

# TIMBRAL NOTATION FROM SPECTROGRAMS : NOTATING THE UN-NOTATABLE?

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## ABSTRACT

This paper outlines a research project currently underway in Malaysia that, through spectrography, seeks to find models that might assist in the future development of a timbral notation. Located within the music creation and performance practices of the researchers, the project has elements of interculturality, which both enrich and inform the research. The authors consider the nature of a music score, the explicit and implicit information it carries, and how this impacts on the models being developed. The understandings elicited to date are not only located in music practice, but are underpinned and supported by the theoretical works of a number of theorists. The overall research project is broken down into smaller discrete sub-projects which are discussed, and contextualized in the wider project. The paper includes a discussion of the score as artifact or ‘thing’ the relationships that are implicit within it, and the infinite potential it contains. Other outcomes are suggestive of a possible model of gestural notation which will be a further avenue of research. The paper concludes with suggestions of future research areas following the models of timbral notation being explored in this project.

## 1. INTRODUCTION

This paper is a brief exposé of a Fundamental Research Grant Scheme (FRGS) project, funded by the Malaysian Ministry of Education, being carried out at the Universiti Pendidikan Sultan Idris, Tanjong Malim, Perak in central Peninsular Malaysia – *Spectromorphological Notation - Notating the unNotatable? Modeling a new system of timbral and performance notation for ethnomusicological, musique-mixte and electroacoustic music compositions*. The focus of this fundamental research is broad,

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encompassing a range of intercultural, performance and sonic representation issues; and this report is necessarily of work in progress as the project is evolving clarity of direction and practical application. The project development and structure, research questions, reflections on the nature of the score and the creation of models for timbral representation are discussed.

This research is seeking answers to diverse timbre notation and music representation questions within three sub-projects that focus on, respectively, ethnomusicology, musique-mixte and electroacoustic music. Crucial to the first and second sub-projects is our interest in developing ways of representing timbre that can be understood from both Malaysian and Western perspectives of performance, and provide a live performance functionality. New compositions are being created as frameworks for these investigations that are experimenting with forms of notation that accommodate timbre as an addition to pitch and duration. A software independent means of notating electroacoustic music is a goal of the final sub-project. The project began in mid 2014, and the first and second sub-projects are currently underway. The third sub-project that focuses on electroacoustic notation will conclude in early 2016.

Denis Smalley (1994) begins to define timbre as “the attribution of spectromorphological identity” [1]. He points to the ‘hazardous operation’ of definition, of expanding the assumed notions of timbre based on acoustic sound and the trouble of refining and standardizing responses to such a complex element or identity. Within *Spectromorphological Notation: Notating the Unnotatable?* we are addressing both the acoustic and electroacoustic, aiming to create an investigative continuum that proceeds and informs from one to another. Elements of the study and documentation of the timbral characteristics of both traditional and modern instruments occurring in the initial stages of the research will lead to experimentation with notation and explorations of the relationships of score and performance. In the creation of new works, the transformation of the acoustic sound spectra through

digital signal processing is extending this exploration into the electroacoustic context.

Further areas of exploration include an articulation of the relationship between the sound and context. This relationship is reflected in the scope of our definition of timbre based on Smalley's approach, and making recognition of Lasse Thoresen's assertion that we need to develop a terminology (and lexicon) to describe the "...phenomenology of music in experiential terms" [2]. This phenomenological approach to timbre was initially begun by Schaeffer and then carried forward by Smalley, and between the writings of all three, begins to accommodate the multiplicity of meanings of 'timbre': structural, contextual, analytical, tonal, and sound quality.

