A COMPUTER AIDED INTERPRETATION INTERFACE FOR JOHN CAGE'S NUMBER PIECE TWO[5]

Benny Sluchin
IRCAM/EIC
benny.sluchin@ircam.fr

Mikhail Malt
IRCAM/MINT
mikhail.malt@ircam.fr

ABSTRACT

Conceptual musical works that lead to a multitude of realizations are of special interest. One can't talk about a performance without taking into account the rules that lead to the existence of that version. After dealing with similar works of open form by Iannis Xenakis, Pierre Boulez and Karlheinz Stockhausen, the interest in John Cage's music is evident. His works are "so free" that one can play any part of the material; even a void set is welcomed. The freedom is maximal and still there are decisions to consider in order to make the piece played.

Cagener, is a project intended to develop a set of conceptual and software tools, that generates a representation of the work. It may be played live or showed as a sonorous installation. We deal here with the *Number Pieces* he composed in the last years of his life. The project calls for sound techniques, logic and musicological knowledge of the 21^{st} century to approach the original ideas of the composer. The computer serves as a partner in making choices of multiple possibilities, mix together sounds of different sources and of various kinds and following compositional ideas clearly stated. The role of the sound projection in space is an important part of the studio preview.

1. INTRODUCTION

The performer approaching John Cage's music composed after the middle of the 20^{th} century is often surprised to encounter a large amount of freedom mixed with a set of precise instructions. As a common result, the musician will determine "a version" in which he will decide on the free elements included in the score. A fixed score is thus created and used repeatedly. The performer will play it without any doubts of the composer's intentions. In fact, most of Cage's scores after the fifties are not to be pre-generated. Each performance should be unique and undetermined. Using the computer helps one to perform, ignoring what and when he is going to play.

2. SILENCE AND INDETERMINANCY IN JOHN CAGE'S EARLY PIECES

In connection with his encounter with Zen Buddhism [1], Cage rethinks his understanding of music. As a result, he composes *4'33"*, a work whose abandonment of intentional sound production drew controversy to his compositions. Cage spoke of silence in a new and positive way. Not only has it an importance in the creation of structure but one has to think of it not as an absence of sound but as a presence to fill an acoustical space.

2.1. The three kinds of "silence"

At first, Cage developed a structural concept of silence, considering it as an absence of sound helping to structure the music by its alternation with sound. The silence between the notes gave the work its cohesion. Later Cage adopted a spatial concept of silence, in which it was composed of all the ambient sounds that together formed a musical structure. Finally his concept evolved towards viewing silence as non-intention. Both sound and silence would exist only in the non-intention manner of nature [2].

2.2. What is indeterminacy?

The principal of indeterminacy allows the performers to work independently from each other. In this way, the musician ignoring the output of his fellow musicians will concentrate on his own part and the set of instructions, which imposes concentration even if degree of the freedom involved is high [3].

2.3. The *Number Pieces*

In Cage's *Number Pieces*, each individual part contains musical events endowed with time brackets, giving the player lower and upper bounds of time for starting and ending each event (**Figure 1**, **Figure 2**). The piece has a definite duration, and the elements occur within the given time brackets. In spite of the fact that only individual parts exist, an ensemble score is implicitly present and yields a strong form [5].

3. THE DIFFICULTY ON PERFORMING JOHN CAGE'S INDETERMINATE WORKS

It is the freedom relationship pre-determination that gives the player the main problem. Even if we find very hard instrumental passages, the main difficulties are: making the choice of when and what is to be played, what order to choose for the elements, the amount of silence to insert between the events, and all this while ignoring the output of the other musicians involved. It has to be kept in mind that by the absence of intention, one should also ignore what he himself is about to perform. This means, that the entire score should be at the player's disposal, and that he will make up his mind intuitively and spontaneously. This research was initiated by that concern. We have approached first *Two*[5] and *Five*[3], as our initial concern pieces with trombone. The interface developed and the analytical results are easily applicable to any of the *Number Pieces*.

