TENOR 2015

INTERNATIONAL CONFERENCE ON TECHNOLOGIES FOR MUSIC NOTATION & REPRESENTATION

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TENOR 2015

First International Conference on Technologies for Music Notation and Representation

Music notation serves the needs of representation, writing and creation. New musical forms such as electronic and/or interactive music, live coding, as well as the migration of musical instruments to gestural and mobile platforms, hybridizations with dance, design and multimedia tend to extend the notion of score in contemporary music, revisiting it through new forms of writing, and spreading it over different media. Until recently, the support provided by computer music to the field of symbolic notation remained fairly conventional. However, recent developments indicate that the tools for musical notation are today ready for a move forward towards new forms of representation.

Musical notation, transcription, sonic visualization, and musical representation are often associated in the fields of musical analysis, ethnomusicology, and acoustics. The aim of this conference is to explore these recent mutations of notation and representation in all these musical domains. The first International Conference on Technologies for Music Notation and Representation is dedicated to theoretical and applied research and development in Music Notation and Representation, with a strong focus on computer tools and applications, as well as a tight connection to musical creation.

The scholarly conference, posters and demo are taking place at Paris-Sorbonne University and Ircam.

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THE NOTATION OF DYNAMIC LEVELS IN THE PERFORMANCE OF ELECTRONIC MUSIC

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ABSTRACT

The "sound diffusion" (or "sound projection"), that is, "the projection and the spreading of sound in an acoustic space for a group of listeners" [1], of works for solo electronics or for acoustic instruments and electronics (so called, "mixed pieces"), has always raised the issue of notating the levels to be reproduced during a concert or the correct balance between the electronics and the instruments.

If, in the last decades, some attempts were made by few composers or computer-music designers, mostly in the form of scores, none of these managed to establish a common practice. In addition, little theoretical work has been done so far to address the performative aspects of a piece, that is, to provide just the useful information to the person in charge of the sound diffusion.

Through the discussion of three historical examples and the analysis of two experiences we developed, we will try to identify some possibly general solutions that could be adopted independently on the aesthetic or technological choices of a given piece.

1. PRELIMINARY CONSIDERATIONS

The notation of electronic music has generated only few, often partial, essays. Most of the literature is either quite theoretical [2], or it delves into the automated translation of electronic sounds into a sort of graphical score, such as in [3]. These experiments were mainly aimed at providing ways to analyse purely electronic pieces more deeply than when simply listening to them, to account for the compositional process, or as an attempt to digitally preserve and archive cultural assets [4].

To our knowledge, little theoretical work has been done to tackle the more general issue of how to notate dynamic levels on a score that is to be read by the computer music performer (CMP) who will perform the electronics during a concert. The CMP does not need to be the composer or the first performer of the piece.

Although this task could be programmed on a computer and automated during the concert, a much better result can be achieved when doing it by ear. The listening and musical skills of a human being are, in fact, still much superior to what a machine can realize. The sound diffusion can be adapted to the acoustics of the hall, the properties of the loudspeakers, the whole audio system, the relationship between these and the acoustic image of the instruments on stage, whether they are amplified or not, and, finally, to the emotional reaction of the audience.

As a consequence, most of the time, the dynamic levels are controlled by ear (and by hand) by the CMP or the composer. Often they are only roughly sketched on the score. If a faithful recording will certainly help as a reference, the information is usually insufficient, especially in the case of particular spatial configurations that cannot be reproduced by a stereo recording.

Therefore, the most effective solution is to notate all the information about the sound diffusion directly on the score that will be used during the performance.

To delimit our scope, we will concentrate on the notation of dynamic levels and will not tackle the issue of notating other parameters used for real-time sound processing, such as, for instance, the transposition factor of a harmonizer.

1.1 Levels vs. loudness vs. musical dynamics

Objectively, levels are normally expressed in decibels, a logarithmic unit that is related to the ratio between the value of a given and of a reference sound pressure (usually, either the threshold of audibility, or the maximum available value in a given system)[1].

However, there are other ways to do it: from the point of view of the perception, the dynamic levels are called "loudness" and use phons (a unit that takes into account

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[1] See `http://en.wikipedia.org/wiki/Decibel` (accessed 3/10/2015)

the psycho-acoustic effect of the equal-loudness curves ISO 226:2003)[2]; from a musical point of view, levels are called "dynamics" and use symbols such as *ff, mf, pp*.

