INTRODUCING TaCEM AND THE *T*IAA*LS* SOFTWARE

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ABSTRACT

This paper introduces the TaCEM project (Technology and Creativity in Electroacoustic Music), funded for 30 months by the Arts and Humanities Research Council in the UK, investigating the relationship between technological innovation and creative practice in electroacoustic music of the last 40 years (http://www.hud.ac.uk/research/researchcentres/tacem/). It is a collaborative project between the universities of Huddersfield and Durham in the UK and outputs from the project will include a book and freely available interactive software. This paper explains the context for the project and its goals, and discusses some of the generic software that is being developed as part of the project, intended not only for use in the project itself but also to be freely available for others to use in the study of any electroacoustic work as appropriate.

1. INTRODUCTION

The evolution of electroacoustic music, from the pioneering post-Second World War era to the present day has resulted in a rich and varied legacy of works. As time advances the need to secure these compositions for posterity comes ever more pressing, no more so than in the case of those originally mastered on analog tape. Even in the digital domain, older formats such as DAT have become obsolete, adding further urgency to the task of copying, and if necessary re-mastering. But this mission, as important as it is, only achieves the first stage in the quest to facilitate knowledge and understanding of the repertory that has emerged.

Whereas instrumental composers provide access to the inner detail of their works through the medium of the score, using a notation that is universally understood, electroacoustic composers rarely provide clues to the underlying compositional process other than those that may be deduced from the aural experience. Although works that combine electronic materials with instrumental music sometimes provide descriptive clues via special scores provided for the players, these rarely provide anything more than elemental cueing information to assist synchronisation in performance. This detachment from both the compositional processes and the technologies used in their production presents major challenges for those wishing to gain a greater insight into the realisation of these works. These challenges materially increase with the passage of time as the memories of the composers become more distant and the technologies used become progressively harder to access. When the composer dies these processes of further investigation become even harder to pursue.

The importance of addressing these issues has been recognised in some quarters, but it is only relatively recently that the wider electroacoustic community has begun to grasp the true scale of what needs to be done here as a matter of increasing urgency. In terms of historical perspective a number of texts provide useful insights into the evolution of the medium, for example Chadabe [6], Holmes [14] and more recently Manning [19]. In so doing the scope and nature of the associated technologies are usefully contextualised, but for the most part such accounts do not embark on detailed analyses of individual works. Other texts have concentrated more specifically on the technical methods that have been employed over the years, for example Appleton [1], Naumann and Wagoner [20], Roads [22], and Puckette [21], and there are further texts that focus on analytical considerations, for example Bennett and Barrière [4], Camilleri and Smalley [5], Licata [15], Roy [23], and Simoni [24]. Further context-specific contributions to the associated literature include Clarke [8], [10], [11], [12], Clarke and Manning [9], Dufeu [13], and Manning [16], [17], [18].

In Dufeu [13], the author has discussed electroacoustic organology by emphasizing the status of the digital instrument as an object and possibly a tool for the analysis of music including real-time processes. Following theoretical ideas of Battier [2] and practical approaches of Baudouin [3] to software reconstructions as an analytical method, the musical instrument itself is described as a possible workspace for the musicologist. Indeed, the code constituting the instrument may hold important information on the processes, structures, and modes of interaction characterizing the work. Not only can this code be observed to trace the relevant data, it can as well and under certain conditions be rewritten and enhanced to enable measurements of, for instance, the processes ongoing from a gestural input to the sound output. The software may also be a basis for the implementation of ways of representation which may not be needed for the performance itself but prove useful for analytical purposes.

The above writings have made significant contributions to our understanding of the provenance of the associated repertoire, and indeed it is the analytical texts that provide perhaps the greatest insight into the issues identified above. However, so far, they have all faced a common problem, how to present analyses that are based primarily on sonic information in the form of written text and graphics. Crucially, only limited attention has been paid so far to the possibility of modelling the techniques employed using modern software in order to facilitate a better understanding of the creative processes that have underpinned the composition of these works. It is the latter perspective that lies at the heart of the TaCEM project.

