METHODS AND TOOLS FOR TRANSCRIBING ELECTROACOUSTIC MUSIC

Pierre Couprie
IReMus, Sorbonne University
pierre.couprie@sorbonne-universite.fr

ABSTRACT

This article presents some tools and methods to carry out transcriptions of electroacoustic music. It introduces the relationship between sound analysis and image or drawing at the birth of electroacoustic music and explains the interest of creating transcriptions. The article contains a proposed framework, based on several years of practice, which links musical analysis to transcription, sound analysis and representation. The different parts of a transcription are then detailed and methods are proposed to create annotations with reference to various examples I have created since the late 1990s.

The last section presents the EAnalysis package, developed with Simon Emmerson and Leigh Landy at Leicester's De Montfort University, in order to create a tool for analyzing, transcribing and representing electroacoustic music. It introduces the interface, the architecture and the transcription features of this piece of software in relation to other technologies.

1. INTRODUCTION

1.1 Schaeffer and the transcription of acousmatic music

In his *Treatise on Musical Objects*, Pierre Schaeffer chose the term "acousmatic" in order to characterize listening which does not include the search for production and transmission practices. He placed listening at the heart of the studied phenomenon. This acoustic listening "symbolically forbids any relationship with the visible, touchable, measurable" [1]. On the other hand, the acousmatic listener can dissect the sound by isolating it, varying its playback speed, intensity, or repeating it. This is the first instrumented listening in electroacoustic music. Analog playback and editing technologies enabled Schaeffer and members of the Groupe de Recherches Musicales (GRM) to analyze sounds through the concept of sound objects.

Studying music created without images through transcription or visualization can seem paradoxical. Indeed, Vincent Tiffon has written that: "The sonogram allows the visual transfer of sounds and music that are precisely designed outside this visual context. At the heart of this paradox, the contradiction resides between acousmatic music and an anti-acousmatic analysis method. Listening to the spectrum changes the pure acousmatic character of this music" [2]. However, in 1952, Schaeffer imagined the possibility of working on the relationship between image and sound through abstract painting: "Some concrete music works immediately demand the graphic translation and it would not be impossible, for example, to compose a concrete music by expressing the equivalence of matter and form of an abstract painting. In any case, this painting would be a better score than notes on music staff paper. Thus, there is an indisputable link between these two new phenomena, which establish a solid bridge between painting and music" [3].

Gaël Tissot has explained the complex relationship between music and visual arts within the GRM [4]. He argues that there has often been a convergence between the morphological work of the composer and the notion of plasticity stemming from the visual field, while going beyond the scope of the Groupe Recherche Image (GRI). Jacques Vidal and François Delalande's animated transcription [5] of the fourth movement of Schaeffer's *Études aux objets* (1959) demonstrates that the idea of using visualization for an instrumented listening to concrete music dates back to at least the 1970s. As for the instrumented listening activity itself, it probably began with the history of the recording [6]. The shift between acousmatic listening and instrumented listening has been accentuated with the advent of digital technologies and their graphical interfaces, since the manipulation of sound can only be controlled through a representation of it.

Acousmatic music and sound visualization are complementary. They are listening practices in which a form of visualization improves the understanding of the phenomenon being listened to. With musical analysis, visualization is even an essential prerequisite, as acousmatic listening is used several times during the analytical process, benefiting from all the possibilities of instrumented listening.

1.2 Why would we trancribe?

We have previously mentioned the lack of visual support as a hindrance to the development of electroacoustic music analysis. The ethnomusicologist Simha Arom points out that the study of traditional oral music requires one "to have a global picture of the sound document in front of us at all times" [7]. The proximity between the analytical approach used in ethnomusicology and the one used in the electroacoustic works has allowed for the develop-

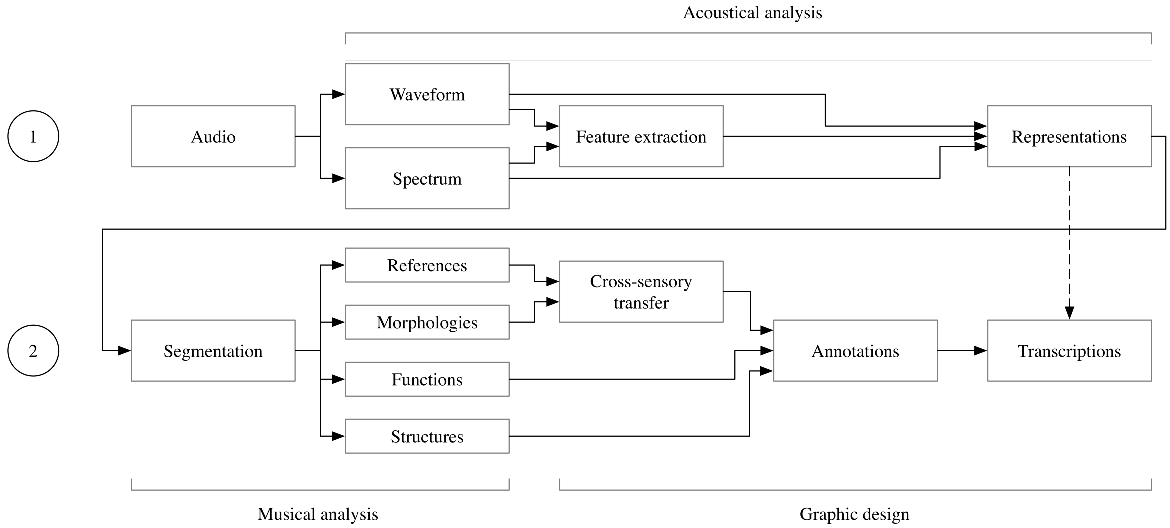

Figure 1. Representation and transcription framework.

ment of transcription in the same way as that used in structural linguistics. This filiation can be found in the work of several researchers such as François Delalande, who has used transcription as a pre-analytical step [8], or in that of François-Bernard Mâche, who has linked the units to their context in a phonological process [9]. Transcribing an electroacoustic work partially follows the steps developed for the structural study of languages. Partially, because some steps such as switching, or the concept of equivalence class are only rarely applicable in a systematic way. The segmentation of the musical flow remains one of the most problematic steps in the analysis of electroacoustic works. Thus presented, transcription remains a primarily descriptive tool.

