Spectromorphological Notation-Notating the unNotatable? – Modelling a new system of timbral and performance notation for ethnomusicological, *musique-mixte* and electroacoustic music compositions.

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Abstract

This project, *Spectromorphological Notation-Notating the unNotatable? – Modelling a new system of timbral and performance notation for ethnomusicological, musique-mixte and electroacoustic music compositions,* is an exploration of the potential of the creation of new models of musical notation that focus on timbre. Supported by the Malaysian Ministry of Higher Education (MOHE) and Sultan Idris Education University (SIEU), the researchers have developed several models which have the potential to be further developed into functional, semiotically rich notations of timbre. An initial issue in the research was the establishment of a definition of the elements of timbre. This involved a major literature review of the philosophical and ontological writings on this topic, and deciding which components of timbre could be expressed through spectrograms - the chosen vehicle for our study. The project connected to several related research projects and we were joined by two French researchers (Prof Marc Battier and Prof Pierre Couprie) from the University of Paris, France. Built around 3 major sub-projects and bookended by Symposia held at SIEU, three models have been developed. The sub-projects are *Notating timbre in Traditional Malaysian Music - an ethnographic approach, Developing Timbral Notation for Performance* and *Notating the Timbre of Electroacoustic Scores.* The first two sub-projects yielded models of notation that, in the view of the researchers, offer considerable potential for further development. These notation forms are based around the colours with which spectrograms populate their visualisation of harmonics (overtone pitches) and a novel form of notation that is based on the Islamic 'Uthmani' Recitations. In the third sub-project, *Notating the Timbre of Electroacoustic Scores,* it became apparent that, though spectrograms could be an important component of a timbral notation for this genre, the complexity of the music, and its cross-over of technology, space, and sound source requires a notation system that reflects all the possible elements. It was felt that the scope of this facet of our modelling was beyond the self-imposed scope of the project. Two compositions have been prototyped in development, both in the second sub-project *Developing Timbral Notation for performance*. Both offer scope for development to a stage where performance is possible and, in such development, will solidify the concepts and processes already modelled from this project.

Abstrak

Projek ini, Spectromorphological Notasi-Notating yang unNotatable? - Pemodelan sistem baru timbral dan prestasi notasi untuk ethnomusicological, musique-Mix dan muzik electroacoustic komposisi, adalah satu penerokaan potensi penciptaan model baru notasi muzik yang memberi tumpuan kepada timbre. Disokong oleh Kementerian Pengajian Tinggi Malaysia (KPT) dan Universiti Pendidikan Sultan Idris (Sieu), para penyelidik telah membangunkan beberapa model yang mempunyai potensi untuk dikembangkan menjadi berfungsi, notasi semiotically kaya dengan timbre. Isu awal dalam penyelidikan ialah penubuhan definisi elemen timbre. Ini melibatkan kajian literatur utama tulisan-tulisan falsafah dan ontologi mengenai topik ini, dan memutuskan komponen timbre boleh dinyatakan melalui spectrograms - kenderaan yang dipilih untuk kajian kita. Projek ini mempunyai kaitan dengan beberapa projek penyelidikan yang berkaitan dan kami disertai oleh dua penyelidik Perancis (Prof Marc Battier dan Prof Pierre Couprie) dari University of Paris, Perancis. Dibina sekitar 3 sub-projek utama dan bookended oleh Symposia diadakan di Sieu, tiga model telah dibangunkan. Sub-projek Notating timbre dalam Malaysian Muzik Tradisional - pendekatan etnografi, Membangunkan Timbral Notasi untuk Prestasi dan Notating yang Timbre daripada Electroacoustic Markah. Yang pertama dua sub-projek menghasilkan model notasi itu, dalam pandangan para penyelidik, menawarkan potensi besar untuk pembangunan selanjutnya. Bentuk-bentuk notasi berdasarkan sekitar warna dengan yang spectrograms mengisi visualisasi mereka harmonik (nada lampau padang) dan satu bentuk novel notasi yang berdasarkan '*Uthmani*' Islam tilawah. Dalam sub-projek ketiga, Notating yang Timbre daripada Electroacoustic Scores, ia menjadi jelas bahawa, walaupun spectrograms boleh menjadi satu komponen penting dalam notasi timbral untuk genre ini, kerumitan muzik, dan cross-over iaitu teknologi, ruang, dan sumber bunyi memerlukan sistem notasi yang mencerminkan semua unsur-unsur yang mungkin. Ia merasakan bahawa skop aspek ini pemodelan kami adalah di luar skop diri yang dikenakan projek. Dua komposisi telah diprototaip dalam pembangunan, baik dalam sub-projek kedua Membangunkan Timbral Notasi untuk prestasi. Kedua-duanya menawarkan skop untuk pembangunan ke peringkat di mana prestasi adalah mungkin dan, dalam perkembangan itu, akan mengukuhkan konsep dan proses telah dimodelkan daripada projek ini.

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Sekirany berkumpulan

Saya mengaku Laporan Ikhir Penyelidikan ini adalah hasil kajian kami Dr Andrew Stewart Blackburn kecuali nukilan dan ringkasan yang setiap satunya saya jelaskan sunbernya.

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Chapter 1: Introduction

1.1 Introductory comments

This research project aims to create a model for a timbral notation system that addresses a need for usability in performance, analysis, and providing a clarity of communication of timbral elements that exist in music and longevity of technological scores. The project focuses on this issue from the different perspectives of ethnomusicologists, performative and electroacoustic music genre, and several models of timbral notation have been proposed.

Existing notation systems allow musical ideas to be communicated across centuries and geographical locations. Notation and analysis of timbre, however, hardly exists. This results in a lack of quantifiable ethnomusicological knowledge of traditional musical sound, and the inability to universally archive electroacoustic music due to the demise and obsolescence of software, hardware and electronic storage systems. In a

The project has utilised spectography to analyse timbre in an investigation of the organology and ontology of sounds. The notational needs of music practitioners, composers and researchers have been considered, and we have proposed several models of notation. This project is funded through the Fundamental Research Grant Scheme of the Malaysian Ministry of Higher Education (MOHE) and so we have limited our outcomes to model creation. The authors believe the proposed models, with continuing development and research, have the potential to become useful notational tools for each of the target audiences.

Three sub-projects have mapped and spectographed traditional Malaysian instruments, Western acoustic instruments, electroacoustic music, and explored the performance ontologies of these. The research methodological approach was grounded in the practice and needs of the participating practitioners – ethnographers, performers, technologists and composers.

Contemporary Western Art and Traditional music notation is (usually) linked to an analysis and the semiotic representation of the musical elements of rhythm and horizontal and vertical pitch (melody and harmony) using stave and stick notation. Precise pitch indications are ‘rounded out’ into the twelve semitones of this system, unable to accommodate precise subtleties of pitch inherent in all music traditions. Further musical parameters such as, articulation (Attack, Decay and Release), and dynamics (volume or intensity) are loosely indicated through the use of staccato or phrase markings (articulations) or dynamic marks (forte, piano or crescendo/ diminuendo etc). Representation of other significant musical elements such as tone and colour (timbre) are limited to instrumental naming or specific performance directions (eg sul ponticello - play near the bridge - for string instruments). This lack, along with difficulties of definition and understanding of timbre are increasingly recognized within both new music and traditional music fields.

1.2 Problem statement

This project investigates the creation of models which have potential for the timbral and performance notation of music, incorporating both acoustic and electronic sound sources, that notates greater content detail of the musical elements noted above. Of significance for Malaysia, and ethnomusicologists working in this country, has been the explanation of the use of spectrograms as a tool which is inclusive of most musical elements should lead to a greater understanding of the individual and unique spectral and tuning characteristics of traditional Malaysian instruments. These methods have been applied to instruments such as gedombak and instruments of Orkestra Tradisional Malaysia. Knowledge, concepts, and experience gained from creating and interpreting spectrograms of the traditional instruments was later applied to the Contemporary Western Art Music research models.

This issue unites the most avant-garde and most ancient music for study and research of how the researcher or composer might give an accurate account and description of the timbre of the sounds they are describing (in the case of the ethnomusicologist) or imagining and creating (in the case of the electro-acoustic, musique-mixte composer) Over many hundreds of years, musical notation (stave and stick, graphic, tabulature and similar) have met these needs when defining duration, pitch and instrumentation, but in describing the ontology of the sound, musicologists and composers resort to words and text devices such as metaphor. Today, there are Malaysian composers who incorporate elements of colour within their scores – particularly within electroacoustic scores (for example, Valerie Ross) or use other forms of graphic notation. The role of the colours appears to have some timbral implications but it has been observed that there is little consistency between composers. Such inconsistency leads to variation in interpretation of the notation itself. Within a spectrogram, there are known and understood colours relating to the relative amplitude (or volume) within a sound structure. By adopting a methodical perspective to the mapping and interpretation of the spectrogram, we can establish a semiotic understanding of the colour ranges encountered. By working with experienced and established composers, performers, and ethnomusicologists, and establishing their needs of a timbral notation system, the models will allow the definition of parameters that can become software independent, though created by developing new softwares.

1.3 Purpose of research; aims and objectives

This study embarked on the following objectives:

1) Using spectrography to investigate the organology and ontology of musical sounds and their semiotic representation focussing on selected Malaysian traditional instruments, selected Western musical instruments, and electroacoustic music.

2) To assess the needs of practitioners (ethnomusicologists, performers, composers and creators) required of a timbral and performance notation system, and to model possible systems for continuing development

3) To investigate how a timbral and performance notation system might be developed, and applied in academic ethnographic, applied musique-mixte and electroacoustic environments.

4) Through symposiums, to make recommendations, based on the findings of the sub-projects and the participants, for a model of a timbral and performance notation system which can be read independently of music creation software.

Within Spectromorphological Notation: Notating the Un-notatable? 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.

1.3.1 Software:

A number of software packages were utilised to visualise the sound characteristics of each instrument, specifically Sonic Visualiser[1] and Pierre Couprie's eAnalysis[2] From the resulting spectrograms, the researchers then considered how the information revealed by the spectrograms may inform our knowledge of the sound, and how this may be applied in the performance of ethnomusicological works.