2. TaCEM: TECHNOLOGY AND CREATIVITY IN ELECTROACOUSTIC MUSIC

The TaCEM project aims to investigate the relationship between the technical and the creative through detailed investigation of a set of eight Case Studies. These will be studies of specific works that are significant in the way that they have engaged with new technological developments in order to realize innovative creative ideas. The works are being selected to represent, as far as possible, different technical, aesthetic and musical approaches. In date they will range from the 1970s to the present and reflect the rapid changes and developments in technology in this period. For each Case Study the context and background of the work will be studied in detail. This will include a thorough investigation of the historical context of each work, in terms both of its technical and creative context, and an account of the position of the work within the composer's oeuvre.

These contextual investigations for each of the Case Studies will inform the detailed research into each particular work. The technology used for each work will be examined in depth, using as appropriate written records, technical charts, software data, interviews with those involved in creating or using the technology and, where the technology is still extant, use of the system itself. The technical investigations will be carried out in tandem with a detailed musical analysis of each work, looking at the way the musical materials are constructed and shaped and at the musical form and structure.

Such an approach raises a number of significant issues, however. How then do we start examining the technology underlying such works and how do we set about communicating these technological processes to a musical audience – purely in the abstract as data? How do we investigate the relationship between the technology and the musical creativity embodied in a particular work? How do we begin to analyse and examine works of electroacoustic music that often exist primarily as sound (and not as a score on the printed page)? How do we provide readers with the means to explore the sound world of such works, the structure of the music and the ways in which technology has played a part in this? The danger is that the music and sonic experience will get lost in a plethora of technical and analytical data and textual description. Our intention is to ensure that in investigating the technical and analytical in depth it is the musical significance of our findings that is to the fore. The outcome of TaCEM should be of musical relevance and should be communicated in ways that enable readers to engage and interact with our findings aurally and experientially.

This means that the traditional means of communicating research findings may not be sufficient on their own; the printed page is limited in what it can offer as a solution to these challenges. It is not aural, nor is it transient. It is fixed and static and cannot offer the reader the opportunity to hear the music and explore it as sound. It cannot provide an interactive, hands-on experience of what the technology used in the composition was like for the composer to work with musically. TaCEM's solution to these problems is to combine written text on the printed page with interactive aural software: software that provides the reader with tools to explore the sonic world of the composition; software that emulates techniques used in producing the work and therefore gives the reader some idea of the practical and creative options out of which work was formed. The software being developed for TaCEM is an extension of the earlier Interactive Aural Analyses (IAA) produced by Clarke ([8], [10], [12]). A detailed discussion of the ideas behind this approach can be found in Clarke [11] and further information on Interactive Aural Analysis is available at: http://www.hud.ac.uk/research/researchcentres/iaa/

One role of the software in Interactive Aural Analysis is to provide opportunities for the reader to listen deeply into the music, exploring how it is musically structured, but all the time doing this in the medium of sound (supported by text and graphics). Interactive sonograms provide such an opportunity. Unlike printed sonograms it allows users to explore the visual representation aurally, interacting with the graphic display. Growing out of this is the possibility to create aural charts: for example, genealogies, taxonomies, and paradigmatic and other structural charts. Unlike printed charts such aural charts allow readers to *hear* the relationships that are represented not just see them. Another aspect is the creation of technical exercises that facilitate the exploration of the musical potential of the technologies used in a work in a carefully controlled way that does not require any particular technological knowledge. Figure 1 is a screen shot from the earlier Interactive Aural Analysis of Denis Smalley's *Wind Chimes*. It shows an aural genealogy, in which the development of musical material through a series of successive processing techniques can be heard (by clicking the on-screen buttons) as it is described. Superposed on this is another screen, one of a series of technical exercises enabling the reader to recreate approximations of the processes employed in the genealogy. Parameters can be adjusted altering the resultant sound and comparisons be made with the choices made by the composer.

One of the first stages of the TaCEM project has been the development of a set of generic tools (*t*IAA*ls*) built on the same principles of aural interactivity. These facilitate the development of interactive software for the study of any work. The tools will be used in TaCEM in working on the Case Studies and will be extended and refined as a result of this over the next two years. However, an initial set of tools is being released now for general use and the rest of this paper describes the current version of *t*IAA*ls*.