Three important factors need to be taken into account: first, the same musical dynamics played by different instruments, or in different ranges of the same instrument, might yield different objective or perceptual levels; second, choices of interpretation play an important role and produce different absolute levels for the same musical dynamics, as pointed out in [5][3]; third, the perception of an acoustic instrument's crescendo is always associated to the production of a richer and broader spectrum, that is, to a shift of the spectral "centre of gravity" toward a higher value. These spectral aspects differ specifically from each instrument and can be easily demonstrated by recording three sound files at three different dynamics (say, *pp*, *mf*, *ff*), clean them from background noises and finally normalize them. Even though they have the same maximum amplitude, their dynamics can be easily and correctly identified.

Hence, simply raising a fader will not be sufficient to convey a real feeling of crescendo, but rather of a sound getting closer. When notating levels into a performance score, which unit should be used: dBs, loudness or musical dynamics?

1.2 Level changes

The notation of levels changes (usually, albeit incorrectly, called crescendo or diminuendo) can use several strategies, like, for instance, crescendo or diminuendo symbols to illustrate the change between adjacent values (Figure 1a), simple straight lines, either with (Figure 1c) or without (Figure 1b) a reference scale of amplitude ranges for each level in the score, or, finally, simple small upward or downward arrows, eventually with some absolute values (Figure 1d-e).
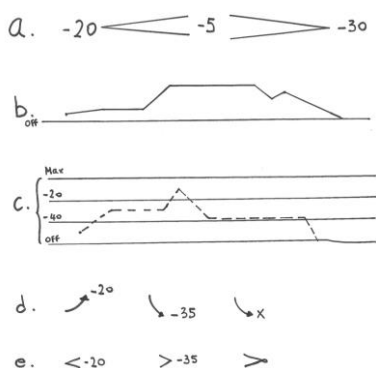
Figure 1. Different ways of notating changes of levels.

[2] See http://en.wikipedia.org/wiki/Phon (accessed 3/10/2015)
[3] "The absolute meanings of dynamic markings change, depend on the intended (score defined) and projected (actual) dynamic levels of the surrounding context", [5] abstract.

These strategies clearly suggest that a compromise between space or information economy and score readability need to be found. Their usage also depends on the nature of the required movements: simply raising a fader to a given static level does not require the same precision as a jagged change over a longer period of time.

2. THREE HISTORICAL EXAMPLES

2.1 K. Stockhausen: Kontakte

Kontakte [6] was originally a 4-channel electronic piece composed in 1958-60 by Karlheinz Stockhausen. Soon after, the composer wrote a version for piano, percussion and the same 4-channel electronic material. The original score shows one of the first, composer-written, attempts to graphically notate the electronic material using unconventional, graphical signs. The second edition, published in 2008, adds some hints at the balance between the amplified instruments and the electronics. In Figure 2, a + above the piano means that the level of the amplification of that instrument should be raised until N (normal) is found.
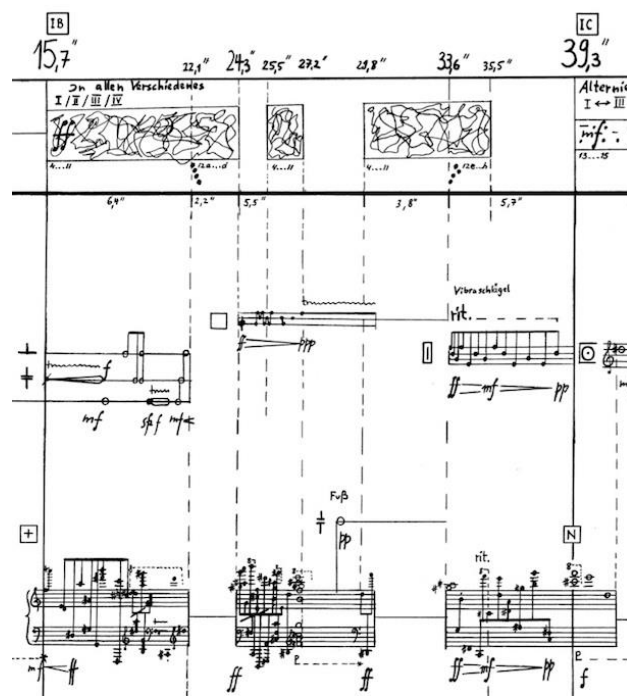
Figure 2. *Kontakte* (p. 1 excerpt, © Stockhausen Stiftung für Musik, Kürten, by kind permission).