As many of our arguments and research outcomes depend on both audio and visual imaging to be understood, the ancillary website provides an opportunity to access this information. This website is http://spectronotation.weebly.com

[1] http://www.sonicvisualiser.org/

[2] http://logiciels.pierrecouprie.fr

Chapter 2: Literature Review

This literature review begins with some definitions of major concepts arising in this research. A brief contextualization is given through a synopsis of the history of timbre and notation studies and practices encompassing techniques, compositions, composers, acoustic and electronic music, and applications of these questions in performance and academia. Aspects of current thinking and research directions are then presented, followed by an outline of the applications of spectography and software, and the perceived limitations of digital techniques to date. Performative questions are raised as a continuum of investigations of practice and theory, as well as the cultural contexts and significances of this work.

2.1. Definitions

Timbre

Timbre has generally been used without any great consistency of meaning, to refer very loosely to the 'colour' of a sound. It has often been treated as a discrete 'parameter' of sound, along with other facets such as frequency, duration and pitch.[3] Creative practice and research in electroacoustic music have revealed the unsatisfactory nature of this imprecision, and opened up the notion to a much more complex and protean situation, where timbre exists in fragile relationships and continua with frequency, spectral content, sonic identity, and source recognition. This leads to a situation where, in many musical examples, it is hard to separate timbre from the overall musical discourse.

Understanding the meaning of timbre is essential before its usefulness as a descriptor, and the elements which together comprise it, can be discussed. Although Denis Smalley's writings and theories on timbre and spectromorphology pertain to acousmatic music, we have found that they are effective and helpful in the description of timbre, and allow us to consider the contextual and cultural environments from which we are creating our spectrograms and assessments. Smalley (1994) begins to define timbre as "the attribution of spectromorphological identity". 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. Smalley (1986) divides spectromorphology into its temporal unfolding (the changes in a sound over time) and the shaping of sound spectra. He describes timbre as "a general, sonic physiognomy whose spectromorphological ensemble permits the attribution of an identity" (1994). He gives the following four definitions (Hirst, 2003):

1. "... that attribute of auditory sensation in terms of which a listener can judge that two sounds similarly presented and having the same loudness and pitch are dissimilar" (Smalley, 1994, p.36).

2. "Timbre is an extension of harmony, or vice versa. The composer uses spectral analysis as a basis for conceptualising the relationship between pitch and sound

[3] www.ears.dmu.ac.uk/spip.php?rubrique117

qualities, and attempts to negotiate fluent border crossings between the two." (Smalley, 1994, p.36)

3. "Through research and through electroacoustic compositional experience we have become very aware of the multiple variables which determine timbral identity. And we have also become concerned to differentiate what is acoustically present in sounds from what is psychoacoustically pertinent.'

4. " The everyday language of qualitative description is accessible to everyone. It is closely allied to the "matter" of sound. Terms like bright/dull, compact/spread, hollow, dense..." (Smalley, 1994, p.36).

Timbre has been further described as an "ensemble of the parameters of pitch, duration, amplitude, spectral components, dynamic evolution, etc. which determine the colour of a sound". (Dictionnaire des arts médiatiques.[4] David Hirst (2003) observes that the French word itself – timbre – identifies the object that creates the sound. He proposes that the German Klangfarbenmelodie – sound colour– is more abstract, and so has validity in many contexts, including this. However, for the sake of general consistency we shall continue to use the conventional terminology – timbre.

Spectrogram (Spectrography)

A sonogram, sonograph, or spectrogram is a well-known spectrum display technique in research, having been used for decades to analyse speech. It shows an overview of the spectrum of several seconds of sound. Viewable features include the onset of notes or phonemes, formant peaks and major transitions. The sonogram representation has also been employed as an interface for spectrum editing. A sonogram represents a sound as a two-dimensional display of time versus "frequency+amplitude". The vertical depicts frequency (higher frequencies are higher up in the diagram) and shades of gray indicate the amplitude, with dark shades indicating greater intensity (Roads, 1996).[5]

Spectromorphology

Spectromorphology is an approach to sound materials and musical structures that concentrates on the spectrum of available pitches and their shaping in time. The concepts and terminology of spectromorphology are tools for describing and analyzing listening experience. 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. Although spectral content and temporal shaping are indissolubly linked, we need to be conceptually able to separate them for discursive purposes - we cannot in the same breath describe what is shaped and the shapes themselves. Each component of the term belongs to other disciplines (visual, linguistic, biological, geological), which is fitting since musical experience radiates across disciplines. A spectromorphological approach sets out

[4] http://www.dictionnairegram.org www.ears.dmu.ac.uk/spip.php?rubrique117

[5] http://www.ears.dmu.ac.uk/spip.php?rubrique34

spectral and morphological models and processes, and provides a framework for understanding structural relations and behaviours as experienced in the temporal flux of the music. (Smalley, 1986, 1997).[6]

The (reverse) application of spectromorphology raises many questions, and has potential to provide some solutions to the timbral/performance notation problem identified in this research. There has been limited research activity exploring timbre in this way, and a need for it has been identified in regard to Malaysian traditional instruments, and the performance and creation practices of electroacoustic and musique-mixte composers in this country and internationally. This project has addressed this opportunity and deficiency.

Spectralism

Spectralism is noted as having a significant influence on music composition and timbre based ideas. Whilst not directly relevant to this project, it is important as background to the development of spectromorphology and thus this research. Acoustic spectral techniques were explored by numerous twentieth century composers searching for the inner nature of sound – aspects that challenged Western music's language of tones, defined through melody, harmony and rhythm (Hamilton, 2003). Spectralist characteristics are seen in the continuous evolution of timbre and dense, complex textures in the music of Ligeti (For example, Atmospheres, 1961) and Scelsi, who focused towards microsounds and minute sonic fluctuations. Other composers included Radulescu, Grisey, Murail, and Stockhaussen. Gainey (2009) traces the history of spectral music from Helmholt in 1863, through harmonic effects of the overtone series by Wagner, Strauss and Mahler in Germany, then Schoenberg, Schillinger, Hindemith, and Debussy, Varese, Messiaen and Boulez in France. Spectralism elevates harmonic and timbral thinking of composers that transformed the use of sounds and developed a liberated approach to form as well as instrumental sound worlds.

Notation

Notation in this project is defined as both 'pen and ink' notation, in the form of traditional scores, graphics and/or text, and computer notation that may involve spectography and other graphic representations of sound. The exponential development of extended techniques for instruments and voice have created an abundance of extended notations, involving both implicit and specific representations of timbre effects in music. As such, much of the research literature is to be found in the scores, and in the recordings of works employing new ideas of sound, notation and performance.

Examples of notation of timbre as symbols, or effects, or technical instructions abound – from, for example, extended Western flute technique practices (which are largely timbre based and have formally existed for more 80 years) to a large range of physical and notational complexities as well as digital sound manipulations through electronics. The influence of electronics on timbral expansion has been important to

[6] www.ears.dmu.ac.uk/spip.php?rubrique28

acoustic performance, and has resulted in performative liberation from set ways of playing.[7] Graphic notations have afforded further timbral freedoms and interpretations (see examples in Sauer, 2009).

Texts containing discussions and descriptions of contemporary notation include Dimpker, in Extended Notation: The Depiction of the Unconventional (2013), which presents acoustic techniques for extending instrumental timbre, and discusses the electroacoustic methods of Ligeti, Kagel and others, and various compositional techniques such as added synthesis (Stockhaussen), the use of harmonizers (Nono), ring modulation (Schaeffer), waveshaping and so on. The Orpheus Institute's publication, Sound and Score (2013), includes vibrant discussions from numerous scholars on a range of score perspectives, including Yolande Harris, who describes the score as evolving to keep up with new expressions and activities, and as facilitating and articulating relationship between time and space, the visual and sonic, and one person and another (p. 196).

The TENOR conferences, initiated by the University of the Sorbonne, Paris, have created a community focused on new forms of notation and technology. Papers presented at these events have included topics such as symbolic notation, digital notation, real-time notation, musical instruments as scores, situational scores, spatialisation scores and our own spectromorphological notation research.[8]

Notation of electronics as a response to the need for replication of musical performance and clarity of compositional intention tends to sit between the notions of both notation and representation. In electroacoustic music the four musical parameters (pitch, duration, intensity, and timbre) are continuously variable (Bossis, 2006). Representations are made via scores, parametric graphs, spectrographic analysis, graphic interpretations, and software realizations. Representation types comprise of Prescriptive representation: standard notation plus instructions (text or graphic); Descriptive representation: capture of performance in standard notation or digitally generated graphic (waveform/spectrograph); and Analytical representation: visual depicting structural elements (Huff, 2013).

Musique-mixte

Musique-mixte is the French term commonly used for music for acoustic instrument/ voice and electronics.

eAnalysis

eAnalysis is a software for Macintosh for music analysis developed by Pierre Couprie, firstly at the University of De Montfort (UK) and continuing at the Institute of Research Musicology, Sorbonne University, Paris, 2010-12. eAnalyse was previously developed by Couprie for music education, to create listening guides for students in

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[7] see https://www.griffith.edu.au/__data/assets/pdf_file/0003/184782/penny_the_extended_flautist.pdf

[8] see http://www.tenor-conference.org/proceedings.html

school that allow for the creation of transcription through audio visual files or other software. The software is very important for music education as it easily allows the complexity of different sounds and the spectrum to be analysed by children. The program involves listening and drawing the music and, amongst other things, it can analyse tracks as sonograms, create graphics such as waveforms, and a graph to show the genetic evolution of a sound. With graphic events you can add analytical parameters and you can transform analytic parameters to graphic properties. The goal for this software is to create software specifically for musical analysis of electroacoustic music that goes beyond transcription, and to explore new forms of representation. The program creates documentation of musical representation, and creates software for musical studies. For many years electroacoustic music analysis has been based on transcription, and this program hopes to expand that function. The idea is to review that and to put noise/sound forward as the central process. The representation is not only to illustrate but also to analyse music and to create visual representation. Different softwares are used for analysis and representation (Couprie).