Timbral elements in musique-mixte works are central to interpretation and realization in performance, but often include somewhat vague or technology specific indications. The authors' experience as performers (flautist and organist) in the musique-mixte domain has prompted aspects of this study, and provides a practical basis for these explorations. In flute works, for example, timbre changes may be indicated by signs (often extended techniques) or words that can be highly evocative and poetic; the electronics may be indicated by effects or technical instructions such as fader control levels, or a particular form of synthesis. Where acoustic and electronic sounds merge, indications of timbre may become the 'property' of the software or mixing desk – the programmed effect. The authors suggest that a creative collaboration working within a performance environment to recreate the composer's intentions, rather than technical instructions, could be more effectively enabled with semiotically relevant timbral representation. In organ works, timbre is often suggested through assumed knowledge of historical performance practice<sup>1</sup>, or specific stop indications combined with an understanding and knowledge of the instrument for which a piece was composed. In the works for organ and live electronics composed since 1998, the aural and spatial effect of the processing on the overall timbral environment is only 'discovered' in the space after all has been set up. A more specific representation of timbral effect in the score would allow the performers to adapt and optimally develop interpretation and technical set up according to the performance space.

Investigations of timbral descriptions of traditional instruments led us to Ngabut (2003) in *Kenyah Bakung Oral Literature: an Introduction* in which the author describes the odeng talang jaran (or jews harp) from the Borneo Kalimantan region. The description includes detailed descriptions of the instrument's construction (dimension, materials, and decoration), mode of playing,

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<sup>1</sup> e.g. *Organo Pleno* for North German baroque instruments, or the *Tierce en Taille* of the Classical French organ tradition.

social function and many other cultural features, but makes only one reference to the actual sound of the instruments: "The sound produced resembles that of a frog" [3]. Assuming one knows the species of frog being referred to by the author, and what call it is giving, perhaps this is helpful. A motivating factor in this project is to try to find an objective, non-metaphorical process for notating the sound of the frog. Through spectrographic measurement we hope, as far as the visual can represent the aural, to find symbols and images that can communicate sound quality in all its complexity to a literate observer.

Referring to sound quality – its spectral content, sonic identity and recognition of source – Udo Will attests:

"...It remains immensely difficult to 'talk about' them – oral cultures have no music theory. Things seem to be different in literate cultures, though. Through the very invention of writing systems, man has acquired means to cope with the elusiveness of sounds: the transformation from an aural-temporal form into a visual-spatial one. Sounds seem to be tamed and time seems more under control if treated spatially, however, this is only seemingly so because the accomplishments of such a transformation are limited and can at times be deceiving" [4].

Combined with the other informal explorations and considerations these comments became enabling texts to launch this exploration of timbral notation.

Central to the project is the music score itself – what is it, and what relationships the various participants each have with this thing or artifact? One common factor in all our understandings is of the score as an object of potential. The project is generating new questions and raising uncertainties about the nature or ontology of musical scores, as well as the syntactical conventions that exist in different cultures. Our references to Ingold and Foucault support this need for exploration. Kathleen Coessens calls the music score a "coded tool in the arts" and furthermore a score "...is a two-dimensional visual and coded artifact that allows for multiple performances or "resounding processes" by musicians...[and merging] the visual and the musical, the fixed and the dynamic, space and time" [5]. These are well-understood concepts, which confirm our (Western) cultural understandings of the ontology of a musical score. The project is also grounded in non-Western, oral-based paradigms: what does the score (as artifact or 'thing') mean within these cultures?

This project will explore the creation of models for the timbral and performance notation of music, incorporating both acoustic and electronic sound sources initially working with traditional instruments, then within contemporary Western Art Music research through the creation and performance of new musique-mixte and electroacoustic

compositions using these possible models and systems.”<sup>2</sup> The overall project consists of two conferences, bookending three sub-projects that, taken together, provide opportunities to envision the possibilities and value of timbral notation, aiming to create models from which to develop practical performance based scores, which are of value to participants in each area. The project’s co-researchers are practitioners in ethnomusicology, acoustic, electroacoustic and musique-mixte as academics, creators and performers.

Already queries are arising regarding our ontological understandings of what comprises a score, and, how it functions and communicates, particularly over time. As Marc Battier, who presented at the project’s opening conference in June 2014, observed

“... the preservation of a [musical] score is a big issue, and has implications for notation”.

A score must be in a form which can be understood and read over long historical time frames, and in a form which allows long term archival storage and retrieval.