Some gestures can be notated, but are hard to realize by hand, as they are very short, as the sudden reinforcement of the, respectively, electronics and marimba (+) in Figure 3.

Figure 3. *Kontakte* (p. 17, excerpt, © Stockhausen Stiftung für Musik, Kürten, by kind permission).

On one occasion (Figure 4, page 32), after lowering the electronics (-), the composer explicitly asks for the channels II and IV to be reduced by ca. 5dB, because of a problem of balance in the original mixing, while the channels I and III remain at the N level.

Figure 4. *Kontakte* (p. 32, excerpt, © Stockhausen Stiftung für Musik, Kürten, by kind permission).

To summarize: if the positions and panning of the microphones are very clearly specified in the technical notes that come with the score, information about the sound diffusion, added only in the second edition, is limited to +, - and N (normal) signs. However, this is already sufficient to have an idea of the sound diffusion.

2.2 L. Nono: *A Pierre / Omaggio a György Kurtàg*

The late mixed pieces by Luigi Nono make an extensive usage of simple, but continuous live-electronic treatments. Since the original score totally lacked information about the electronics, André Richard and Alvise Vidolin, who assisted the composer during several performances, together with Ricordi's editor Marco Mazzolini, embarked on the ambitious task of notating both the electronic setup and the sound diffusion in such a detailed way, that other people might play the piece without requiring other information than what is marked in the score.

In *A Pierre* [7], for bass flute, double bass clarinet and electronics (4 loudspeakers), the dynamics are marked using a mixture of the strategy shown in Figure 1b and musical dynamics, in spite of the fact, that the latter require both a level and a spectral change to be correctly perceived (Figure 5).
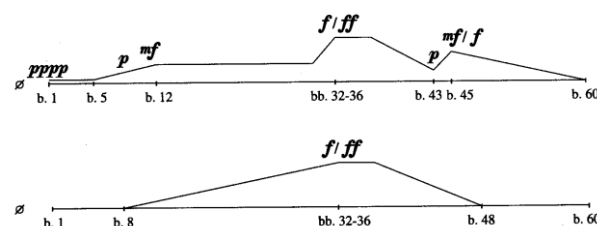
Figure 5. Level changes in L. Nono's *A Pierre*.

In another work, *Omaggio a György Kurtàg* [8], for contralto, flute, clarinet, tuba and electronics (6 loudspeakers), a further distinction is made between microphone faders (M1, M2, etc.), mainly used for sending the sound to the treatments, and output faders (L1-6). In addition, the portion of sound that needs to be recorded by a treatment is greyed in the score (Figure 6).

The notation is adequate to the needs of the composer, and many aspects of it can also be generalized.

2.3 P. Boulez: Anthèmes 2

The Universal Edition performance score of Pierre Boulez's *Anthèmes 2* [9], for violin and electronics, was realized by the composer's musical assistant at Ircam, Andrew Gerzso. Up to now, it is one of the rare examples that features a complete and detailed notation of the electronics (using dedicated staves for each electronic part or treatment). Together with the extensive technical manual, the score allows for the re-constitution of the electronics even without the original patch (Figure 7).

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Figure 6.L. Nono's *Omaggio a György Kurtàg* (p. 8, © Casa Ricordi, by kind permission).

Figure 7. Beginning of P. Boulez's *Anthèmes 2* (© Universal Edition, Wien, by kind permission).

Surprisingly, there are almost no indications about dynamic levels: all the information is, in fact, contained in the Max patch for the piece. The balance between the violin and the electronics is explained in the technical manual and set in the patch. Levels are automated and changed globally, by recalling a different preset for each movement. The presets should be revised during the rehearsals, but, during the concert, only minor adjustments might be required from time to time.

This approach is related to those mixed pieces in which it is mainly the acoustic musician who is responsible for the amplitude of the real-time treatments; the interaction with the CMP, though still important, is therefore less crucial, the work being rather structured around pitches and timbral articulations.

It is therefore clear, that in *Anthèmes 2* the dynamic levels of the electronics play a different role as, for in-stance, in Nono's works, and, hence, do not need to be notated in the same detailed way.