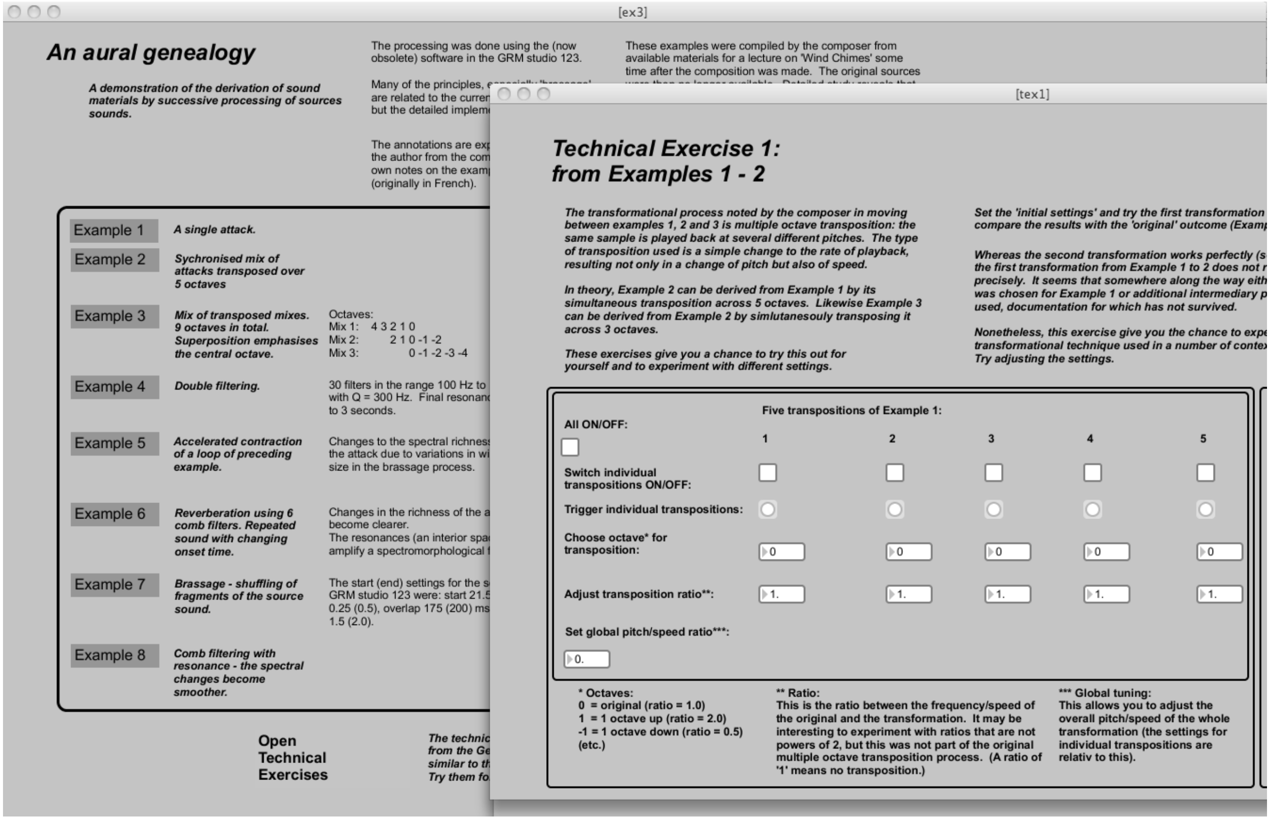

Figure 1. Screenshot from the Interactive Aural Analysis of Denis Smalley's *Wind Chimes*.

3. TOOLS FOR INTERACTIVE AURAL ANALYSIS: *t*IAA*ls*

3.1. Interactive Sonogram

The first major implementation of the *t*IAA*ls* software is an interactive sonogram workspace. Technically beginning from earlier work by Jean-François Charles [7] after patches written by Luke Dubois and included in the MaxMSP standard distribution, the results of an FFT analysis of the source sound, performed in MaxMSP, are stored in Jitter matrices, allowing for further manipulation and visualisation within the Max environment.

The analysis process itself can be performed with the standard range of FFT settings, namely the FFT size, the overlap factor, and various window functions (e.g. Triangle, Hanning or Blackman). The process is operated offline and faster than real time.