## 2. THE PROJECT

Research questions have evolved for each sub-project based on the following investigative parameters:

1. Can an intuitive notation system for electroacoustic music be developed from spectral analysis and spectromorphological representation?

2. What are the elements that composers, musicologists, performers require from a notation system and how can these be represented?

4. Can spectrographic analysis and software be used to provide a method for defining and identifying unique qualities of Malaysian indigenous instruments?

5. Can this information be used to ‘describe’ and notate the specific individuality of sounds, materials and performance methods in ways that expand the range and musical vocabulary of the ethnomusicologist?

6. What parameters of analysis can be defined to provide useful and universally ‘understood’ symbols using spectrographic softwares?

### 2.1 Issues Arising – a problem statement?

This research project is adopting a multi-faceted approach to exploring the possibilities of creating scores that describe and notate timbre and which might eventually come to some degree of functionality. The practice of the various co-researchers and the paradigm of their experience provide multiple sites and contexts for the research. These paradigms also encompass the realms of traditional and non-Western music performance, acoustic

Western art music performance and music creation, and the environments of electroacoustic and musique-mixte. The range of modes of transmission of music and musical ideas is equally broad – being passed from one generation to the next, from creator to acoustic and electronic performance. Further, it encompasses oral and rote learning, common notation scores to software, and works dependent on the software that was used to create them as a way of preserving them. In these notation systems, with the exception of the electroacoustic performance software, there is no way of describing the quality of imagined sound – our ‘frog call’.

What is notation and what is a score? Both are separate objects, but intertwined with cultural, ontological and semiotic inferences, all of which impact the artifact we call the score. In Western art music, a score is an artifact (often on paper, but perhaps in other media or in soft copy) used to communicate the musical ideas of the score’s creator to the performer and, with an assumption of the performer’s active creative input, to the listener. In traditional Malaysian music, we can describe the score as, more commonly, a series of memories and traditions, perhaps articulated mnemonically but not, until quite recently, written down. In this traditional music, pitch and rhythmic inaccuracies that arise from the use of common practice notation are considerable but, except that they are measured in spectrograms, beyond the scope of this presentation.

Our conception of the score as ‘thing’ connects the meaning of the score to Ingold’s theory of ‘correspondence’ [6] drawing us to a significant difference between a score and a spectrogram – the spectrogram is an historical document – ‘this sound **was** like this’. We can measure the sound that happened in this way, and read it as such. Contrarily, a music score (with its multiplicity of meanings) is a ‘thing’ of possibility [7]. It is a creator/composer’s conception of some sounds that, if recreated in this or that way by the performer, has the possibility of generating non-verbal ideas and concepts in the minds of the performers and listeners. Manuella Blackburn suggests a new way of using the spectrogram to help generate compositional ideas in her exploration of the potential of spectromorphology and its associated language as a process for composition” [8]. She writes,

“... spectromorphology can be approached from an alternate angle that views the vocabulary as the informer upon sound material choice and creation. In this reversal, vocabulary no longer functions descriptively; instead the vocabulary precedes the composition, directing the path the composer takes within a piece. This new application is an attempt at systemization and an effort to (partly) remedy the seemingly endless choice of possibilities we are faced with when beginning a new work” [8].

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<sup>2</sup> Blackburn (2014),  
<http://spectronotation.ups.edu.my>

Blackburn's suggestion of the use of spectromorphology as a compositional tool suggests the possibility of changing the historic nature of the spectrogram into one of potential.

Other researchers have struggled with many of the issues that have arisen in our individual and collective deliberations. Rob Weale<sup>3</sup> in the EARS Glossary of terms, Spectromorphology notes there is both interdependence and dynamism in the word *spectromorphology*. Whilst not reducing the historic quality of a spectrogram, this is helpful to this project for the conceptual development of a timbral score, as he describes spectromorphology as a tool for "describing and analyzing listening experience." He continues: "The two parts of the term refer to the interaction between sound spectra (spectro-) and the ways they change and are shaped through time (-morphology). The spectro- cannot exist without the -morphology and vice versa: something has to be shaped, and a shape must have sonic content" [9]. So there is the possibility of dynamism in a spectral score.