In addition to transcription as a pre-analytical step, its use in a pedagogical or presentation context remains the most widely used. I have developed a graphical code that is attractive and easily understandable by a novice audience, for instance the transcriptions which I carried out for the CD-ROM *La musique électroacoustique* [10]. Colors, shapes and their arrangement on the graphical space have been chosen to enhance the understanding and memorization of works. This coding generally corresponds to the origin or context in which the sounds are used. The origin of the sounds is often imaginary – in this way, the approach is close to the concept of sound-image proposed by François Bayle [11]. On the contrary, transcription, which is often absent from theoretical writings on electroacoustic music, offers a wealth of possibilities. Finally, transcription is very commonly used to exemplify analytical discourse.

Whether it is as a pre-analytical step, an educational tool or as an example accompanying a talk, transcription is generally an essential step. This analytical step can also become the first act of creation, for example by using the structure or elements of an existing work in the creation of a new work.

2. THE ANALYTICAL FRAMEWORK

Transcription is usually a complex exercise (Figure 1). The method proposed in this article is divided into two steps.

2.1 Representations

This section concerns the realization of one or more representations which serve as visual support to musical analysis. The waveform and spectrum (linear, logarithmic or wavelets) facilitate the segmentation of the musical flow into sound materials. If the analytical objective is to study slow evolution or to opt for an analysis method without segmentation, then it is interesting to extract audio descriptors. One or more representations are realized during this step.

2.2 Transcriptions

During transcription creation, the type of segmentation is selected from musical analysis:

1. By identifying the origin of sounds (causal analysis).
2. By segmenting the musical flow into morphologies based on an analysis of the acoustic parameters of sounds (morphological analysis).
3. By identifying the musical functions of musical discourse (functional analysis).
4. By identifying elements of structures ranging from large temporal divisions – musical form – to the most finely divided – microstructures (formal analysis).

The analyst can choose between these types of segmentation or mix them. The next step is to convert these analytical elements to annotations that will be assembled to create the transcription. Then, transcriptions and representations can be combined to form analytical or composite representations [1] .

[1] Analytical or composite representations combine several transcriptions and/or representations to create a complex visualization of analysis.

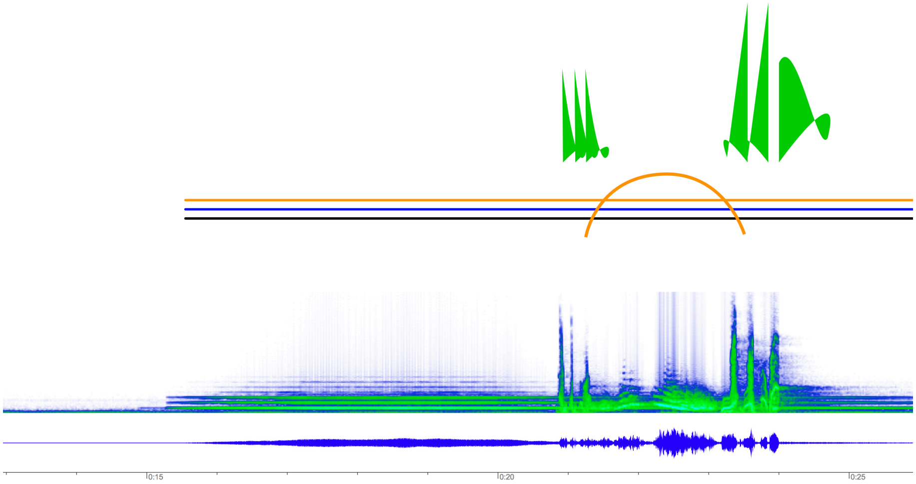

Figure 2. Extract of transcription of “L’oiseau moqueur” (*Trois rêves d’oiseau*) by François Bayle.

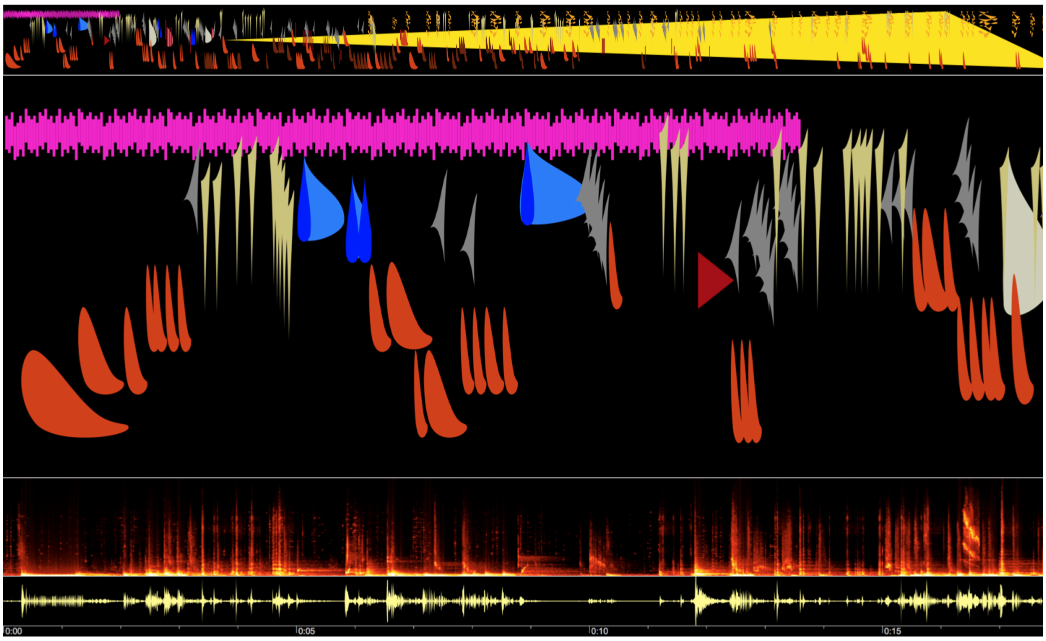

Figure 3. Extract of transcription of “Ondes croisées” (*De Natura Sonorum*) by Bernard Parmegiani.