4. PERFORMING CONTEXT

4.1. Cage instructions

Cage's instructions in the TWO[5] are very brief. It consists of one line concerning microtonal notation for the trombone and one single paragraph concerning the general performance:

"Any changes of dynamics (pp and thereabouts for booth instruments) should be, like changes in breath, as imperceptible as possible. The piano should sound absent minded, without regularity of presence. If there is at some point a very short sound on the trombone it can be extremely loud, inexplicable" [15, score instructions]

4.2. Perfomance particularities

The "Number Pieces", in general, seem to be easy to perform, not presenting special instrumental difficulties. Concerning the way Cage's chooses the "material to fit in the time brackets" Benedict Weisser [14] point out the fact that:

"For as time passed, Cage was filling the boxes with progressively less and less."
[14, 94-95]

What Weisser call "boxes" is what we define as a "generic musical event". As Two[5] was composed in 1991, close to Cage's death, this statement gives some explanation concerning the scarcity of the material used. As there are very few elements every detail becomes important, as for example the attacks and releases of single notes, the simultaneity of chords, pedal actions that could bring unwanted noise or any other external sound source. The main difficulty consists in being "a tool" to make the composer's work comes to live. The musicians have to enter in a special state of mind where the awareness of quality of sound and the quality of silence are important. For this reason a "meditative concentration" is needed.

5. TOOLS FOR COMPUTER ASSSITED PERFORMANCE, CAP

5.1. What is "computer assisted performance"

The musical world offered itself a multitude of tools with the evolution of computer technologies. At first, dedicated to an employment in musical composition, they were oriented and adapted to a use in musical analysis and as aid tools to interpretation [4].

Several practices concerned with the interpretation field were developed. One can mention:

• The use of audio and MIDI sequencers as "super metronomes". It is common today that interpreters enter complete scores in sequencers as a way to work out difficulties in the performance (especially concerned with contemporary pieces). The musician can work progressively the problematic passages by varying the speed.

• The use of sequencers or notation programs to practice playing in ensemble. This is a logical extension of the "Minus-one" idea.

• The use of dedicated tools capable of correcting the player's interpretation.

An increasing number of composers prepare interpreters' oriented computer programs in order to help them play with the computer before starting with the actual musical piece.

There are other examples of computer tools created by or for interpreters, but our concern here is to show a new field developed in the last twenty years.

In our topic here, the interpretation of a category of Cage's work, in which the concepts of liberty and indetermination are predominant, it seems that the paper aspect of the scores is an obstacle in the realization. The wish that the interpreter could navigate freely, non-determined and without restraint through the musical material seems opposed to the fact that the music is presented on paper, and thus in a determined order. Computers may bring a solution to that particular difficulty for Cage's and also other composers' music. The actual playing prevents the musician from doing other tasks to orient his choices in "real-time". For example Iannis Xenakis in *Linaia Agon* (trio for horn, trombone and tuba, 1972) asks for a passage where the different instrumental choices are directed by a "gain matrix". The choice is computer-aided in order to enable a smooth interpretation [6]. *Duel* and *Strategy*, two other works by Xenakis based on Game Theory, received an analogue treatment for a CAP Interface [7]. Of different esthetics, *Domaines* de Pierre Boulez was investigated and lighted by an equivalent Interface [8].

5.2. From concepts to reality

How could one help the player, as well as possible, to perform the score in a context of "indetermination" and maximum of concentration? In what manner could one enable him to represent the Cage's musical thought?

Even if hard instrumental passages are apparently missing, the main obstacles to create a required musical atmosphere are: watching the chronometer, making the choice of when start and stop to play the musical events, the amount of silence to insert between the elements of the events, the quality of silence between events and all this while ignoring the output of the other musicians involved One possible solution was to provide an adapted interface. Here the choice is not only of timing but concerns the material itself.

5.3. Modeling musical pieces

One aspect of the tools proposed here is that they are oriented towards interpretation. In that concern, the interface should "contain" implicitly or explicitly all the instructions, constraints and concepts defined by the composer, as they will establish an "experimentation field". For the construction of CAP tools, the careful study of the pieces of John Cage and its formalization is necessary. The final interface will be, in a certain way, a computer model of the particular piece.