3. HYPOTHESES

3.1 The case of *Spirali (1987-88)*

3.1.1 Setup

In Marco Stroppa's *Spirali* (Spirals) [10], for string quartet projected into the space, the electronics is constituted by a unique setup, exclusively made of six simultaneous, always active, types of reverb. Placed on stage as far as possible from the audience, the acoustic quartet, closely miked, is amplified and only heard through 4 or 6 loudspeakers around the audience, depending on the size of the hall (Figure 8).

Figure 8. *Spirali*: setup with 6 loudspeakers.

Originally performed with analog equipment, *Spirali* was ported at Ircam by Serge Lemouton in 2005 as a Max patch with 18 control faders. The performance of the electronic part was a terribly virtuoso and risky undertaking and required an extensive study and clear skills! In 2013, Carlo Laurenzi integrated the Antescofo language[4] to the patch and automated some controls. This resulted in a more effective interface, with only 13 faders to move during the performance, although it is still quite challenging to perform.

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[4] See `http://repmus.ircam.fr/antescofo/documents` for an abundant bibliography about *Antescofo* (accessed 1/28/2015).

3.1.2 Spatial taxonomy: space families

During the composition, Stroppa organised space into a personal taxonomy made of three space families: points (P), surfaces (S) and diffused space (D). He then related the six reverbs and the amplified instruments to it. Points correspond to the direct amplification of an instrument, to which correspond only one or two loudspeakers depending on the setup (Figure 9)

Figure 9. Points: double amplified quartet (6 loudspea-kers)

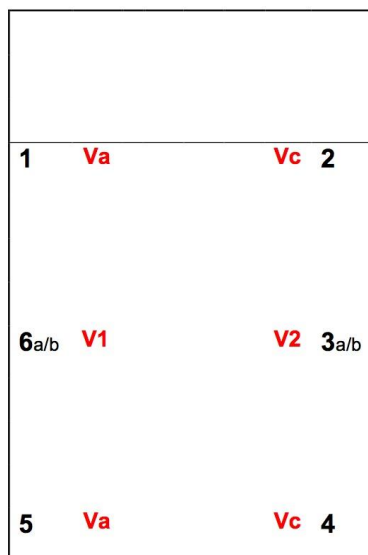Surfaces use only the early reflections and cluster stages of reverberation. At each point two adjacent loudspeakers are added, providing a certain spread (called "width") to the sound image. The control of the width size is automated during the performance (Figure 10).
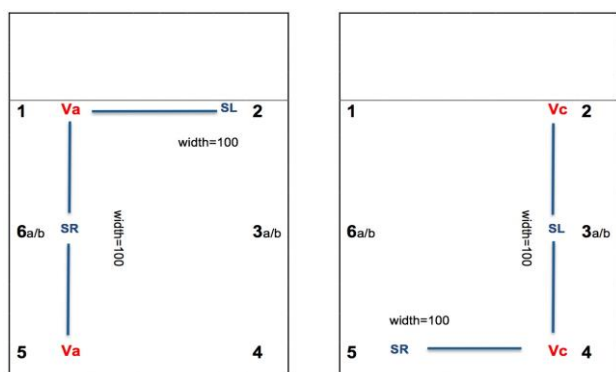

Figure 10. Surface: width spread for the viola and cello.

Finally, the diffused spaces only use the late reverberance, and produce a sound that seems to come from everywhere or… nowhere!

In the performance score, each instrument is considered as one of the voices of the electronics, and is "spatially orchestrated" by the CMP, that is, sent to one or another spatial family depending on what is being played. The final result is an augmented sound image that is not only much larger and deeper than usual, but it also dy-namically varies during the performance. The spatial projection hence highlights the frequently used "spiral-like" materials, characterized by musical figures that present similar musical elements across the instruments at slightly different times.

3.1.3 Notational choices

Given these preliminary factors, and after 25 years of performance experience, a definitive musical score for the electronics was established and written immediately below the instrumental parts.

We decided to notate the composed spatial taxonomy directly, by associating a symbol (P, S or D) and a colour (blue, green or red) to each family. The other parameters (spatial width and reverb time) are automatized in Antescofo, but their change is mentioned above the instrumental score, near the event name (see Figure 11, e.254.1-2), since this proved to be a useful reminder for the CMP.