2.3 The transcription space

The transcription space is the frame that will contain one or more backgrounds and graphic annotations. This space contains several dimensions organized into four categories : the graphical plane, background, annotations and other analytical parameters [2] .

2.3.1 The graphical plane axis

The horizontal axis always represents time and the vertical axis can represent approximate pitches. In each of the three short pieces of *Trois rêves d’oiseau*, the composer François Bayle uses harmonic sounds from musical instruments or from natural sounds such as bird songs. While the real pitch of these sounds has very little importance in the composer’s language, their representation in the form of a single line positioned in a specific register (Figure 2) makes it easy to distinguish them from other sounds [12].

It is also possible to represent spectral heights on the vertical axis. In my analysis of “Ondes croisées”, a movement of *De Natura Sonorum* by Bernard Parmegiani [13], I highlighted, first, the link between spectral heights and categories of sound and, second, the spectral evolution of the material from the bass to the treble (Figure 3) by drawing the spectral thickness and the approximate position of the sound on the frequency scale.

The transcription of other parameters such as the stereophonic position of the sounds highlights the importance of one of the dimensions of the space as an element of the musical form. Alain Savouret’s extract from *Don Quixote Corporation* has the particularity of being built on sounds that are easy to segment with a theme and variations musical structure. Moreover, each sound is positioned on the

[2] I briefly present the first two categories in this section. The creation of annotations is presented in section 2.4 and I do not mention other analytical parameters which are beyond the field of this article.

panoramic in an easily perceptible way, and there is no doubt that the composer used this criterion as one of the variation parameters.

2.3.2 Background

When I realized this transcription [10], I positioned the annotation shapes vertically in relation to the panoramic space (Figure 4). The transcription highlights gestures or articulation between this space parameter and the evolution of the musical structure.

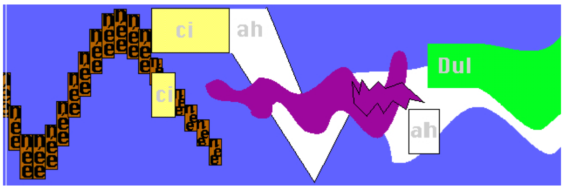

Figure 4. Extract of transcription of *Don Quixote Corporation* by Alain Savouret.

The transcription presented in Figure 4 only includes a colored background. However, it is also possible to add a waveform or a spectrum. In this case, the representation contains several other dimensions:

1. In the case of a waveform, the vertical axis represents the amplitude of the sound-signal mirrored waveform with a linear scale.
2. In the case of a spectrum, the vertical axis represents the frequencies, and the colors represent the intensities in grayscale or with pseudo-color (or false color).

It is pretty rare to use the background for legibility reasons, but it is quite common to juxtapose a waveform or a spectrum to a transcription. In Jean-Claude Risset's *Sud* transcription [14] (Figure 5), I used this technique to ensure that representations complete the transcription.

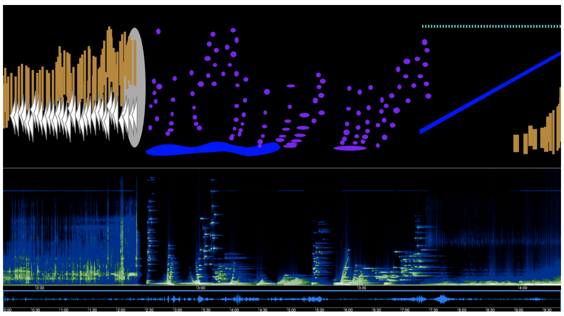

Figure 5. Extract of transcription of *Sud* (part 1) by Jean-Claude Risset.

2.4 Annotations

2.4.1 Semiotic correspondences

Creating a transcription is often complex. The choice of graphics and the link between analysis criteria and graphical properties alone leads to a concentration of many problems. The graphical characteristics of a transcription [15] always sit along an axis which ranges between iconic and symbolic representation. The terms "iconic" and "symbolic" are used here in their semiotic sense. Following Charles S. Peirce's example [16], an icon (shape) refers to an object (the segmented sound unit) by its resemblance relationship, while the relationship between a symbol (shape) and an object is based on a social convention. A drawing of waves to transcribe the sound of the sea, or what looks like an aquatic sound, as I employed in Jean-Claude Risset's representation of *Sud* [14], is relevant to the concept of icon. Greimas and Courtés propose broadening the term of iconicity to define it "as the result of a set of procedures to produce the effect of meaning 'reality'" [17]. Thus, an icon is a "referential illusion" and this is how we analyze these graphic annotations, which might, for example, take their form from the evolution of the intensity of the sound units. Cécile Régnault takes advantage of these referential illusions to describe sensory or factual correspondences [18] between, for instance the granular qualities of visual and sound textures, or the length of a graph and the duration of a sound. Correspondences based on gestural analogies are very efficient in a pedagogical situation or for the performance of an electronic representation of the electronic part of a mixed work.

Alain Savouret's transcription of *Don Quixote Corporation* is largely symbolic. Some of the segmented units are represented as rectangles, the color of which denotes the effects of sound transformation and manipulations. Lasse Thoresen developed a graphical transcription system based on Schaefferian typomorphology [19, 20]. The same remark can be made for the symbols used by Roy in his system for transcribing musical functions [21].