5.4. Modeling as a step in the musical analysis process

The construction of computer models of musical pieces is not a neutral process. It is fundamental to know well the works under study, understand the constraints left by the composer, as well as the historical context of its creation. But these are still insufficient in the modeling process. Every music work has a part of liberty and ambiguity. These "holes" has to be filled up to enable the modeling process. One has to take decisions as a function of his work assumptions, founded on musical and musicological bases. The necessity to represent the score or the processes suggested by the composer on numerical, symbolic or graphic spaces has great importance. Changing the representation of an object permits to see, to consider, to observe and finally to understand it, in a different manner. The modeling process is transformed in a pragmatic analysis of the musical phenomena [9].

6. THE "TIME-BRACKET" MODEL

There already exists an interface built for such performances [10] and a mathematical modeling of "time-brackets" [11] [12]. Our goal was to go beyond the interface as a score substitute, proposing to performers a tool to help them to find, at best, the "meditative concentration" needed (as explained in 4.2). But also, to try to build a model, from the scarce instructions left by John Cage, trying to fill the gaps with algorithms that could represent choice and indeterminacy, leading us to a better understanding of his composer craft. We have started to work with *Two*[5] (1991), a piece for trombone and piano, whose duration is 40 minutes. Music strips make up the individual parts (40 for the trombone and 29 for the piano). Each one is presented in the same way (**Figure 1**, **Figure 2**): a bold number indicating the strip order, and the "time-brackets" marked above (see 2.3).

Figure 1: Piano 9th musical event

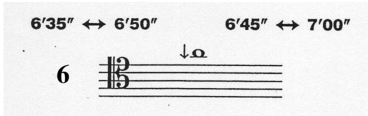


Figure 2: Trombone, 6th musical event

An important part of our reflection was to try to figure out an interface that could present these scores to the performers. This interface should help the player in the performance, and at the same time could help in generating studio previews.

We had implemented two models, an offline in "OpenMusic"[1] computer aided composition software, and a real-time one in MAX/MSP.

The first step in the process, was modeling a graphic representation of each "strip" as a musical event in time. For this, the time structure of the piece was represented as a set of events composed by the score time-line and a time vector. The time vector has the following structure: $\{strt_1, strt_2, end_1, end_2\}$, where $strt_1$ and $strt_2$ are the numbers in the left "time-bracket", and end_1 and end_2 the numbers in the right "time-bracket". I.e., $strt_1$ is the lower bound of the *Starting Time Zone* and $strt_2$ the higher one; end_1 is the lower bound of the *Ending Time Zone* and end_2 the higher one. The final graphic event had a trapezoidal shape (**Figure 3**), where the upper line represents the *Starting Time Zone* and the bottom line the *Ending Time Zone*. The height has no special meaning.

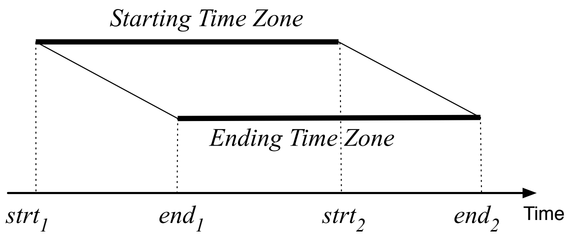


Figure 3: Trapezoidal graphic representation of each musical strip

More than being a graphic representation for each "strip", it allows us to identify similarities between

[1] "OpenMusic" is a software developed by Ircam by Gerard Assayag, Carlos Augusto Agon and Jean Bresson. See: http://recherche.ircam.fr/equipes/repmus/OpenMusic/.

generic musical events. For example, one can see easily the identity between the trombone generic musical events 4, 5, 14 and 26. The same comparaison done only on time brackets will be harder. We make a difference between a "generic musical event", and a "real musical event" A real musical event "i" is the one where the starting ($strt_i$) and ending (end_i) points are defined, i.e. a real musical event is a choice materilization. Where $strt_1 \le strt_i \le strt_2$ and $end_1 \le end_i \le end_2$. This one could be represented by a rectangle (**Figure 4**).