2.2. Contexts

The earliest known music notation in existence is believed to be a Babylonian stone tablature script dating from 1250-1200 BC (West, 1994, p.161). Across time, myriad notations have evolved, many of which are related to tablature and graphic symbols, as well as the meticulously documented rise of Western music notation. Timbral notation has gradually emerged, particularly in the 20th and 21st centuries, as a desirable extension and definition of this musical parameter, but one that is highly challenging to pin down, open as it has always been, to performative interpretation and circumstance. Of concern to this project is timbre-based notation pertaining to acoustic music, *musique-mixte*, electroacoustic music and environmental sound art.

Timbral elements in musique-mixte works are central to interpretation and realization in performance, but often include somewhat vague or technology specific indications. Our 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, 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 (Thoresen, 2001/4).

In addition to the range of issues of comprehensibility outlined above, composers of musique-mixte or other electro- acoustic music have a similar problem, though it arises from a different set of issues. Electro-acoustic music is dependent on both specific software and hardware for its performance. Their music is usually recorded and notated using the software and hardware equipment available to the composer. As either became obsolescent and unavailable, so the music which is composed for them also becomes unavailable for performance. The problem of the notation of music for electronic devices has been raised as a research topic already by many writers and researchers (eg. Blackburn (2011) and within the large MTI Research Centre project of De Montfort University (Leicester UK). However, the specific application of spectrographic software to this area and assignment of parameters to musical and timbral qualities for the sounds of instruments or electronically processed music material has yet to be carried out. As Blackburn (2009) points out, if we reverse the use of spectromorphology from after the event, to using the events it can describe such as onset, continuants, terminations or varieties of frequency analysis this provides the composer with sets of compositional tools and processes which this application proposes will useful in composing for both musique- mixte and electroacoustic music.

Cultural perspectives of timbre relating to geographical location and the background of researchers in this project include cultures of technological disciplines, music genres, and multiple musical practices. Instrumental and vocal sounds and techniques identified through particular traditions create the basis of these studies here: namely Western art music, Malay Wayang Kulit traditions, Arabic *Uthmani* recitation and Malaysian environmental sound art.

2.2.1 Timbre perspectives in Malaysian music

The centrality of timbre to music performance is well documented with regard to many Asian music traditions, for example, Kimi Coaldrake's Understanding timbre of Japanese Koto (2014) which demonstrates a new mode of description through 3D models. Malaysia, as a multi-cultural society, includes multiple Diasporas, and thus a range of musical traditions. Between the main groups generally recognized (Malay, Chinese, Indian), little musical amalgamation is seen and the Chinese and Indian heritages largely retain the distinctive characteristics of their original music. Whilst research is occurring into the development of Malaysian iterations of these styles, for example through the performances of groups such as Hands Percussion or fusions of Malaysian and Western popular music, as well as in studies of electroacoustic music [9], timbral elements have been largely unexplored.

[9] see The Imaginary Space FRGS project at http://www.jeanpenny.com/uploads/5/5/4/3/55434199/the_imaginary_space_frgs_2014_(july_2015).pdf

The work of researchers such as Tan Sooi Beng and Patricia Matusky (2009) in notating the music of Malaysian instruments has focused on transcription of the melodic and rhythmic elements. As outlined above, there has been little or no work to map Malaysian traditional instruments spectrographically, so this study takes this opportunity to undertake this study as a prelude to the more fundamental level of study, namely, developing a model for a timbral notation system.

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 details of the instrument's construction (dimension, materials, and decoration), mode of playing, 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" (ibid.). A motivating factor in this project is to try to find an objective, non-metaphorical process for notating these sounds through spectrographic measurement.

2.2.2 Timbre Perspectives in Western Art Music

The question of notating and representing timbral elements of music has long interested musicians, composers and musicologists of Western Art Music. Whilst spectralist composition techniques, in particular, have expanded the acoustic representation of timbres to some extent, the development and analysis of electroacoustic music has revealed a strong need for clearer identification, definition, and classification of timbre. In particular, a worldwide interest in finding new ways to notate or represent this music has evolved. Across the 20th century questions about timbre became focused towards both acoustic and electroacoustic music and sonic representations, and these have became increasingly bound up with technological growth in the 21st century.

Investigations of timbre from compositional and analytical musicological perspectives have occurred alongside performer and computer musician quests for multiple expressions through timbre. This has led to the desire to create a notation of these elements for reasons that include efficiency of practice and the potential re-creation of works.

2.3 Current Research

There has been a worldwide surge of interest in notational issues in recent years. Notation communities have formed through academic and web based networks that are largely concerned with new forms of compositional techniques and representation of composed music . Whilst it is beyond the scope of this review to cover each and every development, a few examples of recent research and writings on timbre and notation/ representation, semiotics and compositional techniques are given.

Christopher Patton (2007) discusses visual representation of interactive computer music for performer as a system of interactive computer music notation that links Smalley's spectromorphologies to pictographic representations. He makes the

point that notation is rarely complete, that morphological notation systems allow performers to relate to electroacoustic components, and suggests the development of a library of representations. He considers spectromorphology through the following: The perceptual analysis of time-varying aural spectra; a typological, linguistic expression of musical issues related to the perception of electroacoustic composition; provision of an analytical tool towards the development of an electroacoustic notation system.

Manuella Blackburn (2009) discussed the potential of spectromophology as a possible vehicle for the creation of a new way of notating electro-acoustic music. She notes that in its usual iteration, spectromorphology is a tool for analysis – applied after the music is composed and performed. If this application is reversed it could become a new 'vocabulary' and ".. the informer upon sound material choice and creation...[so].. the vocabulary precedes the composition, directing the path the composer takes within a piece" she continues, noting ..."if we can use spectromorphology to describe the internal functioning of sounds and entire work structures that we find to be rewarding, is it possible to re-use this language in the creation of future works? Is it possible to isolate the language we regard as 'successful'?

David Huff (2013) cites the 4 musical parameters of electroacoustic music as pitch, duration, intensity, and timbre that are continuously variable (Bossis, 2006). Representations via scores, parametric graphs (timeline and shapes), graphic transcriptions (sound event shapes), audio signal visualization (waveform, sonogram), software realization (DAWs, CSound, Max, etc) are described. He also suggests criteria for the effectiveness of representations – generality, readability, and playability.

Brian Bridges (2015) proposes that Smalley's theory of spectromorphology (SPM) is a theory of embodied cognition and that electroacoustic music is 'embodied-cognitive praxis'. Smalley's SPM extended the image schema theory. Different gestures have different embodied and functional associations (and causal dynamics), for example, flocking/streaming; grouping/ segregation; grow/integrate/resolve). Patton's theory of 3D SPM influenced notation and classical 3D cognitive timbre-space. The treatment of timbre on the basis of dimensions of movement may help mediation between performance gestures and musical/sonic structures in interaction design, performance systems, DMI's, software interface, and sonification.

2.3.1. Performative considerations

This project is based on specific performance practices, from the drums of traditional Malaysian music to contemporary Western flute techniques, *Uthmani* recitation, electroacoustic music and the experimental symbiosis of timbres from these cultures. This research perspective is thus unique in location, music cultures, sonic world and notational perspectives.

Important in this research is the perspective of the performer through composer/ performer/researcher collaboration processes and evaluations of notation ideas and models. Performance practices in this field are intricately bound up with gesture and sound, multiple representations, and analyzing through practice. Thus far, few texts have explored these areas in depth. A few are mentioned here:

Penny (2009) The Extended Flautist: Techniques, technologies and performer perceptions in music for flute and electronics. DMA Thesis. This thesis explores the performative nexus of flute with digital technologies, focusing on intersections of sonority, technology and perception in performance.

Penny (2016) The mediated space: Voices of interculturalism in music for flute. In Routledge International Handbook of Intercultural Arts Research. Burnard, MacKinley, Powell (Eds). Abingdon: Routledge. This chapter explores intercultural influences on sonority/timbre in flute music.

Traube (2015) Notation of Instrumental Timbre: Distinguishing Cause and Effect in the Relationship Between Technique and Sound. Circuit: Musiques Contemporaines; 2015, Vol. 25 Issue 1, p98. Traube discusses instrumental timbre as the instrument itself, the musician playing, the interpretational style, and the link with the listener as communicated by the composer through instrumental techniques and the use of metaphor.

This review has pointed to significant areas of study within spectromorphological notation and related fields. This project seeks to begin addressing the gap of timbral notation through highlighting music of Malaysia – specifically, the instrumental timbres of Malay drums used in *Wayang Kulit* ensembles, compositions incorporating Arabic *Uthmani* elements, contemporary performance techniques, and Malaysian sound art. These aspects of this study make it unique.

Chapter 3: Methodologies

3.1 Methodological Approach

3.1.1 Initial research process

The process devised to undertake this research was based on a collaborative, and practice-led approach. In the original planning, three sub-projects were envisaged and loosely designed by the project leader (Dr Andrew Blackburn) and principal researcher (Dr Jean Penny). From the initial structure and scope a team of researchers was put together. Very early in the developmental process, discussions were held with Prof. Dr Marc Battier of IReMuS (Sorbonne University, Paris) who expressed an interest to join the project. The research process was then jointly developed by the whole group of invited researchers, through an open symposium held in the Faculty Muzik dan Seni Persembahan at Universiti Pendidikan Sultan Idris, in June, 2014. Participants in this meeting were:

Dr Andrew Blackburn - Leader (UPSI)

Dr Jean Penny (UPSI)

Assoc Prof Dr Hassan Abdullah (UPSI)

Prof Dr Marc Battier Principal researcher (Université de Paris - Sorbonne)

Asst Prof Dr Hasnizam Wahid (Universiti Malaysia - Sarawak)

Assoc Prof Dr Valerie Ross (Universiti Teknologi MARA)

Dr Clare Chan (UPSI)

Graduate Research Assistant En Hafifi Mohktar (Masters)

Soon after this meeting, Dr Clare Chan withdrew from the project, and Assoc Prof Dr Pierre Couprie (Université de Paris IV) joined the group. The approach confirmed and supported by the opening symposium was to sequentially conduct three sub-projects. The projects are:

Notating timbre in Traditional Malaysian Music

Developing Timbral Notation for performance

Notating the timbre of Electroacoustic Scores

It was decided that, after the findings from each were collated and considered, a second symposium would be held with all researchers, composers and other participants to consider how these findings may feed to developing a timbral notation system. An outcome of the second symposium would be recommendations for developing a timbral notation system. This symposium was held in December, 2015 with the international researchers from Paris University in attendance (see Appendix 2 for the Symposium report).