However, there are few totally iconic or symbolic transcriptions, as analysts generally use a medium-term approach and do not hesitate to move along the axis which links iconic to symbolic during the same transcription. The predominance of iconicity makes graphics easier to understand by using analogies between visual representations and sound. On the other hand, the symbolic character offers a wider range of transcription possibilities by allowing different types of sound parameters to be superimposed on the same graphical shape. Learning the meaning of symbols is then often essential, but the analyst can also rely on cultural conventions which can be comprehended by everyone, such as the height of sounds and the vertical position of a graphical shape, the spectral richness or the thickness of the line. Therefore, the choice of graphic shapes depends on the purpose of the transcription and the target audience. When I carried out the transcriptions for the CD-ROM *La musique électroacoustique*, I opted for iconic graphics or for a simple symbolization to allow their use in a pedagogical context while avoiding the pitfall of redundancy.

2.4.2 Links between sound and visual

Drawing on Bertin's work, Cécile Régnault has proposed a table of the correspondences [18] between the visual parameters of annotations and Schaefferian sound object criteria. This table lists a set of common uses which began to spread in the early 2000s. I have experimented with these different correspondences in my representations:

1. Graphical shape: Causality, gait, background-figure, typology.
2. Graphical thickness: Intensity, spectral width.
3. Vertical position: Real or approximate pitch, panoramic, spectral structure, formal structure (formal diagram).
4. Color: Typology, effects, sound layers.
5. Texture: Granulosity.
6. Animation: Space motions.

Most of these correspondences come from inter-sensory transfers or cultural habits related to musical notation: for example, the position or the vertical thickness used to transcribe height or spectral width.

However, I also experimented with transcription at the borderline of graphic art to assess the point when foreground and background exchange their roles. Usually, the background is used as a space which represents the space of time and frequency. The shapes drawn on this background stand out and are represented by units segmented during the analysis. The transcription I have made of *Hétérozygote* and Luc Ferrari's series of *Presque rien* [22] tends to attenuate the separation between form (foreground) and background. The background becomes a part of the forms, or guides a non-linear temporal navigation and the forms no longer stand out in the background. The transcription, usually done on at least two planes, is rendered in a single plane. These transcriptions also provided an opportunity to experience the minimum elements to be included in a representation. Luc Ferrari's music, based on anecdotal and minimalist soundscapes, is perfect for this kind of experimentation. The three transcriptions made of *Presque rien n^o 1, le lever du jour au bord de la mer* contain only one or two graphical shapes whose morphology corresponds to the sound amplitude of the foreground. The background, broken down into several parts, represents the background sounds. In order to simplify reading, the timeline is represented by the horizontal axis. In the third extract (Figure 6), the background and the foreground tend to merge, and it is difficult to say whether there are one, two, three or four forms in the background. The uniform color removes the sound space captured and created by the composer, guiding listening towards the main form and giving an immediate and synoptic vision of the whole.

2.4.3 Synoptic transcriptions

In my analysis of Bernard Parmegiani's "Ondes croisées" for the CD ROM *La musique électroacoustique*, my transcription was published in two forms: the paginated transcription and the enlarged synoptic transcription. These two versions of the same transcription were placed under each other (Figure 3). I had not anticipated the importance of this layout to explain a musical form based on a crossfade. This short piece is built from two types of sound

Figure 6. Transcription of an extract of *Presque rien n^o 1, le lever du jour au bord de la mer* by Luc Ferrari.

materials: held flicker sounds and short sounds organized in a complex texture (a mixture of pizzicato, double bass, elastic, water drop and zarb musical instruments). The scintillating flicker of the beginning turns is the end of the previous part ("Matières induites") and has no role in the construction of the form of this piece. It is therefore based on the progressive appearance of a white noise (from a fire recording) at 0:25, which increasingly attenuates the complex texture of short sounds. The result is a fade that lasts about 1:30. I decided to represent the white noise by a large yellow triangle in which all the other sounds were gradually dissolving. This transcription, presented in a synoptic way, only retained this effect of fading graphically, revealing its musical equivalent. From my point of view, this form is one of the most striking gestures of *De Natura Sonorum*. The sound of white noise is thus at the origin of the musical form of this piece. However, this was not considered to be very important by the authors of *L'envers d'une œuvre* [23]. They considered it as a regression compared to the previous parts. However, the composer insists on presenting this sound as a desire for formal coherence.

The synoptic transcription is ideal for reporting formal processes. In my analysis of François Bayle's *La fleur future* [24], I have made formal transcriptions with linear and formal diagrams. They reveal the evolution of typologies of timbre, the amplitude of envelopes, and the role of silences in this short piece.

3. SOFTWARE

3.1 Available technologies

There are four types of software to carry out representations and transcriptions of electroacoustic music [25]:

1. Software to manipulate the sound spectrum: Audiosculpt[3], SPEAR[4]. The modification of the gain (enforcement or filtering) of regions of the spectrum facilitates the analysis of complex textures or

[3] Audiosculpt is based on SuperVP technology to analyze and manipulate temporal and spectral properties of sounds. It is distributed through the Ircam forum (`http://forumnet.ircam.fr`).

[4] SPEAR is a piece of free software developed by Michael Klingbeil (`http://www.klingbeil.com/spear`).

the study of mixing in which masking effects are used by the composer to orchestrate his material.

2. Sound information retrieval tools: Audiosculpt, Vamp plug-ins [5] inside Sonic Visualiser [6]. For several years, musicologists have used audio descriptors to analyze music.

3. Annotation tools: Sonic Visualiser, ASAnnotation [7], Metascore [8], Acousmographe [9]. From simple temporal annotation to morphological transcriptions, this software is essential for the analysis of electroacoustic music.

4. Musical analysis software: an Aural Sonology plug-in [10] can be used with the Acousmographe, Acousmoscribe [11], and *TIAALS* [12]. These technologies take a step forward in computer-assisted analysis by offering specific functions designed for musicology.

