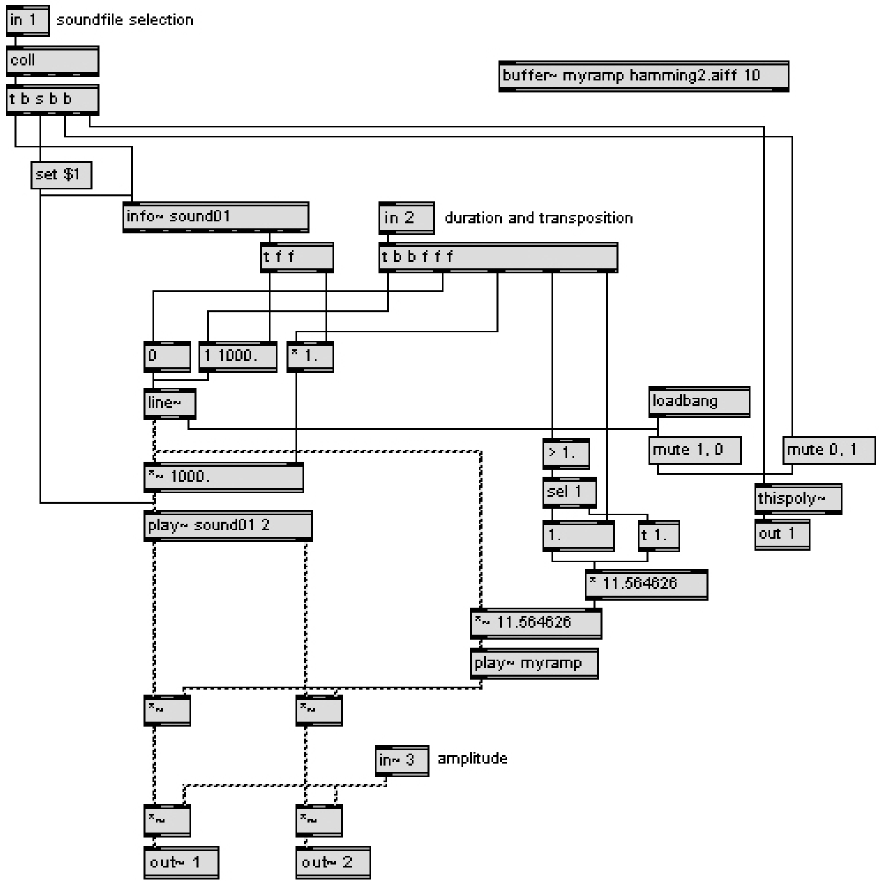

Figure 7

5. Considerations on the issue of interaction

The explanation presented so far encourages us to make some brief considerations on the issue of interaction in music. *Interferências* has a live-interactive component between instrument and computer, as the sounds of the instrument determine the production of another sonic layer by the computer. Data collected from the analysis of the instrumental signal determines when the computer has to trigger sound files. It also influences the transposition and amplitude applied to each sound file, and also the number (density) of events played within certain time spans. The precise choice of which sound files will be played back at each moment and their amplitude and transposition, however, is left for the computer to decide by means of operations that include probabilities and random procedures as explained in items 3 and 4 above. In other words, a certain degree of autonomy in the decision-making process is left for the computer.

Works composed for instrument and electroacoustic sounds on a fixed medium do not play with that kind of interaction. The instrumental sounds do not change the audio signal of the electroacoustic part in any way. Nevertheless, there is interaction of another kind involved in such works - an interaction that does not happen in terms of audio signal, but on the musical level, as perceived relationships between sounds in the instrumental and electroacoustic parts. This kind of interaction is also meant to play an important role in *Interferências*.

These two different understandings of interaction can be illustrated by the considerations presented by Cort Lippe (2002) and Christopher Dobrian (2004), on one hand, and Flo Menezes (2002), on the other hand.

Cort Lippe (2002) mentions the existence of different kinds of interaction and highlights that interaction is not an exclusivity of live-electronics – the performance of a work for string quartet, for example, imposes the need for a constant interaction between performers. The different kinds of interaction range from the simple control of synchronism between events to the case of more complex operations, such as the realisation of decision-making processes both by computer and performer.