A final (and fourth) project would then be undertaken, based on these recommendations to model how such a timbral notation system might organologically

and semiotically operate. Central to this study would be the development of techniques and expertise in recording the various instruments and sound – deciding what the ideal circumstances for capturing the sound might be – in the field, or recording studio. It was not possible to complete this project, being dependent on composers who for a variety of reasons did not develop compositions to a stage where they could be performed, and the ensuing health issues of the Lead Researcher, who had to return to Australia. This final project was to have tested and applied the models in a performative environment. As this is a Fundamental Research grant, it is believed that these issues have not impacted on the basic quality of the research, and it would make an excellent starting point for a research project that applies and tests the models developed here.

All the projects were designed to utilise a qualitative – practice-led research methodology, that allows for a range of methodological approaches within. These ranged from quantitative measurements of instruments, sounds and the like within spectrograms, from which content and characteristics were noted and assessed. Comparative measurements were made between various forms of spectrogram, and these were then measured against other examples that had been recorded. Of equal value were the experiential notes and reflections of the participants as the measurements are applied in artistic and performative environments. It is an approach that is outlined in detail in Blackburn (2011), Penny (2009) Coessens, Crispin & Douglas (2010) et al.

Utilising artistic practice as research methodology, the approach of this research project requires considerable periods of reflection and flexibility, responding to discoveries and findings from within the planned research process. Some areas were given greater importance, for they revealed new information, including:

An extended survey of a very wide range of research and writings on timbre and notation . It allowed the creation of new knowledge and the inter-relationships of the proposed projects became self-evident;

That each sub-project exhibited organological similarities which helped give rise to the models that have been developed.

Developments within each Sub-Project to adapt to and progress the findings and processes which were required, as new findings and approaches were articulated.

As the project proceeded, it was found that ideas and concepts anticipated as part of the development of notations were either being confirmed as important, not needed, or wrong. Many periods of reflection have been undertaken (as written about in the articles, and chapters on each project) and new directions and processes discovered.

3.2 Sub-Projects

The research design was built around a series of sub-projects. The first is entitled *Notating timbre in Traditional Malaysian Music - an ethnographic approach.* The

second sub-project is *Developing Timbral Notation for performance* while the third and final one is *Notating the timbre of Electroacoustic Scores.*

In that three projects, using practice-led research as the pre-dominant methodology relies upon the professional practice of the researcher. It acknowledges the pre-existing knowledge they bring to the research, both as an individual and as an experienced researchers in ethnomusicology, performance , composition and electronica. In particular, the variety of perspectives this methodology allows has been most advantageous in the research project. The 'insider-outsider' knowledge paradigm in particular, has assisted the authors in coming to understand **what** is occurring as, for example, the *Wayang Kulit* performer made his instrumental deliberations in the first project, or the flute player in the second, her understanding of the instrument, its extended techniques and the possibility of applying this in the project.. This 'insider-outsider' reflection is the basis of the research approach described by Donald Schon (1996), requiring the researcher/practitioner to consider their professional practice, and consider what is, and how this knowledge might be used to improve or develop what occurs in the researcher's practice. This reflective process is not to confirm the status quo, but to open the researcher to look for new ways and processes to create positive change in their practice. Central to this reflective process is the knowledge the researcher has both from an awareness or mindfulness while they are playing, teaching or whatever (insider knowledge), and a subsequent process of reflection after the event, perhaps also observed by a knowledgeable other (outsider knowledge). A full discussion of this research methodology is beyond the scope of this report, but attention is drawn to Penny (2011) and Blackburn (2012) who both discuss this extensively in several publications.

3.3 Compositions

The opening seminar was a critical element in changing the methodology through the approach of proposed new compositions. From this seminar, it was proposed that there would be at least 3 new compositions, each exploring a slightly different stance and perspective of timbral notation, which could lead to models which wold be tested in this context.

Initial meetings were held between the composer/researchers within the group - Assoc Prof Dr Hasnizam Wahid and Assoc Prof Dr Valerie Ross. Each thought that several compositions would be possible, and developed for performance. As time passed, it became evident that a lesser number of compositions would be produced. In the end neither composer/researcher finished performance ready works. Development and semi-completed work was prepared by both researchers which allowed modelling to be undertaken. The compositions, at their last stage of development, are given in Appendix 5 below.

Chapter 4: Notating timbre in Traditional Malaysian Music - an ethnographic approach

Researchers

Dr Andrew Blackburn (UPSI)

Associate Professor Dr Mohd Hassan Bin Abdullah (UPSI)

En Hafifi bin Mohktar (Graduate Research Assistant)

4.1 Introduction

Ethnomusicologists often face the problem of precisely and objectively describing the characteristics of a sound recorded in fieldwork activities. In the absence of any other means, written explanations normally resort to metaphor to represent the timbral characteristics of a sound produced by ethnic musical instruments. The extent to which the reader will truly understand and perceive the sound based on the writer's written description is problematic. This sub-project explores some possibilities of incorporating timbral visualisation in the recognition of the unique characteristics of Malaysian traditional musical instruments, with a view of providing a more objective description of the sound of these instruments. Such analysis of Malay traditional instruments is new.

In this sub-project we introduce an instrument recognition process from our solo recordings of a set of Malay traditional instruments which have yielded a high degree of recognition. A large sound profile is used in order to encompass the different sound characteristics of each instrument and evaluate the generalisation abilities of the recognition process.We have found this a useful and practical piece of knowledge and, by 'reading' the spectrograms, a less experienced player is able to emulate a more experienced performer, both in instrument selection and timbral performance practice. Further, using this visual representation, and voicing an instrument timbre to a set of spectrograms, traditional instrument makers have the potential to create instruments which have a consistency of spectral character. With this knowledge the unique characteristics of *Wayang Kulit* instruments are both classifiable and reproducible. [10]

We have limited our cataloguing and analysis to instruments in the percussion sets used in *Wayang Kulit*, focussing on the timbre of one instrument in particular, the gedombak (goblet drum). Our approach is to then use the understanding gained by this process to create a visualise representation of the sound qualities preferred by an experienced and professional *Wayang Kulit* performer when they select a specific instruments for a given dramatic story or context.

10 The latter section of this chapter is drawn from the presentation poster and associated article for the TENOR conference held in Paris in 2015. See Abdullah, M.H & Blackburn, A., 2015.

Background

Ethnomusicology is a field of music that deals with any musical activities and perspectives related to the specific music in a given ethnic group or culture. One of the perspectives of study in this field is the organology of traditional instruments, and an evaluation of the sound produced by the instrument. Researchers who study this field will, as part of their research, describe the sound and music performed by any particular instrument in a community. Such descriptions will include descriptions of the instruments' organology, social significance or context for performance and often a text-based description of its sound characteristics.The disadvantage of this approach is that, in printed text documents, researchers have tried to describe the characteristics of a sound and hope the reader understands the sound quality without having listened to, or accessed the original recording materials.

Though partly addressed by making recordings available online, readers are liable to misunderstand the sound quality, perceiving it differently from the understanding of the researcher. In short, a sound that is described in writing may be imagined differently from the memory of the actual sound recalled by the researcher. One example of this lack of precision – or perhaps a poetic approach to the description of sound – is given by Ngabut in Kenyah Bakung oral literature: here the author describes several traditional instruments from the Borneo Kalimantan region, including detailed descriptions of their construction (dimension, materials, and decoration), mode of playing, social function and many other cultural features, but makes only one reference to the actual sound quality of any of the instruments: "The sound produced resembles that of a frog" (Ngabut, 2004, p.272). Assuming one knows what species of frog giving what call is being referred to by the author, perhaps this is a helpful description. This project advocates an objective mode of timbral description that is useful to readers who do not have a familiarity with the "frog", objectively analysing and referring to the timbre of sound – identifying its spectral content, sonic identity and recognition of source.

Though not descriptive (like a frog) the spectrogram provides a quantitative analysis of the sound of a given instrument. Combined with the characteristics of the sound envelope (Attack, Sustain, Decay Release – ASDR), musicologists and ethnomusicologists have a highly objective sound descriptor. Using spectrograms to allow specific quantitative information of the timbre of traditional Malaysian instruments, relating them to the instruments' organology has not been undertaken. Other ethnomusicologists have explored the approach of using spectrograms for various forms of analysis. This paper focuses on one aspect of this larger project, namely understanding the instrumental sound, selected by a highly skilled professional *Wayang Kulit* performer for specific purposes, and what instrumental timbral qualities can be understood through the spectrogram.

In addition to the Ngabut text referred to earlier, the literature reviewed by the authors for this paper has focused on the use of spectrography in ethnomusicological contexts, and how timbre may be defined theoretically using this tool. One example, of many, is the 1994 study of lamentation practices in rural Russia by Margarita Mazo. In this study the author uses spectrograms to investigate and compare the vocal production in laments with that in normal speech and singing. It ties in with another common and

early use of spectrograms by speech therapists for the diagnosis and treatment of speech or vocal problems. In Mazo's study, the author looked at the difference between the quality of the singing voice used in funerary laments, and compares it with the voice quality in other contexts. The musical application in a specific social context is apparent and central to Mazo's study, and though limited there to vocal intonations, can be effectively applied to (pitched and un-pitched) instruments as in the present research. Spectromorphology also quantifies how sounds changes over periodic time (ASDR) as a characteristic of timbre, and this leads us to consider the theoretical and applied texts of Denis Smalley and is discussed in the research project's literature review above.

From these understandings we may conclude that a definition of timbre in this context, and for ethnomusicological purposes – the organology of traditional instruments and the impact this has on the sound of the instrument – may perhaps be enunciated by judging … "two sounds similarly presented and having the same loudness and pitch are dissimilar", and for our *Wayang Kulit* performers who conceptualise "… the relationship between pitch and sound qualities" (Smalley, 1994, p.36). They then form musical or dramatic opinions as to what is the most appropriate timbre for the given situation.