The FFT data (magnitudes and phase differences) is stored in sets of fragmented matrices, which can then be dynamically loaded according to the regions used for playback, resynthesis, and visualisation. The fragmentation and dynamic allocation of several matrices enables the importation, study of and navigation of even very long works (up to 1 hour or slightly over for a stereo file).

Although the implementation of a global sonogram proves useful for a first approach of a given work, the software aims at an in-depth investigation of its spectral details. First, a variable bandwidth scrub mode enables the user to explore the sonogram by clicking and dragging directly on it and hearing the corresponding temporal frames over a chosen frequency range. Then, shapes can be drawn over particular time and frequency-bound regions and played back or resynthesized within the defined ranges. This leads to the creation of a collection of sound objects, which can be sonically isolated from the rest of the sonogram. Standard drawing operations are available, such as choosing amongst various drawing methods (rectangles, ellipses, polygons, free shapes, lines or points), moving, or copying selected objects. Additionally, shapes can be created from semi-automated processes: for instance, a horizontal line can be regarded as a fundamental frequency and generate a number of new lines corresponding to its harmonics.

An inspector is implemented so that individual shapes can be given names for later reference, and grouped together so that a set of shapes can itself be defined, investigated, and handled as a single, coherent object.

3.2. From the Sonogram to the Chart

As the general purpose of the software is to offer a framework for musicological analyses, its sonogram exploration features are enhanced with another workspace, the chart maker, in which objects – derived from the sonogram or not – can be represented, handled, and interconnected, both visually and aurally.

The interface between the two workspaces – the sonogram and the chart – is a palette, which the user populates with objects taken from the sonogram, from which he can in turn pick to build sets of objects into the chart (figure 2).

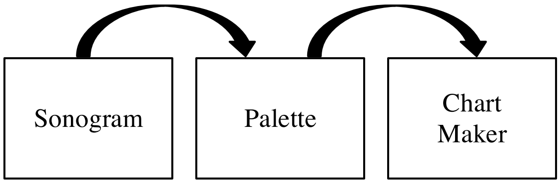

Figure 2. Typical progression of analytical objects between the *t*IAA*ls* workspaces

Unlike sonogram objects, the objects placed on the chart are visually abstract from their sound morphology and are rather a symbolic mode of representation. However, they can as well be selected and played in respect of the interactive aural principle of the software. As the studied corpus within the TaCEM project is by definition heterogeneous, the chart maker is essentially open-ended and provides different ways of arranging the disposition of objects and their connections, and establishing a general organisation. Working from existing charts or building from an empty page, the user can develop and present his analyses by creating and customizing a chart as a table including any number of annotated columns and rows, horizontal and vertical dimensions being open to any relevant parameter. Within this global frame, objects can be drawn and informed with user-defined attributes, allowing for their organisation and presentation according to these attributes. For instance, the topology of objects can be switched from a manually created disposition to a re-arrangement based on the values of quantifiable attributes. Thus, maps can be drawn manually, semi-automatically, or automatically and constitute audio playlists referencing sounds which are not necessarily attached to the teleology of the considered work. As many approaches of one work are possible for one user, several charts can be created within one session and share some of the objects and their properties.

Figure 3 shows a screenshot of the Interactive Sonogram with selected time/frequency regions highlighted (in colour in the original). To the right is the Palette to which certain of the sonogram regions have been exported. Figure 4 shows a detailed view of objects and categories within the Palette.