3.1.4 Reference Level

Our hypothesis for notating the dynamic levels is based on the crucial notion of "Reference Level" (RefLev). The RefLev is a perceptual, empirically established value. It depends not only on the audio setup and the characteristics of the hall, but also on the aesthetical preferences of the CMP. We define the RefLev as the level at which the points (the directly amplified instruments) sound "naturally amplified" in the hall and balanced between each other.

Once the RefLev for the points is specified, the RefLev for the other spaces is defined as the level at which they sound "naturally balanced" with the points.

When all the RefLev's are setup, the same physical position of the faders should sound equally loud, in spite of the differences (size of the instrument, position and type of microphones, nature of the spaces, and so on) for all the spaces[5]. This is, of course, a very personal estimation, as it is not easy to compare, for instance, the sound of an amplified violin, coming from one loudspeaker, with a reverberated sound of a cello coming from all the loudspeakers.

At the beginning of the rehearsals, the RefLev's must be empirically and precisely set up. In the score, they are notated with the letter "N" (normal). Notice that the same RefLev may produce a very loud sound, if the musicians are playing *fff*, or a very soft sound, if they are playing *ppp*.

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[5] This position, as well as the dynamic curves, can be defined by the user in the patch, but, usually, it is located at about ¾ of a fader's length.

3.1.5 Level changes

Once the RefLev's are defined, all the other levels are notated as a dynamic difference with respect to them and marked with 1 to 3 "+" or "-" (that is, for instance, "+++" or "- -"). They are defined as three clearly different and perceptible dynamic layers: one +/– means slightly louder/softer than the RefLev, two +/– means clearly louder or softer, three +/– are extreme levels, from macro-amplified to barely amplified.

These levels are not absolute, but rather correspond to perceptual areas, and will, therefore, vary during the piece as a function of what kind of music is being performed. They indicate subjectively different "steps" in the amplification process: seven dynamic steps were considered as necessary and sufficient to accurately perform the sound diffusion of *Spirali*.

Since the changes between levels are not very complex, the traditional signs of cresc. and dim. were adopted, because they are expressive, use a space in the score that does not depend on the dynamic range and allow for the notation of a duration (see Figure 11).

3.1.6 Final score

Placed below the instrumental score, once the preliminary choices are clear, the notation of the electronics is quite straightforward (Figure 11).

Figure 11. *Spirali*: manuscript score, p. 58 (© Casa Ricordi, by kind permission).

The usage of colours to identify the different spatial families turned to be a very important ergonomic feature, in order to improve the readability of the score. The relation between the notation and the physical gestures needed to operate the control faders becomes more straightforward and faster to learn.

In addition, the isolation of single elements in the instrumental score, using the same colour as the space they belong to, helps to focus on the correct timing and action to perform, especially if the passage is short and/or difficult to perform.

Finally, if printing a score in colours is still not very diffused, because of the production costs, generating a coloured PDF file and performing *Spirali* reading the score on a computer or a tablet already seems very reasonable.

Notice that the acoustic string quartet should not be aware of what is going on in the space, as the spatial changes risk to negatively influence the quality and accuracy of the interpretation. It just has to play!

3.2 Levels of sound synthesis: the case of *Traiettoria*

3.2.1 Setup

Traiettoria [11] is a 45' long cycle of three pieces for piano and computer-synthesized sounds written by M. Stroppa in the early 80s.

The electronics is solely made of eight stereo sound files (from ca. 3' to 7' long), which exclusively use additive synthesis and frequency modulation, with no reference to the piano's spectral structure. A strong connection with the instrument is established by "tuning" the electronic material to some harmonic structures played by the piano. The integration between the synthetic and the acoustic materials is very deeply structured, and can produce a compelling fusion, if the electronics is correctly performed!

The piano and the electronics are loosely synchronised by means of temporal pivots [12].

3.2.2 Spatial families

The sound diffusion of *Traiettoria* is composed of two main spaces:

a. a reduced space, made of the amplified piano (2 loudspeakers placed near the instrument) and of one loudspeaker facing the piano's sound board and placed under the instrument, from which a mono version of the electronics is diffused, so as to sympathetically interfere with the resonating strings.

b. an enlarged space, around the audience, uniquely reserved to the electronic sounds.

The constitution of the enlarged space was not specified in the original score, and could span from two loudspeakers behind the audience to a whole Acousmonium[6]. Ideally, the more loudspeakers are at avail, the more dimensions the enlarged space may have, and, therefore, the more subtle and expressive the spatial nuances can be. But the difficulty of the electronic performance is significantly increased!