4.2 Research Objectives of Sub-Project 1

Malaysian musical heritage has many unique instruments, which give it a sound that is, for Malaysians, emotionally significant. The instruments which comprise this set have specific physical properties in addition to significant cultural semiotics, which have been described by many writers – for example Ross (2011). The music which belongs to this set of instruments has been transcribed using the usual tools available to ethnomusicologists, providing culturally important documentation of the performance practices and music. However, almost no work has been undertaken to map and transcribe the sounds, identifying the unique qualities which characterise each instrument, and how the instrument sounds differ according to the material from which they are made - or how the different performers from each area create individual or localised timbres. This study aims to address this a pilot set of spectrograms drawn from instruments of the Malay Traditional Orchestra or *Wayang Kulit* ensemble. It is intended that this project will demonstrate how such an approach adds to the knowledge of the instruments, and makes dissemination of the culture easier, and similar to work undertaken with traditional instruments and music of other cultures[11].

Spectrograms of both solo and ensemble groups were made to contextualise the timbral location of the instrument, and then some instruments will be investigated at great depth. Within the larger FRGS project, this study will pioneer optimal techniques and conditions for creating and assessing spectrograms for a Malaysian ethnographic environment. These techniques will be refined and applied in the other sub-projects that follow.

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[11] For example, see Fletcher, N., 2003 http://www.didjshop.com/austrAboriginalMusicInstruments.htm

Finally within this whole project, the knowledge of individual instrumental timbre will contribute to the development a model for the timbral notation of instruments. This timbral notation model will allow ethnographers to more completely notate all the musical characteristics of Malaysian Traditional Music.

4.3 Problem Statement

For the past few decades, many ethnomusicologists have been trying to precisely describe the sound of any musical activities in many different ways. Some of them describe the sound of music in a narrative way, while some of them give some meaning and use metaphor or other type of sound representation to describe the characteristics of a sound. Ethnomusicologists also face difficulty in describing a sound of music or an instrument from their fieldwork. The current practice in Malaysia is that a sound is given a description based on the ethnomusicologist's understanding. The description is verbal and as such may be perceived differently by other people. How can this situation be overcome or addressed? Spectrograms have been used to objectively to describe the organology of instruments of other cultures but not in Malaysia.

In the field of ethnomusicology, researchers normally describe the sound based on their perception or use a local terminology to describe a particular sound. Most indigenous musical instruments are not constructed to any standard pitch, size or measurements. One may note that almost all ethnic musical instruments – even from the same general regions or makers, have different sound quality and pitches. For example, in the Kompang (frame drum) ensemble of the Malay people, the sound of the kompang depends on the tautness and thickness of a skinhead as well as the size of the instrument. However, the kompang must be tuned to the "Bunyi yang diterima" (acceptable sound) before being played. A kompang ensemble normally consists of 15 to 25 players who perform on similar instruments in interlocking rhythmic patterns to celebrate joyful occasions in the Malay community.

The individual kompangs used in an ensemble are all tuned to a certain pitch, made as close as possible to one another. However, even though there is no standard tuning set for the kompang, an experienced kompang player is able to tell the 'acceptable sound' of a kompang. The 'acceptable sound' of a kompang to the players is described as (kuat) loud, (gemersik) penetrating, (tajam) sharp and (tegang) taut. How can one precisely understand and perceive the sound of a kompang as loud, penetrating, sharp and taut? Can one precisely describe the 'sharp' sound of the kompang? Given that the sound of any indigenous musical instrument is mostly not standardised in nature, there is a need to find ways of identifying and recognising the "acceptable sound" of any particular musical instrument, not only for researchers, but especially for beginners and those who are not expert in that field.

Moreover, contemporary Western arts and traditional music notation is usually linked to an analysis and the semiotic representation of the musical elements of melody and harmony (vertical and horizontal pitches) using common music notation. Precise pitch indications are 'rounded out' into the twelve semitones of this system, unable to further accommodate the precise subtleties of sound which are inherent in all music

traditions. Further, musical performance parameters such as articulation (attack, decay, sustain and release) and dynamics (volume or intensity) are loosely indicated through the use of staccato or phrase markings for articulations, or dynamic marks (forte, piano, crescendo, diminuendo, and so on).

Representation of other significant musical elements such as tone and colour (timbre) are largely limited to instrumental naming or specific performance techniques (sul ponticello – play near the bridge for string instruments). This weakness, along with the difficulties brought about by the multitude of definitions and understandings of timbre are increasingly recognised within both new music and traditional music fields.

4.4 Aims and Objectives

This project aims to explore the creation of a model for the timbral and performance notation of acoustic music that notates more content details of the various elements of sound. Of significance for ethnomusicologists who are working in this field, will be the use of spectrographic notation leading to the creation of an authentic transcription library and catalogue inclusive of significant musical elements. It is hoped that such a catalogue will lead to a greater understanding of the individual and unique spectral and tuning characteristics of traditional Malay musical instruments. This method will be applied to piloted using the gedombak, gendang, serunai, and rebab. Knowledge and experience of creating spectrograms of the Malay traditional instruments will then be applied into the forefront of music making using these possible models and systems. Whilst the research and research questions suggest an on-going and complete cataloguing of instruments from traditional ensembles, this article will focus on the research and understandings gained through the consideration of one instrument – the gedombak.

*4.4.1 **Project 1 Research Questions***

In exploring the possibilities of using the spectrographic features in ethnomusicological study, there are many related questions that can be addressed.

How can an ethnomusicologist describe the sound of a musical instrument?

What are the elements that ethnomusicologists require from a notation system and how can these be represented?

Can this information be used to describe and notate the specific individuality of sound materials and performance methods in ways that expand the range and musical vocabulary of the ethnomusicologist?

What parameters of analysis can be defined to provide useful and universally understood symbols using spectrographic software?

4.5 Methodology

From a list of instruments catalogued by Ross, we identified the range of instruments that are normally considered members of the Malay traditional Orchestra (See Table 1).

Table 1 Class MALAY Traditional Orchestra

Winds	Seruling (1)
	• Bansuri (1)
	• Serunai Kedah (2)
	• Serunai Kelantan (1)
	• Percussion: Pitched
Unpitched	
	• Bonang (1unit:Bflat pentatonic) Sarun peking
	• Sarun barung 1
	• Sarun demong 1
	• Kempul (1 set)
	• Gong Agung (1)
	• Gong Suwukan (1)
	• Greteh (2 units chromatic)
	• Gambang (1unit:B flat pentatonic)
	• Angklung (1 set chromatic)
	• Rebana Ubi (Sets) Jidor
	• Kompang
	• Maruas
	• Rebana Melayu asli ibu & anak (1 each)
	• Gendang Panjang ibu & anak (1 each) Kesi (1)
	• Plucked Cak (3) Cuk (3) Gambus(3)
	• Bowed Rebab (1)

In conducting this study, various methods were utilised to obtain valid, useful data and information which were designed to answer the research questions, and locate the outcomes of this sub-project in the wider research project. The methods were grounded in the performance practice of a *Wayang Kulit* ensemble. While exploring all the possibilities of using spectrograms as a tool to describe the characteristic of a

sound, researchers analysed this practice. This method is identified with practice-led research–the methodology underpinning this project. Three phases cumulatively documented, analysed, applied and reflected on project activities and outcomes. The various reflective sections in this, and other sub-projects is a key criterion of the research, supported by textual analysis.

Our initial research activities included identifying the timbral characteristics of a few selected Malay traditional musical instruments such as gedombak (hourglass or goblet drum), gendang (cylindrical drum), kompang (frame drum), serunai (double-reed oboe type instrument), and rebab (spike-fiddle). Expert players were selected to play the instruments for the purpose of recording.

A number of samples of Malay traditional instruments were recorded (as wave files) both in an ensemble and solo context. The instruments included the gedombak, gendang, serunai, geduk and gong and were played by expert musicians in both solo and ensemble music for the purpose of recording. The recordings used uni-directional microphones, and focused on the desired instrument. As noted, the recordings of the instruments were made in two contexts – solo, in which the selected instrument played alone, and in an ensemble, where the selected instrument was recorded (close miked) within the ensemble. The 'spillage' of sounds from the other instruments in the ensemble provided a musical context for the highlighted instrument, and this helped to demonstrate its role within the ensemble.

It was decided to focus our study on the gedombak - an hourglass-shaped drum, which is described and detailed by Abdullah (2004). Using an 'Artist-in-Residence' Mr Zuarman bin Ahmad from the Faculty of Music and Performing Arts at Sultan Idris Education University, as our expert performer, various gedombak were recorded in a neutral studio environment. Language and material differences were noted in addition to identifying finer performative techniques.

Figure1: Testing the different gedombak for performance

In this process, field and studio recording techniques were documented by the Graduate Research Assistant, and elements such as microphone characteristics and preferred placements collated for publication in appropriate technical journals to assist

other recording engineers. The characteristic differences of the spectrograms of each gedombak were measured and listed, adding to the overall knowledge of the instrument.

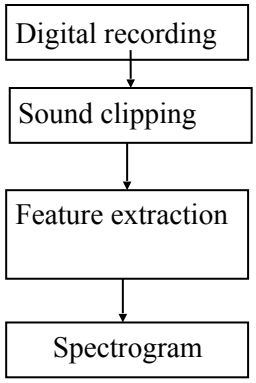
This process has added to the organological understanding of the gedombak, providing a quantifiable and measurable base set of knowledge of the instrumental timbre of this Malaysian Traditional Instrument. The timbral knowledge established in this project will allow the researchers to continue their research in the subsequent sub-projects. In creating and analyzing the spectrograms, an understanding of the timbral information which is important to ethnographers will be gleaned, allowing the modelling of a timbral notation system which will gain semiotic universality.

4.6 Findings

The various recordings were then converted to spectrograms with a variety of filters and perspectives. These are outlined below. Three software packages – eAnalyse, Sonic Visualier and Praat - were used to create the spectrograms, which provide a visual representation of the recorded clips used in this paper.

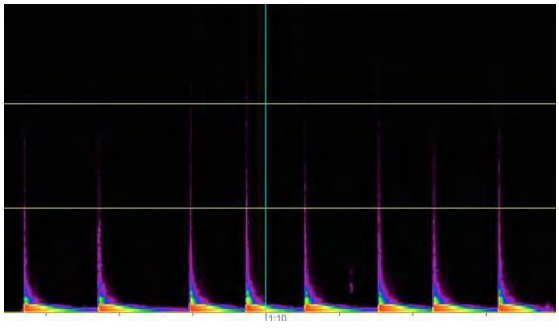
The process that has been followed is shown in the following flowchart (Figure 2).