The score, if incorporating some form of spectrography, will probably contain graphics that also have semiotic qualities. Martin Herchenröder, in discussing the score of Ligeti's graphic score of the organ work *Volumina*, adds musical and performative gesture to the inherent quality of a score as he attests

"... it is a coherent system of signs [semiotics], whose details can all be translated into musical patterns. A look at the third page of the score of *Volumina* illustrates the cluster through visual analogy. The horizontal dimension corresponds to the flowing of time: The time sequence of musical events (according to the reading habits of the western world) is a left-right succession of notes. Thus, in principle, each event is fixed in time - the new cluster in the right hand as posits an approximately after 17 seconds, after another 10 seconds of complete, another 4 seconds later" [10].

It has been argued that this gestural quality is also semiotic and tied to the sonic gesture. The 'left-right' succession of symbols and their vertical location on the page indicating pitch (high/low) also has sonic inferences that offer potential for developing elements of performance notation [11]. Treating the score of *Volumina* as an *xy* graph for time and pitch, we can see that the evident gestures and sonic shapes are potentially useful in timbral notation. It is an area where the left-right and vertical associations could be helpful in 'notating' gestures, which, by their musical outcomes are also timbral. O'Callaghan and Eigenfeldt have demonstrated how spectral density can be implied within acoustic and musique-mixte compositions [12]. Combining colour, which can be ascribed various meanings, and graphic, gestural

notation as outlined above is proving a rich potential model in creating gestural notation in the musique-mixte performance environment. This model is described in greater detail below.

## 2.2 The Sub-Projects

This research project is structured with three principal sub-projects, which, though operating in parallel, allow a sequential development of models and notational ideas. The applications used to create the spectrographs used in this project are Pierre Couprie's eAnalysis [13] and Sonic Visualiser [14].

### 2.2.1 Project 1 Ethnomusicology Project

The ethnomusicological sub-project, using spectrograms provides traditional music professionals with an objective understanding of the nature of the sound quality of specific instruments, and the musical or ritual context in which they prefer to use it. As a music tradition that is oral, transmission of music and pieces is achieved by rote, repetition, and aural memory. This research is not an attempt to standardize the sound of instruments. Instead, it adds to the knowledge of the Wayan Kulit artform, which is presently in a difficult phase. In parts of Malaysia, including one of its places of origin, Kelantan, it is banned. University programmes, such as those maintained by UPSI, are important in the continued artistic viability and vibrancy of Wayan Kulit (Director of Kelantan Arts and Culture Museum, personal communication in Penny/Blackburn FRGS *The Imaginary Space*, 2014). This spectrographic process is demonstrating the value of profiling instruments, allowing makers objective knowledge of the range of sounds preferred by the musicians who play and perform.

The first process within this sub-project has been to record the sound of, then create spectrograms of, traditional Malaysian *Wayan Kulit* shadow puppet music theatre. UPSI maintains a group of resident musicians specializing in this musical form. In performance, a group of four to six musicians and the master puppeteer are all located out of sight behind a large translucent screen, which is the stage for the shadow puppets. Our study includes an exploration or profiling of sounds preferred by professional traditional musicians in certain percussion instruments.

The orchestra of the *Wayan Kulit Siam* (as found in Kelantan, Malaysia) consists of percussion instruments including a pair of double-headed drums – gendang, a pair of single-headed goblet-shaped drums – gedumbak, a pair of vertically standing drums (gedug) hit with beaters, hand small cymbals – kesi, a pair of inverted gongs – canang, and, a pair of hanging knobbed gongs – tetawak. Melodic instruments include the serunai (a double-reed instrument, similar to the shawm) and a three-string spike