After several decades of experience, and thanks to the work of Carlo Laurenzi at Ircam, the electronics was implemented in Max. As in *Spirali*, a spatial taxonomy was defined, but, this time, only as a result of the perfor-

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[6] See http://fr.wikipedia.org/wiki/Acousmonium (accessed 1/28/2015).

mances with several different audio systems and configurations, and not when the piece was composed. Then, a suggested, standard taxonomy for the sound diffusion was defined: 7 families of spaces (totalling 11 main loudspeakers, see Figure 12). Each family is given a name and a symbol and is controlled by one fader: FC (Front Centre), Pf (Piano), U (Under the piano), F[R/L] (Front [Left/Right]), M[L/R] (Middle), R[L/R] (Rear), RC (Rear Centre). It is for this taxonomy that a new notation was established.

3.2.3 Notational choices

When *Traiettoria…deviata* was first published, it was provided with a unique, exhaustive notation of the synthetic sounds [13], a simple notation of the two main diffusion spaces (M=under the piano, D/S = left/right) and a double time staff (Tpo, Figure 13). The absolute times placed in the middle of the time staves are temporal pivots, the other markings belong to either the piano or the electronics[7].

Figure 12. *Traiettoria*: standard audio setup.

Notice that the traditional cresc/dim signs are used, but that the composer explicitly asks for a shift of the

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[7] Since the electronics has to be tuned to the piano's A by slightly changing the reading speed, these times are not meant to be strictly followed, but to serve as an indication. Because of this, the usage of a stopwatch would simply not be precise enough. None of the pianists with whom we have worked ever used one during a concert.

spectral centre of gravity toward a higher region together with the movement of the faders. This was done with a HP-filter placed on the electronics' stereo input moved together with the fader.

As impressive as it may look, this notation proved not to be very practical for the sound diffusion. It contained too much information that was not required during a concert and too little information regarding the actual spreading of sound.

Finally, its "orchestral" appearance made it difficult for the pianist to grasp which sounds are easier to hear, and therefore to visually identify the essential cues corresponding to the temporal pivots to which the performance had to be synchronised. A more pragmatic and expressively efficient solution had to be found.

3.2.4 Reference Level

Based on our experience with *Spirali*, we defined a RefLev for *Traiettoria* as the subjective level at which the piano sounds "naturally amplified", and the electronics "naturally balanced" with it. However, here, it did not seem necessary to explicitly mark it in the score (with N). Three degrees of +/- indicate, as in *Spirali*, six perceptually different dynamics for the piano or the electronics.

Figure 13. *Traiettoria…deviata*: original version, p. 21 (© Casa Ricordi, by kind permission).

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During the performance of *Traiettoria*, the most difficult task is to find a musical balance between the sound in the hall and the piano (and some electronics) on stage. How to compare, for instance, an electronic sound coming from behind the audience with the piano? When the same level is indicated in the score, it is the task of the CMP to (subjectively) estimate the correct sound image and intensity.

3.2.5 Composition of the sound diffusion

Even though, in theory, there are as many ways to perform the sound diffusion of *Traiettoria* as there are concerts, the practical experience showed that some strategies were more musical and tended to be regularly repeated.

In the tradition of the acousmatic music, the sound diffusion is thought as a real orchestration of the electronic voices over a moving, imaginary space. Stroppa composed a precise hierarchy that organises not only the audio setup, but also the spatial form of *Traiettoria*.

For instance, *Traiettoria…deviata* starts with a barely amplified piano that gets increasingly louder, that is, more amplified. This yields a larger and larger sound image. When the electronics joins in, it fades into the piano's decaying resonance, and comes out only from U (see 3.2.2). Little by little, the constricted space of the electronics opens up to the Pf and the F groups, thus unfolding its image around the piano. It is only at 1'57 that the R group is activated. A detailed analysis of the spatial form of the sound diffusion of *Traiettoria* is beyond the score of this text, but it is important to remark that, since it is an important part of the composition of the piece, it needs to be precisely and correctly notated.

Each spatial group is represented by one fader on the control interface[8] and by one vertical position in the score. Since each group is identified by a letter, it needs to appear in the score only when it is active. In this way, the usage of the space within the page is more efficient.

3.2.6 Level changes

It did not seem necessary to find a more refined way to notate level changes than what was used in *Spirali*. In the few moments, where a random spread is needed, it is directly asked for by some text written in the score and each CMP can freely choose how to perform it.