Figure 2: Flowchart of processes



A series of recordings of the instruments demonstrated that the underlying phonetic representation of an unknown utterance can be recovered almost entirely from a visual examination of the spectrogram. The most common format is a graph with two geometric dimensions: The horizontal axis represents time; as we move right along the x-axis we shift forward in time, traversing one spectrum after another; the vertical axis is frequency and the colours represent the most important acoustic peaks for a given time frame, with red representing the highest energies, then in decreasing order of importance, orange, yellow, green, cyan, blue, and magenta, with grey areas having even less energy, and white areas below a threshold decibel level.

Figure 3: Spectrogram of a gedombak



In Figure *4* we see the spectrogram of a gedombak beaten in a series of single taps in the middle of the skinhead. What can we learn from this spectrogram? After discussion and receiving further clarification from the expert player, it has been ascertained that the fourth beat of the sound in Figure 4 is the sound preferred by the expert player. One can tell the characteristics of the preferred sound by simple analysis of the colours and density of sound as shown in the spectrogram. Here, we see the preferred sound has the following characteristics: a strong attack (onset) that is followed by the most rapid decay of all the samples shown here; the fundamental tone, which is indicated by the brightest colours (red, yellow, green and blue) is also the most evident in this beat; the decay (length of the sound before it is finished) is the shortest of all the samples; the harmonic overtone series, as indicated by (especially) the height of the purple column, is at least as rich as any in the samples. Although the 4th beat sound (preferred by our expert performer) has a quite similar fundamental tone and overtone characteristics to the 8th beat (the last,) the 4th beat has a significantly faster decay. In addition to the instrument being a preferred one for the player, the performance technique that provides this most desirable sound should also be identified. This will be undertaken in subsequent studies.

Different filters have been applied to the one recording of the gedombak. The results show different features of the sound performed on the same instrument. Below are the examples of different spectrograms showing different features and characteristics of a sound performed on this Malay traditional instrument.

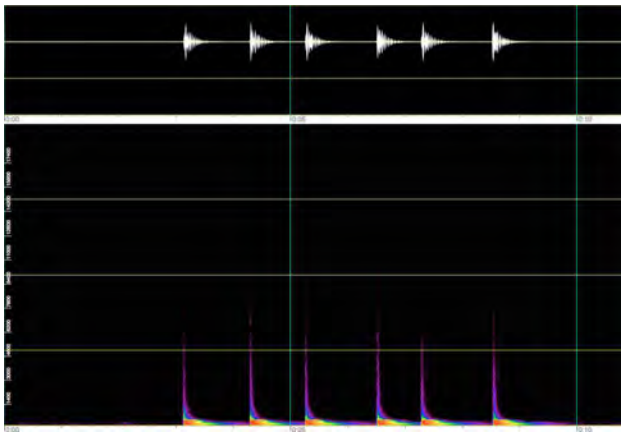


Figure 4: Spectrogram of a Gedombak with the waveform at the top.

In Figure 4, the waveform indicates the sound envelope (Attack, Sustain, Decay, Release – ASDR) over periodic time, and one of the ways Smalley suggests consideration of sonic characteristics. In combination with the harmonic spectral information provided in the lower section of the figure, it becomes possible to identify the preferred sound and performance approach of the player. We can confidently say that he expert player's preferred sound 'looks like this', and the task of the player is then to reproduce the sound quality to 'look' like it too.

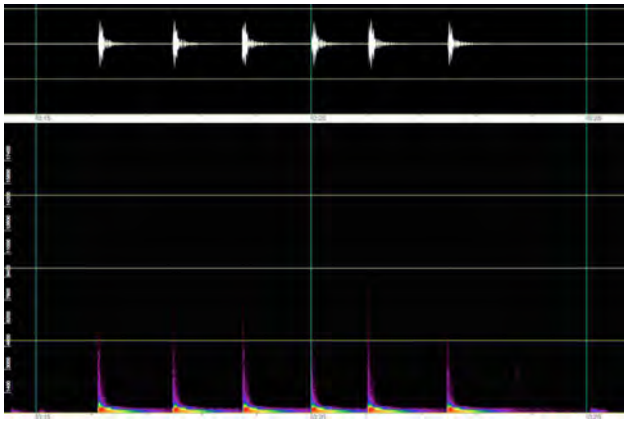


Figure 5: Spectrogram of a smaller sized Gedombak – waveform also at top.

A smaller gedombak (Figure 5) shows slight, but significant differences to the larger instrument discussed above, in both its sound envelope (ASDR) suggested by the wave form, and its harmonic overtone structure. In the Wayang Kulit ensemble, the gedombak is indicated as the large regularly spaced columns of Figure 7.

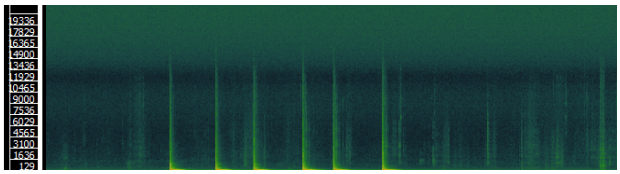


Figure 6: Zoom in Spectrogram of a Gedombak

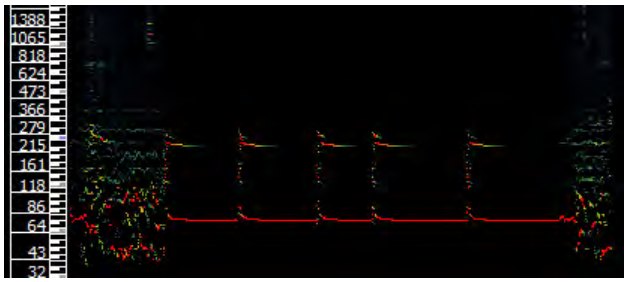


Figure 7: Spectrogram of a Wayang Kulit ensemble

Figure *7* is a spectrogram of the entire *Wayang Kulit* ensemble, recorded in the manner noted earlier. The microphone is focused on the gedombak, but the very strong sounds of the other instruments, particularly the serunai, are clearly evident. In this spectrogram, the higher partials of the sound have been filtered out, indicating only the

fundamental tones of the various instruments. The long red horizontal lines represent the melodic lines of the serunai. The pitch variations and arabesque ornamentation so characteristic of the instrument is also visible. The gedombak pitch is visible in the five vertical columns of sound.

4.7 Reflections

The spectrograms of gedombak (goblet drum) in the *Wayang Kulit* ensemble are preliminary attempts to explore the potential of a spectrogram as the basis of models of a performative notation that includes useful timbral information. It is an initial phase in the plan to use spectrograms of individual instruments to identify preferred timbral quality of instruments for use in specific musical/dramatic contexts – why a *Wayang Kulit* 'master' selects one instrument over another in a given performance? Identifying the specific timbre 'preferred' by our *Wayang Kulit* master, enables us to appropriate artifacts which an ethnomusicologist can objectively use to describe the timbre of the instrument, identifying the combination of overtone and onset qualities. This approach also allowed our identification of the unique timbral qualities of both an individual instrument (gedombak) and performance techniques that have lead to its selection. In achieving this level of specificity in this small component, has placed us in a position to assess the potential of a spectrogram as a precursor to a score timbral representation in performance.

Just what is timbral notation? It needs to represent: gestural elements; contain harmonic overtones; have semiotic significance; and more. How might timbre be meaningfully represented? A potential conflict also becomes apparent: the representation of timbre from an historic document – a spectrogram is a diagram of a sound that has already occurred – must become one which offers the performative potential inherently extant in a common or graphic musical score. The resolution of this is yet to be realised, but working for it creates an opportunity for different forms and styles of score. In the ethnomusicological project, we have opened a door to new types of performance score. In an applied ethnomusicological context, the profiling of timbre linked to the organology of an instrument is a tool that is highly applicable in Malaysia. It also opens ideas that appear to inform concepts and practices in the other sub-projects of the overall research project.

4.8 Conclusion

In this sub-project, we dealt with recognition of sound samples and presented several methods to improve recognition results. Tones were extracted from a database of Malaysian traditional musical instruments (gedombak, gendang, serunai, and so on). We have used two different parameters in this analysis – sound analysis through spectral mapping, and morphology over time. From the experiments, we could observe evident results for spectrogram and autocorrelation. Maximum and minimum values of amplitude for autocorrelation for all musical instruments have different ranges. The harmonic range indicated through the spectrograms of gedombak is much wider than those of gendang and serunai. Our results suggest that the estimation of spectrogram

and autocorrelation more effectively reflects the timbral difference in these musical instruments. From the gedombak spectrograms we are also finding that it is possible to objectively demonstrate an experienced performer's preferences of tonal characteristics for the instrument.

We limited our cataloguing and analysis of this group of instruments, focussing on the timbre of the gedombak (goblet drum) as a pilot for this approach. We developed an instrument recognition process from our recordings of Malay traditional instruments, which from the instances, yielded a high recognition rate. The sound profile of the gedombaks encompass the different sound characteristics of each individual instrument and we were able to evaluate the generalisation abilities of the recognition process. Our approach was to use the understanding gained by through this process creating a visual representation of the sound qualities preferred by an experienced and professional *Wayang Kulit* performer as they chose a specific instruments for a given dramatic story or context. Being able to identify that this instrument was preferred over that, for a specific dramatic moment in a *Wayang Kulit* play gives an objective reference for a given choice.This is a useful and practical piece of knowledge: with spectrograms a less experienced player can emulate the more experienced performer and; instrument makers have the potential to create instruments which have a consistency of spectral character. With this knowledge the unique characteristics of *Wayang Kulit* instruments are both classifiable and reproducible.

Our research has demonstrated a process by which a preferred timbre (either by instrument or performance technique) can be objectively and reproducibly identified. With further development, as recommended above, it follows that in having such a tool, interested parties can use it to identify and create a notation system for this purpose.