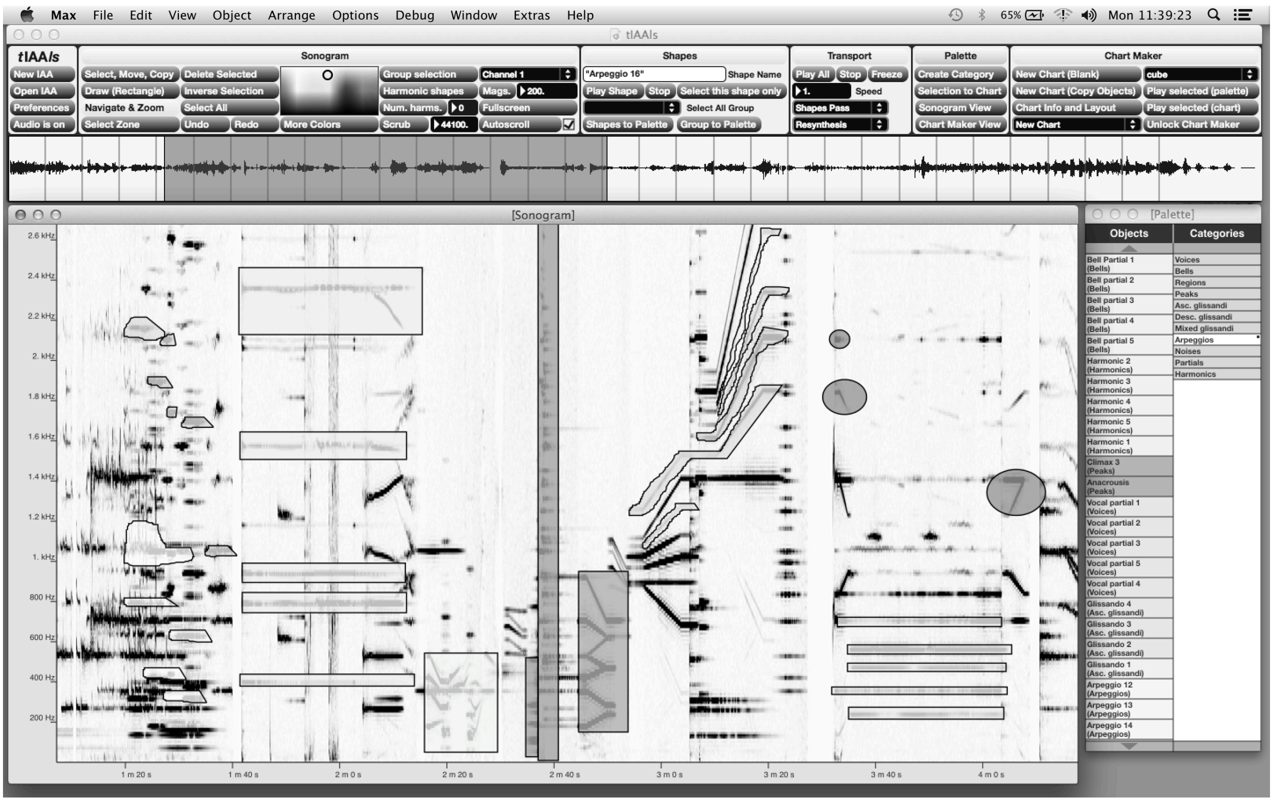

Figure 3. Screenshot from the Interactive Sonogram with Palette

Figure 5 again shows the Palette and to its right the Chart Maker in which a chart is in the process of construction. It shows a number of regions that have been imported as buttons on the chart and additional graphic objects such as connecting lines. (On a large screen it is possible to display the Interactive Sonogram, Palette and Chart Maker all at once, otherwise it is possible to move fluently between displays by selecting 'sonogram' or 'chart' mode).

Working using the Interactive Sonogram, Palette and Chart Maker in combination facilitates the creation of a wide variety of different types of analytical charts which incorporate on-screen buttons that play back specific regions of a pieces, defined in terms of time span and frequency range. In this way many of the problems of referencing extracts from music that exists primarily as sound and not in a score can be overcome.

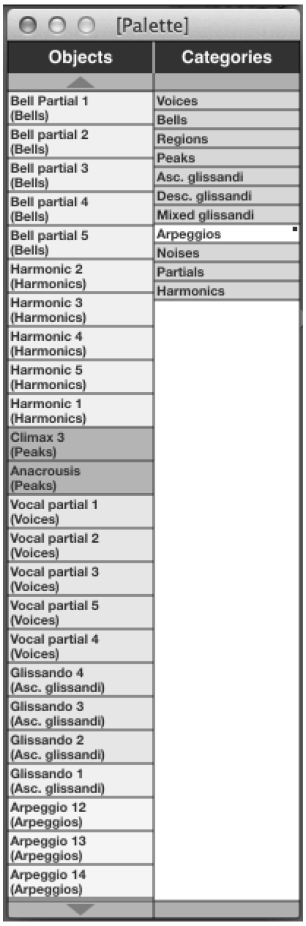

Figure 4. Objects and categories within the Palette

3.3. Further tools

Although the development of the Interactive Sonogram and the associated Chart Maker have been the initial focus of our work, it is envisaged the range of tools will expand as the project progresses, in response to the requirement of particular Case Studies. Some of these are already under development:

Extensions to the sonogram tool help the analyst to explore frequency relationships within a work. A selected passage can be selected and its principle frequency components displayed either in terms of Hertz or annotated as pitch. Selected frequencies (or ranges) can also be used to filter the sound as a way of highlighting events in a particular tessitura or draw attention to the significance of a particular frequency in a passage (e.g. a range of different events occurring at a particular pitch).