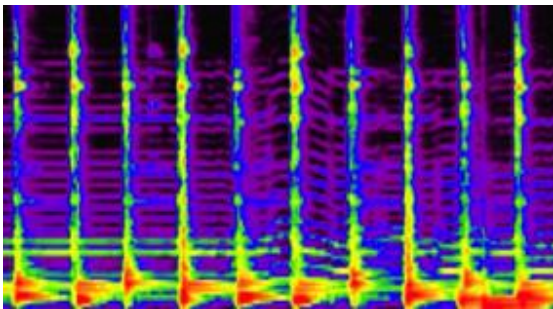
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<sup>3</sup> [www.ears.dmu.ac.uk/spip.php?rubrique28](http://www.ears.dmu.ac.uk/spip.php?rubrique28)



**Figure 1.** Testing the Gedumbak

bowed instrument – rebab. The instruments, while individually important, gain their true significance in an ensemble and dramatic context. When making recordings of various instruments, initially it seemed sensible to just record the instrument in a dry unadorned environment. However, in order for the *Wayang Kulit* leader (Pak Hussain) to make his assessments, the recordings that ended up being made were of the whole group playing



**Figure 2.** Spectrogram of Wayang Kulit ensemble –segment of recording focused on Gedumbak with strong onset feature.

while testing out the Gedumbak for different dramatic environments. Selecting instruments for their suitability in a given drama (normally, the stories are drawn from thirty or so traditional stories) means that the players are more interested in their collective role than the individual, so the recordings were made to reflect this. The gedumbak was close miked, and the rest of the ensemble sound was allowed to spill into these microphones. The longer red lines in the last section of this short segment show the moment when the serunai enters.

Why, for example, is one pair of Gedumbak preferred in one piece over another? Spectrograms can show a profile of the sound, which may then be attached to a musical (or in the case of *Wayang Kulit*) dramatic context. Spectrograms further show us that by using different modes of playing, different timbral qualities can be emphasized in the same instrument – brighter or more mellow and so on. Co-researcher, Mohd. Hassan Abdullah has pointed out that mnemonic forms of teaching and communicating musical content in Malaysian traditional music also imply different timbral and gestural modes of playing. So, we ask the question, can this content be

given a visual (spectrographic) or written form, and applied in the other projects?

A second strand in this project investigates a ‘Western’ facet – the creation of a recorded catalogue of extended flute performance techniques, using a concert flute, which have been spectrographed and analysed for their characteristics. These characteristics are being extracted for the development of a form of spectral representation that can be adapted for use in common notation scores, particularly for acoustic instruments. This strand has been productive, opening ideas and knowledge that leads into the second sub-project, combining acoustic and electroacoustic musical contexts in new compositions.

### 2.2.2 Project 2 *Musique Mixte* project

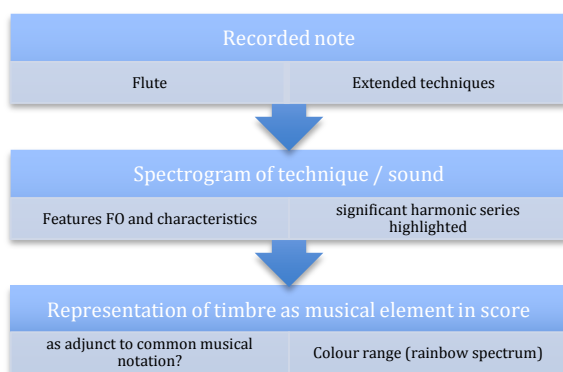
The musical score as semiotic medium can be understood as an “infinite substance” [15] that activates the musician’s ability to imagine and translate notation into a temporal unfolding of new knowledge and experience. As we look towards extending performance practices into new conceptual contexts and relationships, new paradigms that reflect and drive new expressions and activities evolve. Timbral notation as a context of change motivates explorations of shifting performative relationships, new ways of thinking and performing, and a reconceptualization of the score/performer relationship.

This part of the project will create models for spectrographic notation as performance scores. Analyses of notation, timbre and organology associated with chosen instruments and electronics (*musique mixte*) will be undertaken to develop a framework for investigating spectrographic analyses, evaluations and outcomes. New works will generate performance analyses through phenomenologically based studies, following the sound spectrum and performer responses to new musical works.