In planning this research project, the intentions of the research team were twofold: first as a means of creating a symbiotic graphic notation that would objectively enable Malaysian traditional musicians, instrument makers and scholars to identify an 'ideal' sound or preferred sound for the instruments; secondly, the sub-project was intended to act as a springboard for the development of possible notation and composition/performance models in the second and third projects. In both these objectives, the outcomes have been successful.

Chapter 5: Developing Timbral Notation for Performance

Researchers: Dr Jean Penny

Dr Andrew Blackburn

Assoc. Prof Dr Hasnizam Abdul Wahid

Assoc. Prof Dr Valerie Ross

5.1 Introduction

The musical score as semiotic medium can be understood as an "infinite substance" (Barenboim, 2009) that creates for the musician the facility to imagine and translate notation into a temporal unfolding of new knowledge and experience. As we look to extend performance practices towards new conceptual contexts and relationships, new systems / paradigms that reflect and drive new expression and activities evolve. This context of change impels explorations of notation and score, shifting performative relationships, and investigations for ways to magnify and communicate ideas. Timbral notation is explored here as a facilitator of new ways of thinking and performing, contextualised within the notion of the performer/score relationship.

In this sub-project, the performer's perspective is applied to the development of a variety of timbre notations in music for flute. These processes aimed to produce a set of fundamental sonic representations that pave the way for developing a viable system of spectrographic notation. The context of this sub-project consists of two contrasting new compositions as notational models.

The chapter elaborates on the "problem" or need for this research, itemises research questions posed, discusses methods used, theoretical frameworks developed, and documents notation processes undertaken within the two composition collaborations. This research is fundamental: developing new ideas that will later be applied to performances of completed works. Future analyses and evaluations are expected to include phenomenological studies as the notations become performance ready and multiple responses are activated.

5.2 The Problem: Aspects of performative need

It has become critical to expand forms of timbre notation as new sonic ideas have evolved in music composition and performance. Developing new notation of timbre that is both stimulating and informative for the musician, that increases clarity of information, and is not entirely reliant on metaphor, verbal description or technical processes (as has been the case in earlier scores) is our challenge. Most common amongst research in this field are explorations of various types of technology use (see,

for example, the work presented at the International Conferences on Technologies for Music Notation and Representation (TENOR)[12].

This project's uniqueness lies in its intercultural and transdisciplinary approaches to developing a musical notation model for timbre through spectrography – a model that accounts for the notational needs of the performer, has clarity and embedded knowledge and information that communicates directly to a performer whilst still allowing for individual creativity of interpretation. The conventional idea of a written score has been used, rather than newer iterations that might include considering the instruments as notation, or the performance as notation, or live real-time notation, live coding, networked score notation, or other hybrid forms of notation being thought about and developed around the world (ibid.).

The spectrographic elements of our study imply a certain type of visualisation of sound that might represent timbre amongst other things, and pictorial views of layers of sonic components and processes. Spectrograms have acted as revealers of subtle expression and nuance, articulations and shapes, and colourations of the sound. How transformations from highly saturated images of spectrograms to clean readable lines of notation can occur, how these might inform the performer, and how functional they might be in real-time performance was central to our questioning.

5.3 Aims and objectives

A performer's notation needs clarity and embedded knowledge or information that is clear, readable, interpretable, and informative of what the music is about. Spectrographic notation of timbre is posited as a stream of representation opening up new dimensions of musical practice and cultural understandings, with the purpose of expanding communication of sonic parameters.

The main aim of this sub-project was to focus on developing notation models through collaborative composer/performer/researcher experimentation with notation and spectography. There were 3 main objectives:

1. To collect spectrographic information about timbre and develop ways of transforming this into the notated score;
2. To examine and evaluate performative perspectives of spectrographic-related notation through new compositions; and
3. To provoke and explore new ways of thinking about timbre, notation and performance.

5.4 Research questions

The multiple layers of a spectrograph emit different levels of information, multiple meanings, different streams of representation – all systems that require understanding

[12] at http://www.tenor-conference.org/proceedings.html)

and evaluations of the relations of the score. The following research questions were proposed:

1. How effective are current notational styles in representing and articulating the sounds of instruments?

2. What information about instrumental sound do spectrographs give us?

3. How is timbre captured by spectrographic representation? How can this be notated?

4. How can spectrographs work as performative scores? How can they be read? Is this functional in a real-time setting?

5. Are the visual representations of timbral characteristics dependent on vast arrays of instructions (eg. pages of explanations, recording or video demonstrations in the score)? Is there a code that we can develop?

5.5 Methodologies: Theory, Structure and Framework

The project evolved through investigations of spectrographic notation, relevant theories, practices and aims, and the development of a viable research framework. It was structured around the development of notation ideas for two new compositions. Each work utilised different methods and structures, outlined below, and both evolved from creative practice: the developing processes (acts inside music composition and performance); moving between practitioner / observer; preparing artistic works; documentation; and creation of materials for analysis. Identification of performance elements and connections, as well as the characteristics of spectrographic imagery, created a basis from which to follow distinctive ideas of notation.

Early work on the new scores began with a definition of the flute sound – the components of sound shapes, morphology, intensity, perception, texture – and how this might be transferred into a visual timbre-based notation. Various extant timbral techniques on the flute were recorded and cataloged as a starting point for consideration preceding the models that included notation related to two concepts: a blend of *Uthmani* recitation phonemes and flute sound emerging from spectrographic images; and the transformation of spectrographic elements into timbrally expressive colour structures.

Transdisciplinary components of the research included language and phonetics, graphics, harmonics, sonic transformations, colour, and intertextuality. The concept of intertextuality is based on Julia Kristeva's use of the term (Revolution in Poetic Language (1974), Word, Dialogue and Novel (1966), The Bounded Text (1966-7)). Coming from the Latin, meaning to intermingle while weaving, Kristeva posited that all signifying systems are a confluence and transformation of all past and present signifying systems, a result of relationships to other texts and linguistic structures. This idea transfers into music notation easily as transposition of one sign system or cultural understanding or soundscape into another. Any new notation is a transformation of all past notations: it takes into account experience and knowledge, previous practice and evolving ways of living. It becomes a confluence of interpretation, and aesthetic

conception. Roland Barthes similarly argued ("readers create texts, not authors" (the death of the author 1967) that any text is a new tissue of past citations and is constituted only in the moment of its reading. Thus the reader's own previous readings, experiences and position within the cultural formation also form crucial intertexts. Being aware of these ideas helped us in the formulation of culturally authentic and practice-worthy iterations of notation development that evolve from practice.

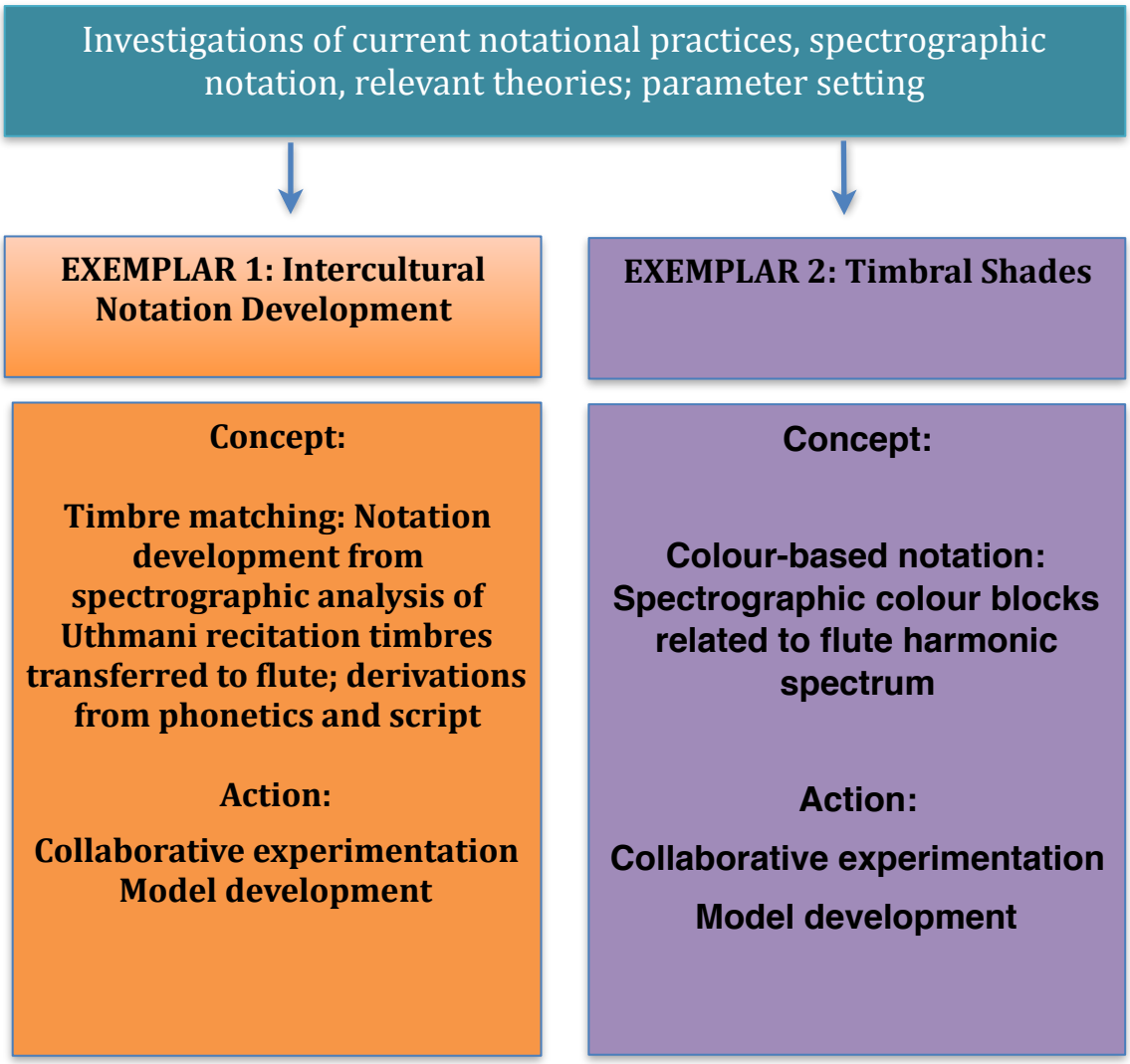
This project has also followed on from intercultural music research contained in the recent FRGS project, The Imaginary Space: Developing Models for a Malaysian/ Western Electroacoustic Music (2012-0028-107-02-FRGS, 2012-14) [13]Composer/ performer/researcher collaborations were central to this work, particularly in the first exemplar detailed below, where cultural elements and knowledge exchange were at the forefront of the concept development and performative practices investigated. As we have found, notation also deals with perception and inspiration.