Spatialisation is becoming an increasingly important feature in electroacoustic music and often taking on a functional structural role, not simply used decoratively. Another set of tools under development therefore relate to the presentation of information about the spatial positioning of sounds. Deconstructing a stereo (or multi-channel) mix into its spatial components is a complex task, as is the display of multiple channels (sometimes in 3D). Nonetheless our goal is to provide tools that help analysts explore the spatial aspects of a work and to present their findings to their readers.

3.4. Technical Exercises

Another aspect of the approach, as outlined above, is to allow the reader to explore for themselves the techniques used by the composers and to discover something of there creative potential. In this way the reader gains a deeper understanding of the methods used by the composer and of the choices the composer made in producing the work.

Depending on the environment used by the composer, units of audio synthesis, recording, processing and playback can either be simulated or extracted from the programs used by the composers themselves. Once identified, re-implemented and made accessible to the user, such units can be manipulated and explored according to settings which are not necessarily determined according to the composer's final choices: hence, using the software may lead, for the user, to a situation of experimentation which can be assumed as a simulation of the composer's working situation. The technical exercises can be implemented in such a way that what has been defined as an element for sound or musical production can be explored both in an abstract way, and within a more limited (and guided) parametric space which is relevant to the composer's methods and aesthetics.

As an example of a technical exercise from one of the existing IAAs consider the timbral modulation technique used by Jonathan Harvey in *Mortuos Plango*. The analysis software [8] for this work includes technical exercises that permit readers to create their own modulations using the principles and technique adopted by the composer. In this way they can develop first hand experience of the way the composer worked and the choices he faced.

Another example can be found in the earlier-mentioned analysis of Denis Smalley's *Wind Chimes* [10]. Here the software includes an aural taxonomy illustrating how a wide range of sounds, including extended textures, was derived from a single brief attack. A related series of technical exercises enable the reader to re-create an approximation to this succession of processing, choosing alternative parameter settings and discovering through practical experience how material for the work was developed and shaped.

In a similar way to these earlier IAAs, TaCEM will seek to elucidate the range of techniques used by the composers selected for the Case Studies and explore the relationship between techniques and creative practice.

Whether the audio processes present in the works studied through the TaCEM project are attached to the studio or to the stage, the technical exercises built from the different works could constitute a general library, from which the user of the software could experiment different combinations for further experimentation – either simultaneously or chronologically. Also, if some particular processor such as a reverb unit or a module of additive synthesis is present in several works, the possibility to interchange different implementations of a same type of process may lead to useful comparisons between their sound and musical characteristics.

4. CONCLUSIONS

The TaCEM project will investigate the relationship between technological invention and innovative creative practice in electroacoustic music. It will produce a set of Case Studies illustrating some of the ways in which new ways of forming musical works has been enabled by developments in music technology. The study of this interrelationship is important for the development of a full historical and musical understanding of a period of rapid change in electroacoustic music. It is also important for gaining a deeper understanding of particular works and of the factors influencing their formation. Furthermore it is necessary to examine and document the development of this relationship if the electroacoustic community is build on past experience as technology continues to evolve and composers continue to seek out the new creative potential in these developments. The project is a timely one in that many of the earlier technologies have or are becoming obsolete and knowledge and documentation of them and their use is in danger of being permanently lost. It is therefore important to capture this information now and interpret it so that its significance can be preserved.