Unfortunately, these software packages have limitations:

1. They cannot analyze audiovisual files, they only use sound files, and most of these are only stereophonic files. Video music and multitrack works are very common in electroacoustic music. Moreover, video is a good support to analyze performance.

2. Several of these packages cannot export their data to readable files or import data from other software. There is no format to exchange analyzed data between them but nevertheless, analyzing electroacoustic music requires the use of several software applications from the extraction of data to creating representations.

3. The interface is often limited and not adapted to musical studies. For example, there is no possibility to navigate inside a file and to compare different moments of a work or of different works.

4. While they have interesting features (such as the Timbre Scope of Acousmographe or the drawing of audio descriptor values on the sonogram with Sonic Visualiser), most of them are difficult to use in some contexts (e.g. with a long work, without the possibility to filter data, or to synchronize with a graphic representation).

3.2 An example: EAnalysis

In October 2010, Simon Emmerson, Leigh Landy, Mike Gatt, and myself began the New Multimedia Tools for Electroacoustic Music Analysis research project at the Music, Technology and Innovation Research Centre at Leicester's De Montfort University. As part of this project, I developed the EAnalysis [13] software to gather the essential tools for the analysis, representation and transcription of non-written music. EAnalysis is a workspace where the user can create representations, import [14] data from other software or recorded during performance, analyse them, and export in different formats [15].

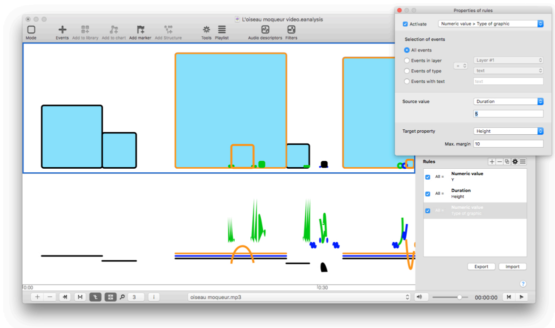

Figure 7. EAnalysis: Style sheet to create different transcriptions from the same analysis.

3.2.1 From ideas to software

The first idea of EAnalysis is to disconnect the graphical rendering from the musical or sound analysis. This feature uses a simple style sheet. One of the main difficulties when making a graphical transcription is to be able to experiment in different directions. Unfortunately, no existing software allows you to quickly modify several graphic parameters. The analyst realizes his transcription by drawing on a view and the graphical parameters are fixed once and for all. To transform this transcription, he must modify graphical shapes one by one. EAnalysis contains an additional layer: each graphic parameter can be associated with an explicit (intensity, grain, space, etc.) or neutral (keyword, text, number, etc.) analytic parameter (Figure 7). The correspondence between the graphic parameters and these analytic parameters is recorded locally on each view. A style sheet is used to create new rules for linking analytical and graphical parameters. Thus, it is easier to change a graphical transcription without affecting the parameters of the graphical form. This system also allows the user to

[5] Vamp is a plugin format dedicated to sound analysis (`http://www.vamp-plugins.org`).
[6] Sonic Visualiser has been developed by the Centre for Digital Music at Queen Mary, University of London (`http://www.sonicvisualiser.org`).
[7] ASAnnotation is free software based on Audiosculpt and has been developed at Ircam (`http://recherche.ircam.fr/anasyn/ASAnnotation`). Unfortunately, its development has been halted for several years and its compatibility with recent systems is not assured.
[8] MetaScore has been developed by Olivier Koechlin for the multimedia library of the Cité de la Musique (Paris). This software combines text, images, audio-visual files and animation to realize listening guides.
[9] The Acousmographe has been developed by INA-GRM (`http://www.inagrm.com/accueil/outils/acousmographe`) since the 1990s.
[10] The Aural Sonology plug-in was developed from Lasse Thoresen's research by the INA-GRM (`http://www.inagrm.com/aural-sonology-plugin-0`). It contains basic shapes to transcribe parameters of sounds based on an augmented schaefferian typomorphology.
[11] The Acousmoscribe has been developed by the Scrime (Bordeaux) from Jean-Louis Di Santo's research (`http://scrime.labri.fr`), and uses a spectral typomorphology.
[12] *TIAALS* is developed by the universities of Huddersfield and Durham (`http://www.hud.ac.uk/research/researchcentres/tacem/`). This software is still in its beta version and allows typological or paradigmatic charts to be created from extracts of the spectrum.
[13] EAnalysis is free software (`http://eanalysis.pierrecouprie.fr`).
[14] EAnalysis supports importation from audio, video, CSV, Pro Tools information session, and XML Acousmographe
[15] EAnalysis supports exportation to image, video, and CSV

generate different types of representations (for example animation, graphical curves, and out-of-time visualization).

The second idea is to help the user in his analysis by providing an analytic events library. EAnalysis contains fifteen preformatted analytic parameters (sound objects, Spectro morphologies, language grid, space, etc.) and users can add their own parameters and group them into a list, as well as to create a library to share with other users. The interface to edit events and manage their properties is simple and flexible.

The third idea is to experiment with new forms of representation by breaking with the traditional time-frequency view. One of the problems of graphical representation is the limitation of the dimensions and consequently of the functions or musical parameters which are represented.

A typical two-dimensional graphic representation can represent only three or four parameters at the same time. It is possible to add more, but this can complicate reading of the graphical output, and limit functionality. I have already presented in a previous article why a 3D analytical representation would be an error [26] because it would confuse the readability of the analysis. EAnalysis provides a simple solution to this problem as it allows for the simultaneous use of several types of views (Figure 8).

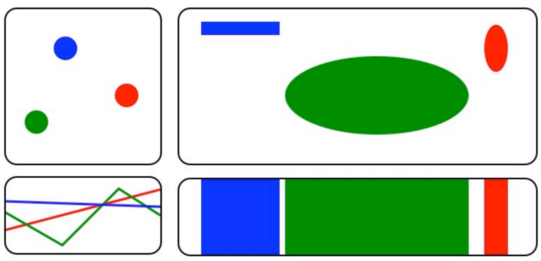

Figure 8. A representation combining several types of views (transcriptions and representations).