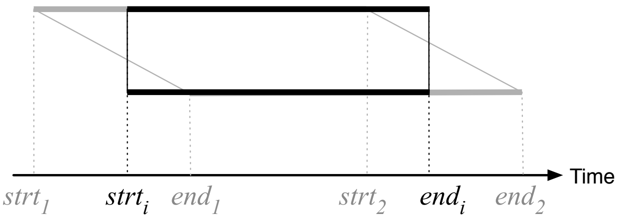


Figure 4: A "real musical event" represented as a rectangle

There are some properties one can easily be infered from the trapezoidal graphic representation, the generic event:

1. Cage's durations are $strt_2 - strt_1$ or $end_2 - end_1$, are a kind of nominal duration Cage gives to an event. The starting time span and ending time span are equal, resulting in a paralelogram, $strt_2 - strt_1 = end_2 - end_1$.
2. The maximum duration, $end_2 - strt_1$, is the maximum length an event can have.
3. The fact that , $strt_2 > end_1$ means that one can choose a starting point placed after the ending one, resulting in a void musical event. (idea so imporatnt to Cage, as he often indicates that the performer can choose, all, part, or nothing of the material to his disposal). In this case $strt_i > end_i$.
4. An implicit parameter that can be deduced is the "trapezoid slope", represented by the difference $end_1 - strt_1$ (as the heigth has no actual meaning). The slope is strongly connected with the performance. Concerning the trombone part, as it is wholy consisted of sustained notes, the knowledge of this parameter allows the performer to better manage his air capacity, in order to keep with the composer's indication. Regarding the pianist, the slope will be an information that allows him to manage his performance with regard to the time indications.

6.1. Offline model

The main purpose of the offline implementation was to study the possibility of generating several audio versions of the piece, and extracting parameters for musical analysis. For this we have built a first model in OpenMusic (**Figure 5**), with which we were able to:

1. Read text files with a representation of the time vectors (**Figure 6**),
2. Compute musical events with fixed "start and end" times,
3. Read audio recordings of each musical strip[2],
4. Rescale audio files to the durations computed in step 2,
5. Represent a *Two*^{5} version (**Figure 7**) as graphical schema in a OpenMusic graphical interface (a Maquette), and
6. Save the data, derived from the calculation, in a file having the following data structure (**Figure 8**):

[*instrument starting_time duration sound_file*]

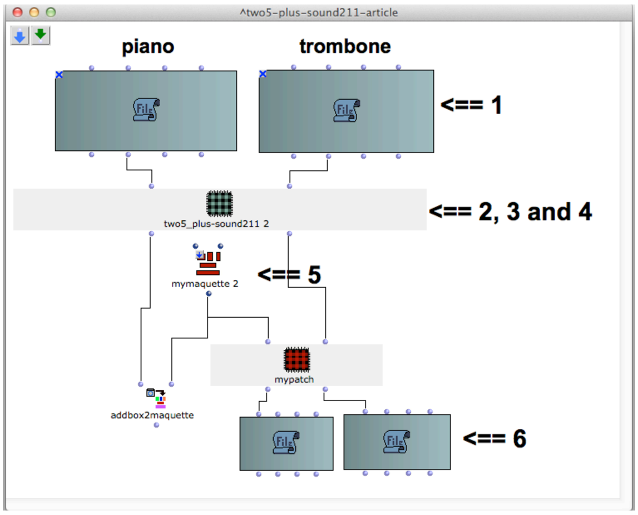
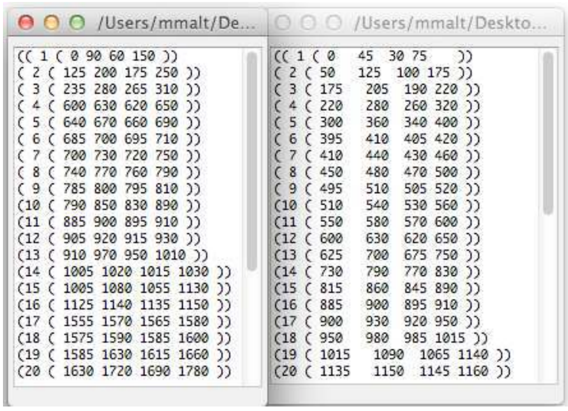