Likewise, Christopher Dobrian (2004) states that the control of synchronism between events by means of real-time applications does not necessarily configure interaction, but reaction. Interaction only happens, according to him, when both computer and performer have a certain level of autonomy to make decisions in real-time based on their reciprocal influences.

Flo Menezes (2002), on the other hand, believes that the most important kind of interaction between instruments and electroacoustic resources happens by means of the musical relationships established between them. For this reason, he states that, in order to be effective, the musical relationships need to be planned beforehand by the composer in the electroacoustic studio, which attests to his preference for working on compositions for instrument and electroacoustic sounds on fixed medium (although he also includes live-interaction components in some of his works).

The divergence between Lippe and Dobrian, on one hand, and Menezes, on the other hand, reveal that interaction can be understood both as the influences occurring between computer and performer in real-time and in terms of the musical relationships as (potentially) perceived by the listeners. Indeed, it is not difficult to imagine a situation in which the listener perceives the occurrence of musical interaction (relationships) when it does not actually happen from the composers' point of view.

6. Final considerations

This paper presented some considerations regarding sound material, compositional approach and the role of the live-interactive component used in *Interferências* (2003), for cello and computer.

One of the consequences of the approach adopted is that both computer and performer have a certain degree of freedom regarding the musical events they generate. For the performer, freedom is manifested in the process of choosing the pitches that she/he plays. The computer, in its turn, carries out some probabilistic and random processes for the selection of samples to be triggered and processed in real-time – which results in a sonic layer that cannot be completely predicted in detail beforehand.

The investigation carried out in *Interferências* can benefit from the use of other processes, such as Markov chains, genetic algorithms and other AI tools. Also, some other kinds of interaction between instrument and computer can be investigated. It is in this direction that I intend to pursue my next live-electronics compositional explorations.

6. References

Barreiro, Daniel L. (2000). *Abordagens sobre o tempo na música contemporânea*. Master's Dissertation, Pontifícia Universidade Católica de São Paulo (Brazil).

__________. (2006). *Portfolio of Compositions*. PhD Thesis, The University of Birmingham (United Kingdom).

Barreiro, Daniel L. and Zampronha, Edson S. (2000a). "Um estudo de quantidades temporais a partir de uma análise qualitativa". *Revista Eletrônica de Musicologia* [online], 5(2). Available from: http://www.humanas.ufpr.br/rem/remv5.2/vol5.2/barreirozampronha/barreirozampronha.htm [Accessed November 2006].

__________. (2000b). "A seqüencialidade e as dilatações e compressões na percepção do tempo musical". *IV Fórum do Centro de Linguagem Musical da PUC-SP* [online]. Available from: http://www.pucsp.br/pos/cos/clm/forum/sumario.htm# [Accessed November 2006].

Chion, Michel (1983). *Guide des Objets Sonores*. Paris: Buchet/Chastel [excerpts of the translation by John Dack and Christine North found online on the EARS website: http://www.ears.dmu.ac.uk [Accessed November 2006].

Dobrian, Christopher (2004). "Strategies for Continuous Pitch and Amplitude Tracking in Realtime Interactive Improvisation Software". *Proceedings of the 2004 Sound and Music Computing conference (SMC04)*. France: Paris. Available from: http://music.arts.uci.edu/dobrian/PAPER_051.pdf [Accessed August 2006].

Lippe, Cort (2002). "Real-Time Interaction Among Composers, Performers, and Computer Systems". *Information Processing Society of Japan SIG Notes*, Vol. 2002(123), pp. 1-6. Available from: http://www.music.buffalo.edu/faculty/lippe/pdfs/Japan-2002.pdf [Accessed August 2006].

Mandelbrojt, Jacques (ed.) (1996). *Les unites sémiotiques temporelles*. Marseille: Laboratoire Musique et Informatique de Marseille.

Menezes, Flo (2002). "For a morphology of interaction". *Organised Sound 7(3).* Cambridge: Cambridge University Press, pp. 305–311.