This multiple-view system (or composite representation) allows one to view the properties of an event from different points of view. I have already successfully experienced this type of representation in one of my previous analyses [27].

3.2.2 The architecture of EAnalysis

The architecture of EAnalysis contains three main user elements.

The **multimedia player** allows for the use of one or more audio and/or movie files inside the same project. It is at the heart of the software. This player contains all the functions useful for the analyst: loop playback, speed variation (without changing the pitch), etc.

The library of events is divided in two parts: graphical events and analytical events (Figure 9). These two types of events are different presentations of the same object. As shown in Figure 10, an event contains a set of properties divided into three categories:

1. Main properties: The name of the object and its temporal and frame coordinates.
2. Graphical properties: The type of shape and all other graphic properties.
3. Analytical properties: The list of analytical parameters.

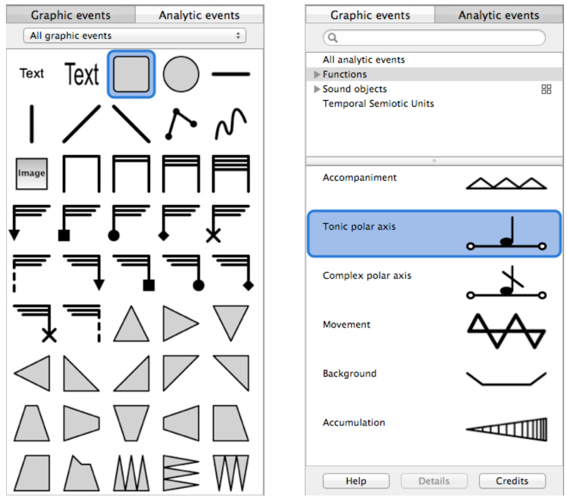

Figure 9. EAnalysis, library of events: Graphic events (left) and analytic events (right).

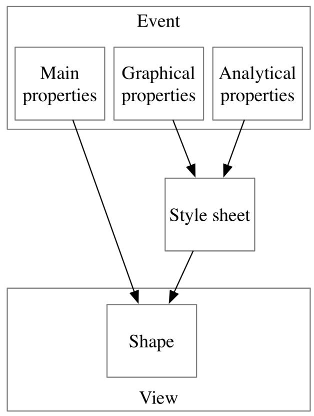

Figure 10. EAnalysis: Architecture of events (annotations).

Because events contain three types of property, they can be used for different strategies and with different levels of complexity:

1. Graphic events are very simple shapes such as are available in every drawing application: rectangle, ellipse, text, polygon, image, etc. This level is adapted to first annotations of the piece before analysis, working at listening with children, or creating beautiful graphic representations.
2. Analytic events are preformatted shapes for analysis. Each event contains a graphic shape and one or more analytic parameters. Working with preformatted analytic events is a good starting point for students to learn musical analysis or for specialists to apply existing theories.

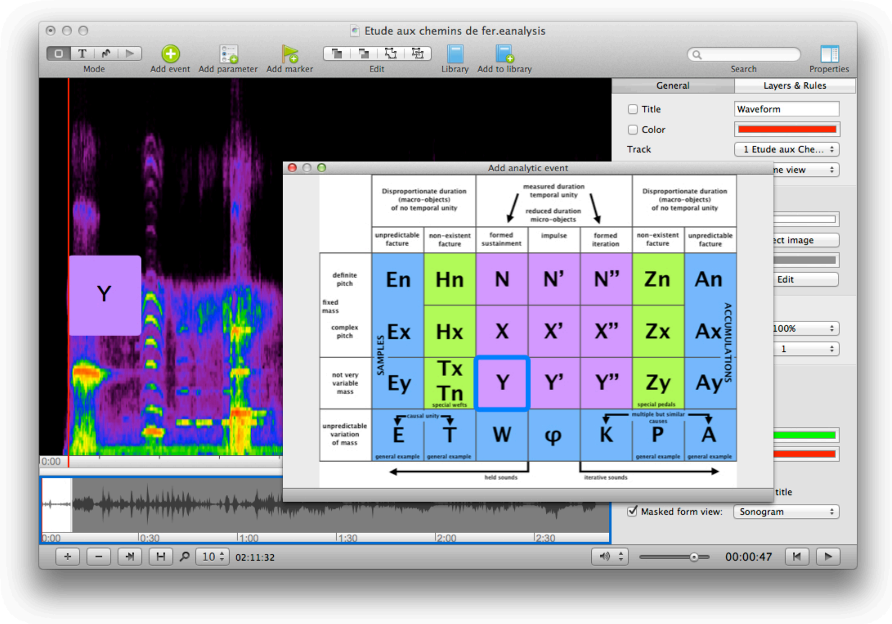

Figure 11. EAnalysis, library of events: Add a sound object from the Schaefferian typology.