Figure 5: OpenMusic *Two*^{5} calculations steps


/Users/mmalt/De...

```
(( 1 ( 0 90 60 150 ))
( 2 ( 125 200 175 250 ))
( 3 ( 235 280 265 310 ))
( 4 ( 600 630 620 650 ))
( 5 ( 640 670 660 690 ))
( 6 ( 685 700 695 710 ))
( 7 ( 700 730 720 750 ))
( 8 ( 740 770 760 790 ))
( 9 ( 785 800 795 810 ))
(10 ( 790 850 830 890 ))
(11 ( 885 900 895 910 ))
(12 ( 905 920 915 930 ))
(13 ( 910 970 950 1010 ))
(14 ( 1005 1020 1015 1030 ))
(15 ( 1005 1080 1055 1130 ))
(16 ( 1125 1140 1135 1150 ))
(17 ( 1555 1570 1565 1580 ))
(18 ( 1575 1590 1585 1600 ))
(19 ( 1585 1630 1615 1660 ))
(20 ( 1630 1720 1690 1780 ))
```

/Users/mmalt/Deskto...

```
(( 1 ( 0   45  30 75    ))
( 2 ( 50   125  100 175 ))
( 3 ( 175   205  190 220 ))
( 4 ( 220   280  260 320 ))
( 5 ( 300   360  340 400 ))
( 6 ( 395   410  405 420 ))
( 7 ( 410   440  430 460 ))
( 8 ( 450   480  470 500 ))
( 9 ( 495   510  505 520 ))
(10 ( 510   540  530 560 ))
(11 ( 550   580  570 600 ))
(12 ( 600   630  620 650 ))
(13 ( 625   700  675 750 ))
(14 ( 730   790  770 830 ))
(15 ( 815   860  845 890 ))
(16 ( 885   900  895 910 ))
(17 ( 900   930  920 950 ))
(18 ( 950   980  985 1015 ))
(19 ( 1015   1090  1065 1140 ))
(20 ( 1135   1150  1145 1160 ))
```

Figure 6: Piano and trombone, time vectors translated from Cage's "time-brackets"

This offline model, allowed us to, quickly, represent and evaluate a completely "indeterminate" performance.

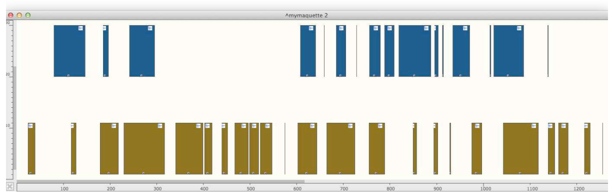


Figure 7: A *Two*^{5} version (the first half of the piece with "real music events"), represented in "OpenMusic" maquette

[2] Benny Sluchin (trombone) and Sylvain Rapappport (piano) recorded this audio extracts.

(trombone	17000	36000	ts_trb_01_1.aif)
(piano	76000	11000	ts_pf_01_1.aif)
(trombone	95000	72000	ts_trb_02_2.aif)
(trombone	184000	15000	ts_trb_03_1.aif)
…			

Figure 8: Extract of data from a calculated "version file" (time in milliseconds)

As a first algorithm we used a very single random process where for each event we calculated a fixed "*start_time*" and a fixed "*end_time*" as follow:

$$start\_time = \sigma(strt_1, strt_2) = strt_i$$
$$end\_time = \sigma(end_1, end_2) = end_i \qquad (1)$$

Where,

$\{strt_1, strt_2, end_1, end_2\}$: are the elements from the time vector shown above, and $\sigma(a,b)$: is a random uniform function that chooses a value between (a,b). Naturally, other algorithms are under study. One should mention here the probabilistically approach of Alexandre Popoff [11] [12].

6.2. Real time model

The real time model had as main purpose, to offer an interface for the performance; it was built in the MAX/MSP[3] graphic programming environment.