3.2.7 Main/Secondary loudspeaker(s)

Together with the taxonomy explained in 3.2.2, the sound diffusion of *Traiettoria* extends the concept of loudspeaker. Each spatial family, identified by a letter, represents the "main loudspeaker", defined as the loudspeaker

(or the couple of loudspeakers) that is heard as the main source of diffusion.

It is, however, always possible, depending on the characteristics of the hall or personal taste, to enlarge the focus of a single loudspeaker by diffusing the same electronic material into nearby loudspeakers (called "secondary loudspeakers"), at a softer level, so as to change the acoustic image of the main loudspeaker, without directly perceiving the other ones.

Being rather a performer's aesthetical choice, we decided not to notate this sound-diffusion technique, except when it had a compositional role.

3.2.8 Score

The final score is still under preparation, but concrete experiments and current sketches showed that simply notating the levels above the piano part was not sufficient to achieve a good performance and efficiently learning from the score.

After some tests, we found that adding a sonogram window of a mono mix of the synthetic sounds on top of the page was the best choice to correctly perform the electronics.

Even if a sonogram is very concise and cannot precisely represent pitched and rhythmic material, the most important temporal elements are still clearly identifiable and help both performers to follow the spectro-morphological unfolding of the electronics. And if some special pitch or rhythmic structures need to be marked, it is always possible to locally add this information on the sonogram or between it and the dynamic levels.

Thanks to the very explicit images of the sonogram of synthetic sounds, learning the correct synchronization is no longer difficult (Figure 14).

When dealing with several sound files that are inherently unbalanced[9], the sound diffusion can become a tedious and cumbersome task, as each new sound would require a different position of the fader to compensate the inherent lack of balance.

To avoid this problem, a special solution, called "relative faders" (RelFad) was implemented in all the patches for Stroppa's electronic works. Before being multiplied by the value corresponding to the position on the control interface, each RelFad is first multiplied by a value written in the Antescofo score. In this case, if the written values are just right, it is enough to keep the fader at its neutral value (1.0). However, if unpredictable circumstances modify the perception of the diffused sounds, the RelFad can still be moved away from its neutral value.

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[8] A MIDI mixer or an OSC-driven device, such as an iPad.

[9] For instance, because they are synthesized with radically different techniques and have extremely dissimilar spectral contents.

As a consequence, the movement of faders during the performance is greatly reduced, and the performance itself becomes more ergonomic and gesture-effective. The written values lay half way between the realm of the composition and of the interpretation and can always be very easily changed. One might also imagine to have presets of good values for different acoustical situations.

Since they were implemented, RelFad's have greatly improved the task of learning to perform the electronics of a mixed piece, and have helped to spread the sound diffusion technique to a larger community of CMP's.
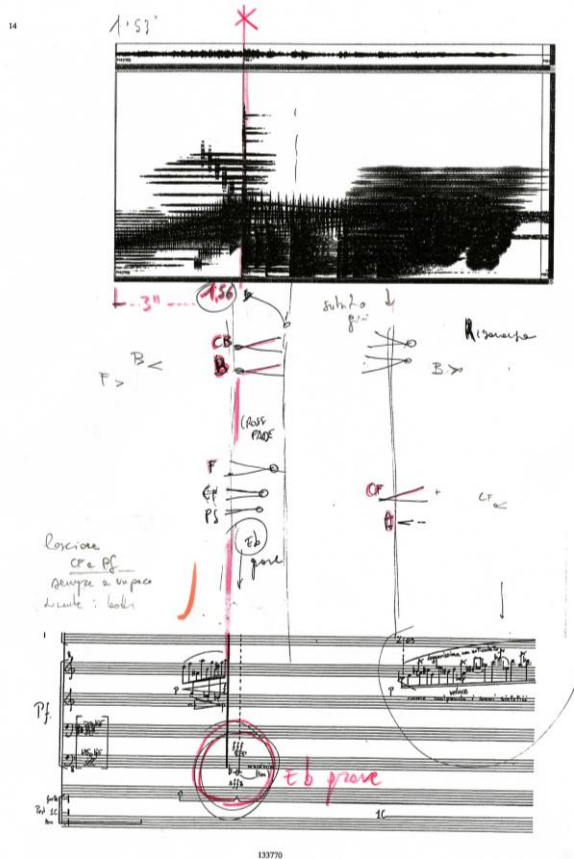

Figure 14. *Traiettoria* : sketch of the new electronic score. Relative faders

4. CURRENT STATE

The notation of dynamic levels in the performance scores of *Spirali* and *Traiettoria* was inspired by the late Nono's works, but the musical context is very different and has a totally diverse goal.