We question the role of the score as mediator between mind and sound [16]. What information is conveyed through spectral timbre notation? What are the semiotic implications of sound codification? Is the information rigid, or a point of departure for the performer? A performer’s notation needs clarity and embedded knowledge or information that directly communicates to them – that is clear, readable, interpretable, and informative of what the music is about. The multiple layers of a spectrograph emit different levels of information, multiple meanings, different streams of representation – all systems that require understanding and evaluations of the relations of the score. What can a performer expect – information of spectral density? Aesthetically, a spectrograph is a beautiful object – but just how effective and informative is it as timbral notation for the performer? Is it instructional, or suggestive, gestural, strictly coded or freely interpretable? Can a spectrograph be as revealing or evocative as a beautifully notated score? Can it evoke spatialities, mem-

ories, or sonic energies? What is the need for this as notation?

Investigating the recordings and single frame spectrographs of the Western flute extended techniques will allow us to experiment with the flautist to see how effective this is in the re-creation of timbres. The form of timbral representation on which we will focus does not consider fundamental pitches or duration, rather an emphasis of specific overtones. Pitch and duration are indicated using common musical notation. As a catalogue of sounds and acoustic performance techniques, the spectrographic series (see Figure 3) as a research process model provides some ways forward to link timbral representations to scores in a musique-mixte environment.



**Figure 3.** Process of model development from Flute Catalogue of extended techniques

According to Bhalke et al. [17], a single frame of a spectrograph contains information including:

- (i). Fundamental Frequency;
- (ii). Harmonic components;
- (iii). An indication of the relative amplitude of the harmonic components;
- (iv). Spectral Centroid.

Can the composer say to an instrumentalist “play your instrument to reproduce this quality of sound,” indicating their musical ideas through spectrographic information? It is our sense that such compositional detail potentially denies certain instrumental ontologies. In art music, the instrumentalist brings many personal and musical contributions to the performance outcome – what we might loosely define as ‘interpretation’.

Yolande Harris argues that sound “binds people together in space in a contextual manner” [18]. This concept of the score as relationship – between performer and notation, between composer and performer, between memories, communications, live sound, recorded sound, gesture, or cultural practices – interrogates and challenges our experience of performative modes and conventions. These are relations and ecologies that can be examined through concepts of heterotopia (Foucault), contexts of understanding (Gadamer) and correspondences (Ingold).

Can a circle can be drawn around the score as space, and the spectrograph act as facilitator and activator of that space? In a recent study of intercultural music performance in Malaysia<sup>4</sup>, heterotopia was articulated through the performative lens, the performance as a context for understanding artistic realisation of intercultural knowledge and experience. This space was posited as an ecology: a set of relationships, the music, the performance, a symbiosis of elements of the cultures, collaborations and connections that occur [19].

Digital media tends to handle music as encoded physical energy, while the human way of dealing with music is based on beliefs, intentions, interpretations, experience, evaluations, and significations [20], but the exploration of timbral notational elements and relations might activate questioning and re-assessment of values; the search of microstructures might lead to a search for sonic essences and deeper self understandings; new dimensions evolve, new ways of thinking and living (performing) result. These questions engage us with discovering the meaning of the music as new dimensions of musical practice open up.

### 2.2.3 Two models arising from Sub-Project 2?

Limiting the new content of notation to timbral qualities (and for now limiting its measurement to the ‘single frame’ timbre information outlined above Bhalke et al), the research teams are sensing that the information contained in a spectrogram is useful in determining the timbral quality of a sound at a given moment and dynamically over time. However, the uniform colour response of spectrographic software means the strongest elements of tone are always brightest and use fixed colour ranges. The spectrogram responds to relative prominence of tone with the same colour spectrum. To ask a performer to play a green or red sound on this basis is, therefore, meaningless. However we if (for example) ask a player to make a sound with the first and second harmonics (octave and fifth above the FO) emphasized (giving the tone a somewhat nasal quality), it could be indicated above common music notation in the form of, perhaps, a rainbow colour grid (i.e. red, orange, yellow, green, blue, indigo, and violet) related to the first seven frequencies of the harmonic series. Retaining common music notation, means that the target note (FO) would be black. An instrumentalist would need to acquire knowledge of the possible harmonic series for their instrument, and the instrumental technique required to produce such combinations of sound. Timbre indications could then be read as coloured dashes above musical phrases or individual

<sup>4</sup> *The Imaginary Space: Developing models for an emergent Malaysian/Western electroacoustic music* (2012-14). Fundamental Research Grant Scheme, Ministry of Education, Malaysia.

notes. This approach allows the retention of score relationships and its potential quality while providing the composer with a means of specifying timbral quality within their score.