The main interface (**Figure 9**), has 6 fields, some may be switched on or off according to the performer's wish.

6.2.1. *The global view – 1*

The global view displays a presentation of the entire duration of *Two*[5], using the trapezoidal event representation. It allows the performer to have a global view of the piece at a glance. As Cage mention about the context-specific character of his time-bracket notation:

"Then, we can foresee the nature of what will happen in the performance, but we can't have the details of the experience until we do have it."
[13, 182]

This global representation enables another perspective of the piece. The printed score orients a natural local view. For example, in this particular case, a five-part structure is easily perceived.

[3] © www.cycling74.com.

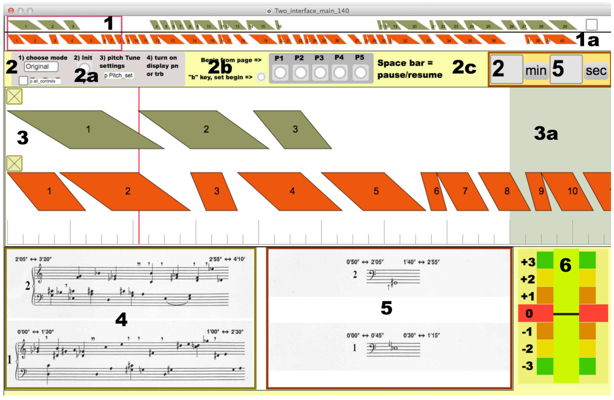


Figure 9. The main interface

6.2.2. *Main tool bar – 2*

Presents all the controls needed to calculate the events, start/stop the interface and a digital chronometer for the performance.

6.2.3. *Pitch tuning settings – 2a*

This zone allows setting the "seventh tone pitch tuner" (**Figure 11**) parameters: the input levels, the pitch analysis type (*fiddle~* by Miller Puckette, or *Yin*[4] by Chevigné&Kawahara), the smoothing analysis settings and the reference pitch.

6.2.4. *Page zone – 3*

The page zone is the main interface field. Here, the trapezoidal events (or, as in **Figure 10**, "real music events", showed as rectangles, in correspondence with the calculus and performance mode chosen) are displayed. A time cursor runs on a "page" whose horizontal size, in this case, is 8 minutes.

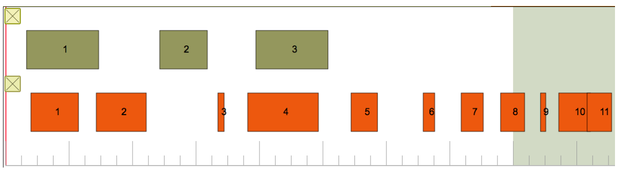


Figure 10. "Real music events" representation

The performer can choose to display, or not, the global view or the events (his own events or the partner events).

6.2.5. *Shadow view – 3a*

This sub field, allows the performer to anticipate, viewing the first 90 seconds of the next "page".

[4] The Yin algorithm was implemented in MAX/MSP by Norbert Schnell.

6.2.6. Piano score strip field – 4

This field displays the piano music strips from the original Cage score.

6.2.7. Trombone score strip field – 5

This field displays the trombone music strips from the original Cage score.

6.2.8. Seventh tone tuner - 6

This field is a display allowing the trombone player to tune, and check its tune (**Figure 11**). Cage asks for a particular microtonal setting, dividing a semitone in seven equal steps.

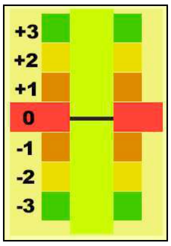


Figure 11. Seventh-tone tuner

The Cage's seventh tone concept is far from intuitive, bringing huge difficulties in the control of such demand. The performer has to practice in order to gain facility in this aim. This part of the interface would help to train the ear and get closer to the written score.

7. CONCLUSIONS

As stated earlier, the modeling process is transformed in a pragmatic analysis of the musical phenomena that leads us, step by step, to model some of Cage's concepts.