In Nono's works the notation was intended to approximately indicate the behaviour of the levels, in order to provide a schematic structure for the performance of pieces which allowed for a certain degree of improvisation from both the instrumental and electronic parts.

Stroppa, on the other hand, intends to confer a much higher responsibility to role of the CMP, who is required to possess a performance skill comparable to that of an instrumentalist. For this reason, the performance score

must contain all the information needed to interpret the piece and accurately represent the time relationships between the acoustic instrument(s) and the electronics.

It is obvious that such a detailed performance score needs some time to be learnt and practiced.

Finally, this score may also have the crucial function, not only to effectively transmit precise information about the sound diffusion to other CMP's, but especially to make it possible to understand how to render a complex orchestration of synchronized spatial events between electronics and instruments.

Due to the complexity of the music and the amount of actions involved in the sound diffusion, learning the score by heart rapidly became a necessity. However, the performance score was still extremely useful during the learning phase and the rehearsals.

5. CONCLUSIONS

Our experience has shown that it is possible to find generalized and efficient symbols to notate the sound diffusion of electronic works, if it is not automated.

Our first step was to identify a spatial taxonomy adapted to a given piece, in order to find an intermediate layer of notation between the compositional concepts, the performance needs and the physical audio setup.

The next step was to define the meaning and the value of a RefLev for each situation and to notate all the other relative dynamic changes with respect to this subjective value. Introducing RelFad's also greatly improved the gestural aspects of a performance.

Our next step will be to extend this experience to the control of real-time treatments.

Acknowledgments

6. REFERENCES

[1] L. Austin, "Sound Diffusion in Composition and Performance: An Interview with Denis Smalley" in *Computer Music Journal*, vol. 24, no. 2, pp. 10–21, 2000.

[2] H. Eimert, F. Enkel, and K. Stockhausen, "Fragen der Notation Elektronischer Musik" in *Technische Hausmitteilungen des Nordwestdeutschen Rundfunks*, vol. 6, pp. *52-54*, 1954.

[3] G. Haus, "EMPS: A System for Graphic Transcription of Electronic Music Scores," in *Computer Music Journal*, vol. 7, no. 3, pp. 31–36, 1983.

[4] N. Bernardini, A. Vidolin, "Sustainable Live Electro-acoustic Music", in *Proceedings of the*

International Sound and Music Computing Conference, 2005. `http://server.smcnetwork.org/files/proc eedings/2005/Bernardini-Vidolin-SMC05- 0.8-FINAL.pdf` (accessed Jan. 28, 2015)

[5] K. Kosta, O. F. Bandtlow, E. Chew: "Practical Implications of Dynamic Markings in the Score: Is piano always piano?", in *Proceedings of Audio Engineering Society 53rd International Conference, London*, 2014.

[6] K. Stockhausen, *Kontakte*, Stockhausen Stiftung für Musik, Kürten, Germany, 2008 (`www.karlheinzstockhausen.org`).

[7] L. Nono, *A Pierre. Dell'azzurro silenzio, inquietum*, Casa Ricordi, Milano, 1985

[8] L. Nono, *Omaggio a György Kurtàg,* Casa Ricordi, Milano, 1983.

[9] P. Boulez, *Anthèmes 2*, Universal Edition, Wien, 1997.

[10] M. Stroppa, *Spirali,* Casa Ricordi, Milano, 1988.

[11] M. Stroppa, *Traiettoria…deviata, Dialoghi, Contrasti*, from *Traiettoria*, Casa Ricordi, Milano, 1982-88.

[12] J. Duthen, M. Stroppa, "Une Représentation de Structures Temporelles par Synchronisation de Pivots", in *Proceedings of the Symposium: Musique et Assistance Informatique*, Marseille, pp. 305-322, 1990.

[13] M. Stroppa, "Un Orchestre Synthétique: Remarques sur une Notation Personnelle", in *Le timbre: Métaphores pour la Composition*, J.B. Barrière Ed., Editions C. Bourgois, Paris, pp. 485-538, 1991.