Adapting this approach using graphic notation could include the dynamic quality of the spectrogram, which can include indications of duration, pitch, relative amplitude and the ASDR envelope. These could be incorporated into a form of notation that may resemble a colourised version of, for example, Ligeti's score of *Volumina*. The representation of music in this form might also be readable as a type of gestural notation, of pertinence to software instrumental performance, though this is a process currently being examined in our pieces. This approach must be considered only a starting point – a model for investigation.

#### 2.2.4 Electroacoustic Music Project

The third sub-project is an exploration of the use of spectrograms to create a form of timbral notation, which could be used in electroacoustic compositions as a way of preserving the music independently of the software/hardware used to create them. As noted earlier, finding a mode of preserving a score is a major concern. One possible approach, and which culturally locates this research in South East Asia, is an exploration of the potential of adapting 'Uthmani' notation used in Qurannic recitation as a form of timbral or gestural notation. This exploration is not based around content, but is focussed on the context of how 'Uthmani' is used, written and recited 'through sound'. Hasnizam Wahid from UniMAS – Sarawak, and one of Malaysia's leading electroacoustic composers, is particularly focusing on this area. This project is yet to begin as the first two projects are creating many of the fundamental bases that must first be established. It is anticipated that this detailed research will begin in July 2015, continuing until the end of the year.

### 3. FUTURE PATHWAYS

Having identified some of the possible pathways for finding models of spectrographic or timbral representation in a score, this section suggests directions that this research might follow. They are not presented in order of preference or significance, but remain possibilities that address the outcomes of the research so far, outcomes yet to be realised and issues and meeting challenges so far identified.

If one were to wish for a software, and we will look at supporting software development in later research phases, it would be along the lines of a reverse-action of spectrographic software – i.e. a program such as eAnalysis currently takes an audio file and from it creates an image: is

it possible to take that spectrogram and create an audio file to 'recreate' the sounds of the original file.

A simple outcome (though conceptually complex) would be to take some of the various software packages and have them sonify a spectrogram. Some simple experimentation with existing software packages, using Audio Paint [21] have been undertaken. The results using these are not promising. The concept might be helpful in realizing electroacoustic scores without access to the software used to create it. There are many issues and concerns at this juncture, which make this process one for a separate and continuing research project, developing and evolving models that might be forthcoming from this project. Some of the problems lie in impact of the space in which a sound is being projected and its influence on timbre. For multichannel electroacoustic works there is the question of how one will 'record' the original sound – as separate channels with individual spectrograms, which might then be reconstructed? Combined with the possibilities of the models outlined above, and acknowledging the many complexities, is a worthy goal to gain the ability to recreate fixed works long after the original software or hardware that created it is lost.

### 4. CONCLUSIONS

Our research to date seems to allow an optimistic attitude that spectrograms can be used as the basis of a timbral notation. The cultural significance of the score as an artifact and the relationships it implies – from composer/creator to performer to listener – must be accounted for in any new notation practices that develop to allow for specific timbral elements demanded by the composer. Our suggestion within instrumental contexts of a rainbow spectrum adds a new layer of complexity to the score, but we assert this enriches the various relationships established within the score's environs. The model of gestural notation appears to have the potential to provide a technically workable yet semiotically rich notational ontology, which will provide the basis for investigation in the electroacoustic/acousmatic context. In this sub-project, it is predicted that what Smalley describes as the discrimination of "...the incidental from the functional" [22] will be major areas of consideration. In many ways, findings relating to this project are the posing of more questions. Nevertheless, some elements of what will develop into models of timbral notation are suggesting themselves to the research group.

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