We have performed *Two*[5] several times using conventional setting (printed parts and stop-watches). A clear preference towards minimum visual communication and good acoustical space was stated.
The CAP interface, we presented, helped to get everything on the screen: the music to play, the timing, and a tuner for the microtonal control. The music was liberated from original paper pages representation and unveiling the form of the piece, hidden in its original form. Concerning the players, they can concentrate on performing when using a CAP interface. After determination of the "real musical events", in the context of "Number Pieces", they do not have to prepare any personal version, they do not need to be distracted by watching a chronometer, they do not need to loose their concentration handling paper pages or calculating start or ending times from the "time-brackets". One might wonder: when all decisions regarding the starting and ending points from events of the scores are made by a computer, what remains to be done by the performer/interpreter? The performers can ignore completely what music is being performed and just concentrate in their own performance. They can focus on the sound and silence quality required. The pianist can manage his time performance, in order that each musical event "fit" in the "real musical event" calculated, and the trombonist could be aware of his breath and tuning. In this way, the computer interface is a way to free the performers from interfering tasks, in order to get closer to Cage's original instructions.
Concerning future research:

1. Investigation of other Number Pieces, and even enlarging to other Time-brackets works, such as "Music for …" series (1984-7). Always taking into account the composer's instructions.
2. The interface we have developed can be easily adapted to other works. In cases of large numbers of performers, the zone giving information on the structure of the piece, could be used for musicological reasons, and switched off during a performance.

8. REFERENCES

[1] D. Nicholls, *John Cage*, University of Illinois Press, Unbana and Chacago, 2007.

[2] James G. Chilton, *Non-intentional performance practice in John Cage's solo for sliding trombone*, DMA dissertation, University of British Columbia, 2007.

[3] J. Pritchett, *The Music of John Cage*, Cambridge University Press, Cambridge, 1993.

[4] Mikhail Malt, Benny Sluchin, "L'interprétation assistée par ordinateur", *Le journal de l'Association des Anciens de Sciences et Musicologie*, Hors-série, n° 1, Avril 2011, p. 17-21.

[5] R. Haskins, *The Number Pieces of John Cage*. DMA dissertation, University of Rochester, 2004. Published as *Anarchic Societies of Sounds*, VDM Verlag, 2009.

[6] B. Sluchin, "*Linaia Agon*, towards an interpretation based on the theory" (Proceedings of Iannis Xenakis International Symposium, May 2005, Athens, Greece, p. 299–311.

[7] B. Sluchin, M. Malt, "Play and game in *Duel* and *Strategy*" *Xenakis International Symposium 2011*, London 1-3 April 2011.

[8] B. Sluchin, M. Malt, "Open form and two combinatorial musical models: The cases of *Domaines* and *Duel*", *MCM (Mathematics and Computing in Music) Proceedings*, Springer Verlag, 2011, p. 257–269.

[9] D. Keller D, B. Ferneyhough, "Analysis by modeling: Xenakis's ST/10 080262", *Journal of New Music Research*, vol. 33, Number 2, 2004, p. 161-171.

[10] Georg Hajdu, "Quintet.net: An Environment for Composing and Performing Music on the Internet", *Leonardo*, Volume 38, Number 1, February 2005, pp. 23-30.

[11] Alexandre Popoff, « Indeterminate Music and Probability Spaces: the Case of John Cage's Number Pieces », *MCM (Mathematics and Computing in*

Music) Proceedings, Springer Verlag, 2011, p. 220–229.

[12] Alexandre Popoff, « John Cage's Number Pieces: The Meta-Structure of Time- Brackets and the Notion of Time », Perspectives of New Music Volume 48, Number 1, Winter 2010, p. 65-83.

[13] John Cage, Joan Retallack, Musicage: *Cage muses on words, art, music*, Wesleyan university Press, 1996.

[14] Benedict Weisser, *Notational Practice in Contemporary Music: a Critique of Three Compositional Models (L. Berio, J. Cage, B. Ferneyrough)*. University of New York, Ph.D Dissertation, 1998.

[15] John Cage, *TWO^5, for piano and tenor trombone*, Peeters Editions, 1991.