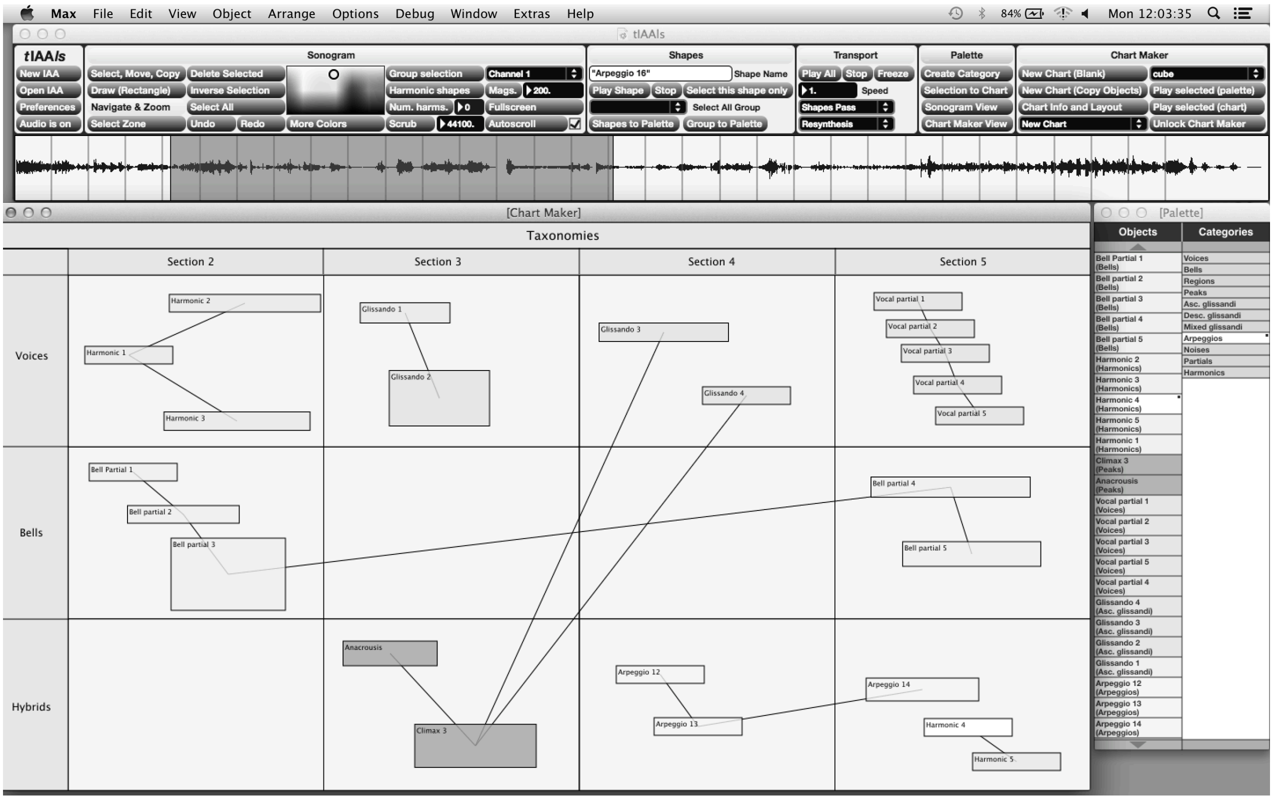

Figure 5. Screenshot of the Palette and Chart Maker

In investigating this topic and in presenting the project's outcomes a significant challenge is to find appropriate means of communicating the findings. Technical aspects need to be presented to a musical readership in ways that demonstrate both the technology and its musical potential. Analytical findings need to be presented in ways that relate the analysis to the music itself, in a context where score are for the most part not relevant. We are also keen that readers should not be limited only to our interpretations but be given the means to explore further for themselves, possibly deriving alternative readings of the music. Our solution is to combine printed text with software that allows the reader to learn through manipulating sound interactively. The early stages of this project have resulted in the first version of generic tools for interactive aural analysis, *t*IAA*ls*, designed to facilitate the development of such software. *t*IAA*ls* enables users to work with any recorded composition and investigate it aurally and interactively by means of the interactive sonogram tool. They can present their findings by creating aural charts to illustrate structural, thematic or other features using selected regions from the sonogram. Aspects of pitch and spatialisation can also be represented using *t*IAA*ls*. The software tools will be refined and expanded as TaCEM develops in response to the analytical challenges of the repertoire being investigated.

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