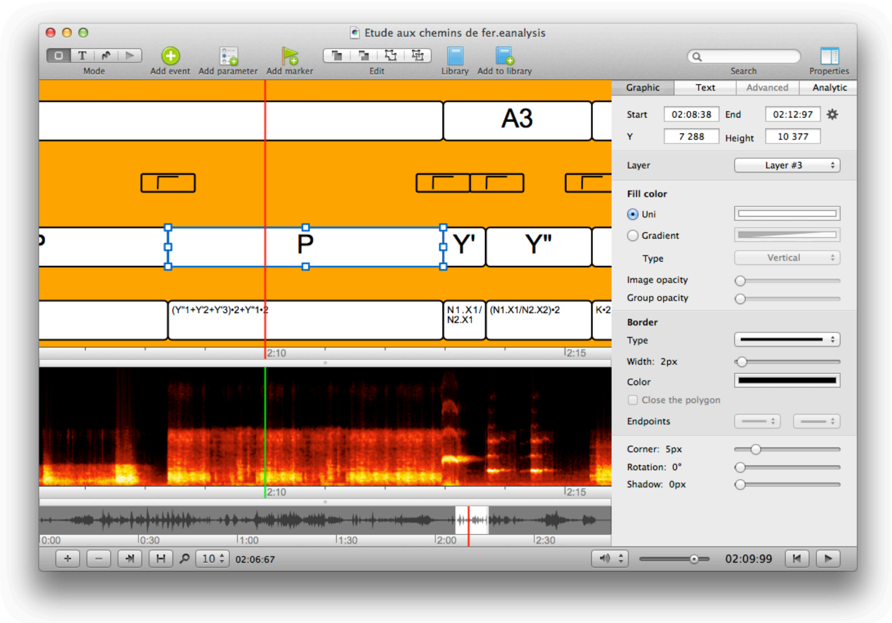

Figure 12. EAnalysis: Views to draw events or display sound representations.

3. Users can also create their own analytic events with personalized analytic parameters. This level is highly flexible, allowing the user to adapt representation and analytic segmentation to the analyzed work or to a personalized analytical theory.

A graphic event does not contain any analytical parameters but it is possible to add one, while an analytic event contains the definition of all properties related to the object. These properties can obviously be supplemented or modified by the user. They are presented through a list sorted by categories on several levels.

In practice, the navigation between the different analytic events presented through a list was not necessarily very practical or explicit. Consequently, I added a floating window to display the events in a different way (Figure 11). This window contains a clickable image from which the user can drag and drop the different events in views.

The third element is a set of **views** to display the graphical and analytical properties of events. These views are displayed in a single window. Figure 12 shows the main window with an example of three overlapping horizontal views. The user can add as many views as he wants to this window. The playback heads of the individual frames are synchronized, but the frames can be independent in their

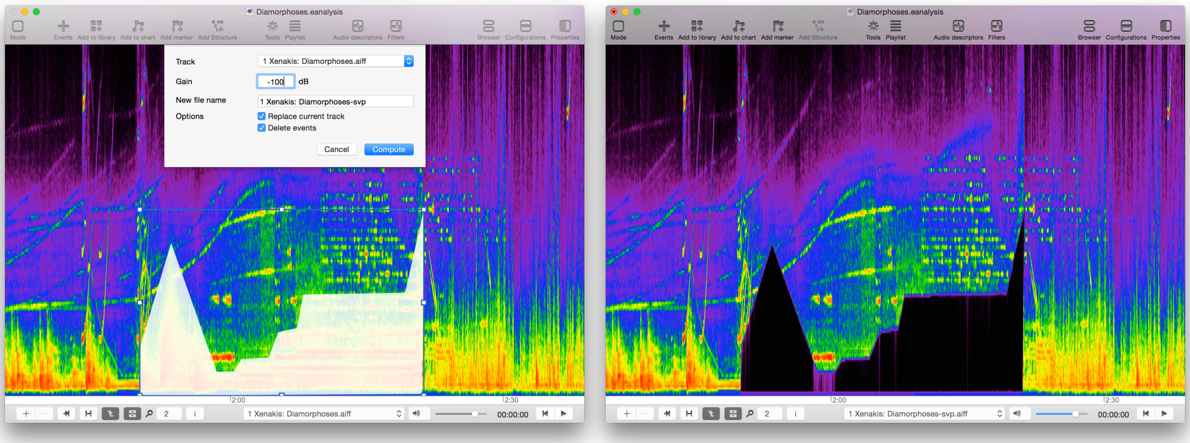

Figure 13. EAnalysis: SuperVP filter from a graphic shape.

zoom level. Thus, in this figure, the bottom view, representing the waveform, displays the entire audio file in a synoptic mode, while the two upper views are set to a zoom level to show details. Each view also has a set of parameters (background, color, playhead, timeline, mask according to another view, etc.) which can be easily modified.

3.2.3 Modes and markers

EAnalysis integrates three modes: normal, add text and drawing. These modes allow the user to create events with different tools. Normal mode is the default mode. The user adds an event by 'drag and drop' from a preformatted list or from his own library to the view. With add text mode, the user enters text during playback and can annotate audiovisual files with words or sentences. Each part of the text is an event and the user can switch to normal mode to change its graphic properties. This mode has been realized for analysts who prefer to work with text or for simple annotations of ideas during the first listening. The drawing mode is for users who prefer to draw with a mouse, graphic tablet, or interactive whiteboard. This mode is very useful to create very simple annotations on a white page, to highlight a spectrum, or to work on a whiteboard while listening with children. Moreover, if users use a graphic tablet, pressure will be detected and could be used to create artistic drawings like calligraphy.

These three modes were the first features that were developed to respond to various users' needs. They were not created as individual elements but as part of a global architecture.

Annotations (events) are also completed with markers. Markers are just time positions with simple graphic properties. They can be used to annotate ideas on first listening, or to mark breaks or structure parts. Events and markers are editable in time view, making this the default view to visualize, listen, and edit analyses. Other views are to display other data.

3.2.4 From events to filter

Since version 1.1.1, EAnalysis has been able to communicate with SuperVP to calculate gains changes in graphical annotations. SuperVP (Super Phase Vocoder) is a technology which has been developed by the Ircam Analysis/Synthesis team and is available as a command-line tool or through Audiosculpt.

Users choose any rectangle, polygon or freehand annotation to apply a gain modification (by filtering or reinforcing) and immediately display the result without exiting the software (Figure 13). This function can be used to suppress a part of the sound in order to improve the perception of the rest of the spectrum or to facilitate the perception of a low intensity spectral area.

4. CONCLUSION

This article presents the method used to create transcriptions of electroacoustic music. This method is based on several techniques drawn from acoustics, semiotics, design and musical analysis. The proposed framework relies on the practice of transcription and representation in musical analysis.

Based on a critical study of existing software, the article also presented EAnalysis software, developed since 2010. This has fixed some musicological problems encountered with other software. Moreover, EAnalysis also contains new features for musical analysis such as the use of audio descriptors or the realization of charts.

The success of EAnalysis now allows us to imagine evolution towards software which is open to the influence of all techniques used in musical analysis for the creation of transcriptions and representations. In 2018, EAnalysis will be merged with other software which I have been developing since 2006 for the creation of listening guides (iAnalysis). This fifth version of iAnalyse enhances the workflow used for transcriptions and covers the different steps of musical analysis, from the recording of a performance to the realization of listening guides through the realization of complex representations.

5. REFERENCES

[1] P. Schaeffer, *Treatise on Musical Objects: An Essay across Disciplines*. University of California Press, 2017 (1966).

[2] V. Tiffon, "La représentation sonagraphique est-elle une aide pour l'analyse perceptive de la musique électroacoustique ?" *Lien*, pp. 3–15, 2006.

[3] P. Schaeffer, *A la recherche d'une musique concrète*. Paris: Seuil, 1952.

[4] G. Tissot, "La musique électroacoustique au GRM : un art plastique ?" *Filigrane*, vol. 16, 2013. [Online]. Available: http://revues.mshparisnord.org/filigrane/index.php?id=543

[5] F. Delalande and J. Vidal, "Partition animée," INA, 1970. [Online]. Available: http://www.ina.fr/video/CPF03008561

[6] F. Delalande, "L'analyse musicale, une pratique et son histoire," in *Pratiques et objectifs des transcriptions des musiques électroacoustiques*, R. Campos and N. Donin, Eds. Geneva: Droz-HEM, 2009, pp. 131–153.

[7] S. Arom, *La boîte à outils d'un ethnomusicologue*. Montréal: Presses de l'Université de Montréal, 2007.

[8] F. Delalande, *Analyser la musique, pourquoi, comment ?* Paris: INA, 2013.

[9] F.-B. Mâche, *Musique au singulier,*. Paris: Odile Jacob, 2001.

[10] P. Couprie, "Transformation/transmutation. Analyse d'un extrait de Don Quichotte Corporation d'Alain Savouret," in *La musique électroacoustique*. Paris: INA-GRM-Hyptique, 2000.

[11] F. Bayle, *Musique acousmatique propositions… …positions*. Paris: INA-GRM-Buchet Chastel, 1993.

[12] P. Couprie, "Three Analysis Model of L'Oiseau moqueur on of the Trois rêves d'oiseau by François Bayle," *Organised Sound*, vol. 4, no. 1, pp. 3–14, 1998. [Online]. Available: https://hal.archives-ouvertes.fr/hal-01265026/

[13] ——, "Comment c'est fait ? Analyse graphique d'un extrait de De Natura Sonorum de Bernard Parmegiani," in *La musique électroacoustique*. Paris: INA-GRM-Hyptique, 2000. [Online]. Available: https://hal.archives-ouvertes.fr/medihal-01305248

[14] ——, "Représentation de Sud de Jean-Claude Risset," in *Portrait polychrome Jean-Claude Risset*. Paris: INA-GRM, 2001.

[15] ——, "Graphical Representation: An Analytical and Publication Tool for Electroacoustic Music," *Organised Sound*, vol. 9, no. 1, pp. 109–113, 2004. [Online]. Available: https://hal.archives-ouvertes.fr/hal-01265027

[16] C. S. Peirce, *Écrits sur le signe*. Paris: Seuil, 1978.

[17] J. C. Algirdas Julien Greimas, *Sémiotique. Dictionnaire raisonné de la théorie du langage*. Paris: Hachette, 1993.

[18] C. Régnault, "Correspondances entre graphisme et son : les représentations visuelles de l'objet sonore," in *Du sonore au musical. Cinquante années de recherches concrètes (1948-1998)*, S. Dallet and A. Veitl, Eds. Paris: L'Harmattan, 2001, pp. 307–337.

[19] L. Thoresen, "Spectromorphological Analysis of Sound Objects: An Adaptation of Pierre Schaeffer's Typomorphology," *Organised Sound*, vol. 12, no. 2, pp. 129–141, 2007.

[20] ——, *Emergent Musical Forms: Aural Explorations*. London: University of Western Ontario, 2015.

[21] S. Roy, *L'analyse des musiques électroacoustiques : modèles et propositions*. Paris: L'Harmattan, 2003.

[22] P. Couprie and D. Teruggi, "Hétérozygote et les Presque rien," in *Portrait polychrome Luc Ferrari*. Paris: INA-GRM, 2001.

[23] P. Mion, J.-J. Nattiez, and J.-C. Thomas, *L'envers d'une œuvre. De Natura Sonorum de Bernard Parmegiani*. Paris: INA-GRM/Buchet Chastel, 1982.

[24] P. Couprie, "Quelques pistes pour analyser la structure de La fleur future de François Bayle," in *Die Klangwelt des François Bayle*, M. Erbe and C. von Blumröder, Eds. Vienne: Verlag Der Apfel, 2012, pp. 205–209. [Online]. Available: https://hal.archives-ouvertes.fr/hal-01261202

[25] ——, "EAnalysis: Developing a Sound Based Music Analytical Tool," in *Expanding the Horizon of Electroacoustic Music Analysis*, S. Emmerson and L. Landy, Eds. Cambridge University Press, 2016, pp. 170–194. [Online]. Available: https://hal.archives-ouvertes.fr/hal-01290982

[26] ——, "Dessin 3D et système immersif pour la représentation de la musique électroacoustique," in *Proceedings of the Electroacoustic Music Studies Network confernce (EMS'07)*, Leicester, 2007. [Online]. Available: https://hal.archives-ouvertes.fr/hal-01258371

[27] ——, "(Re)Presenting electroacoustic music," *Organised Sound*, vol. 11, no. 2, pp. 119–124, 2006. [Online]. Available: https://hal.archives-ouvertes.fr/hal-01265028/