The framework for sub-project 2 research (see Figure 8 below) began with investigations of current notational practices and spectrographic notation, theories, parameter setting and the decision to focus on new notations for flute works with two exemplar compositions.

Collaborative composers/ researchers on this project included Prof Hasnizam Wahid (UNIMAS, Malaysia) and Assoc. Prof Valerie Ross (UITM, Malaysia). These collaborations followed McCarthy and Wright's (2007) linear process of anticipation, connection, knowledge sharing, interpretation, reflection, and appropriation with the potential and aim of recounting through performance. Processes included initial discussions and concept development, recordings of flute techniques, recordings of vocal recitation, recordings of flute/voice matching, documentation of notations emerging, and generation of models for evaluation. It was planned that Assoc. Prof Hasnizam Abd. Wahid would use spectrograms in a unique way to assist with tonal matching of flute to *Uthmani* recitation units, and some preparatory work was undertaken toward this (see below); the other work has developed the idea of colour-based notation through spectrograms defining colour and the timbral intensity of flute harmonics.

[13] http://www.jeanpenny.com/uploads/5/5/4/3/55434199/the_imaginary_space_frgs_2014_(july_2015).pdf.

Figure 8: Research Framework Sub-Project 2



5.6 The Works: Two compositions, two directions

5.6.1 New intercultural notation development: Notating and relocating Uthmani recitation units with Professor Hasnizam Wahid

This phase of the project activated distinctive intercultural exchanges and synthesis of musical elements. Knowledge of language and sound, and new ways of thinking and perceiving sound occurred through exchanges and experiments in the studio. The aim was to generate notation from a variety of sources: vocal recitation, flute techniques, spectrography, and graphic recitation annotations.

The work was based around *Uthmani* vocalisation characteristics (vowels, articulations, pitch) and timbre matching on Western flute achieved via spectrograms of voice and flute recordings. We began with a recording of a flute line composed by

Hasnizam Wahid (see score of A Piece for Jeannie, Appendix 5.2). Questions arose, such as: How will timbral notation emerge from this? What is to be spectrographed? At this point the composer began the process of turning his methodologies around. Essentially we started again, with recitation recordings and spectrograms, followed by flute/voice tonal matching. We regarded this as a backwards method, working to superimpose notational timbres on a composition via knowledge of Arabic recitation and flute techniques, combining to create new timbres readable through spectrographic related music notation.

Spectrograms of each word and flute match were compared, revealing a strong similarity of sound envelope. This matching was difficult, and involved considerable re-thinking of flute playing techniques - especially mouth shaping, air and blowing techniques and articulations. The following list shows the phonemes with suggested phonetics and mouth techniques used in the transferral to flute.

PHONEMES

sin	long s, kick n	
zeil	tongue low to top of teeth (1) slow tongue, quick z with kick, taper (lengthen l)	
zeil	soft, tongue down; taper	
deil	Dael; normal d	
hor	gutteral	(Kghor) h-or
ha	(airy)	(Hah) wide embouchure < >
ghrein	(“French”)	+ slight flz and > n
rein	soft r, light	(Rhein) a-i
zor	air in cheek	(Zhoh) air puff z, clear (tongue down)
zor	airy middle	(Dzhor) puff and air
thor	cheek air	the tongue between teeth (back and down)
dot	tongue stop	
sot	tongue stop	
shin	lengthen n	

ARTICULATIONS: s, z (long), z (soft), d, h, ghr, r, z, th / n,l,r

VOWELS: i, ei, o(r), a, ai (ae), ai (ahi),o

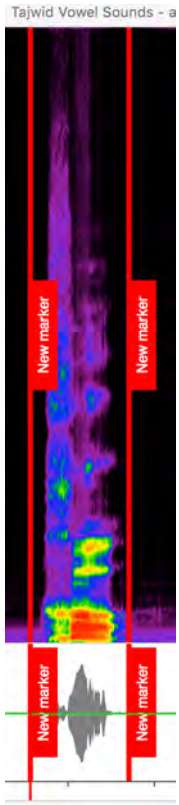
Learning to produce these words vocally informed the flute iterations through physical sensations (mouth formations, air speed, tongue positions, and a variety of sonic emphases) as well as aural acuity. Flute recordings made centred on mid register E flat, and timbral matching was visually assessed through sound envelope comparisons seen in the spectrograms. Refined sounds resulted from the image

matching as shapes were identified, with the attacks and fade out of sound units assuming great importance in addition to vowel shapes and lengths. These envelopes began to show ways for forming graphic notation. Following on from these was the production of combined textures of voice and flute sounds. With this, the notational inflections and meaning of vocal sounds were actively transferred to the instrument.

RECORDINGS AND SPECTROGRAMS OF *UTHMANI* VOCALISATION AND FLUTE TONAL MATCHING

The following images of spectrograms show vowel sounds which the flute player imitated while playing. The potential for this form of timbral notation from spectrograms is revealed in the following examples of '*Uthmani*' vocalisation, translated to the flute.[14]

Figure 9: Detail of Spectrogram of Tajwid Vowel Sounds - Har eAnalysis

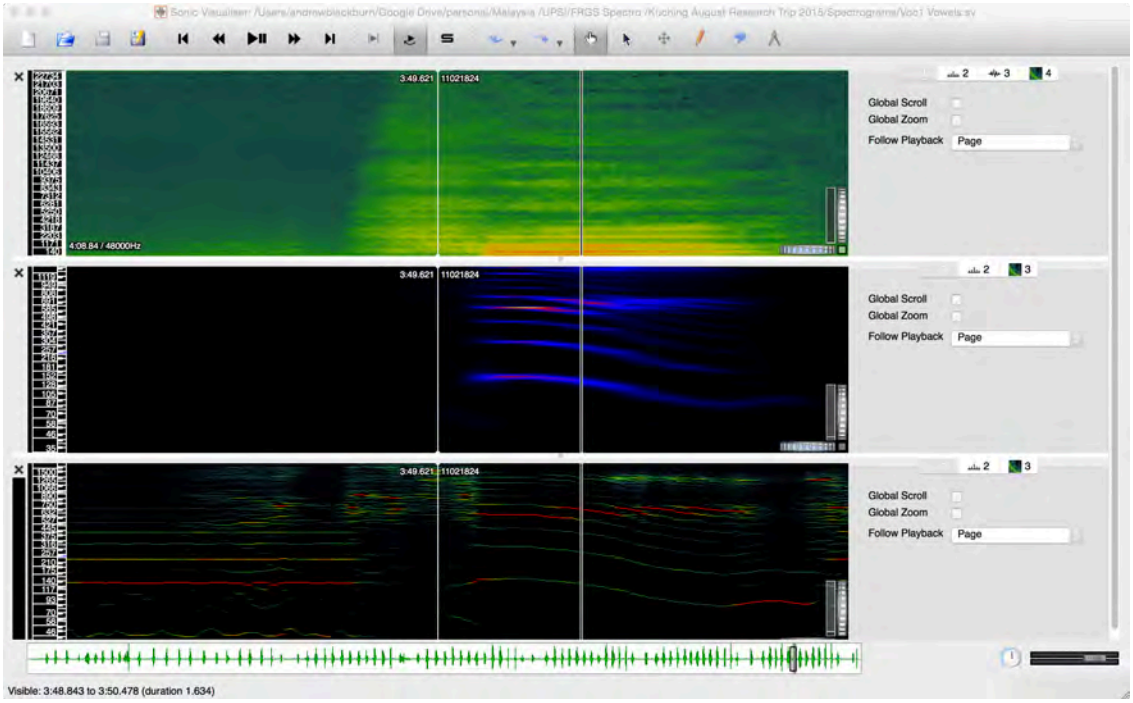


Between the first 2 spectrograms in this section - (fig.9 and fig.10) we see the similarity of shape of the ADSR envelope. Figure 9 shows the sample, spoken vowel used (Har) and the flute imitation of it. Note the airy breathy aspirate start to the vowel which moves into the voiced section and tapers off quite sharply. In the flute version - here spectrograph in Sonic Visualiser– we see a similar shape. While the timbre of the two

[14] The files of the original spectrograms are available at http://spectronotation.weebly.com/project-2-files.html Please note that the software needs to be installed and configured on your computer for these files to work.

samples differs between the two samples(a male voice, and flute) the similarity of the *shape* of the sound is surprisingly similar.

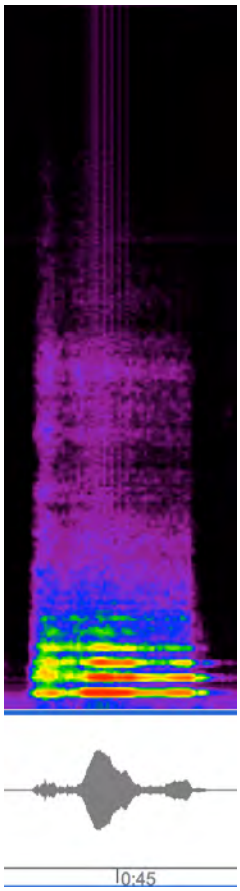
Figure 10: Flute spectrograms of Har (Sonic Visualiser) - note the similarity of ADSR visible between this and the previous image (fig. 4)



The soft sibilant opening here is quite apparent in the spectrogram, moving to the voiced central vowel (with the red tones). Notice the rapid increase of tonal richness above the red section (higher pitched overtones in purple and blue) which then fade out as the final ‘r’ is given. The sound quality of the note is seen to change dramatically through the note’s duration.

Being able to see the shape of these notes, and the way the timbre is changed during each, is a revealing point. By using known and learnt vowel sounds from the tajwid, the timbre and expressive shape of the note is also made consistent, and

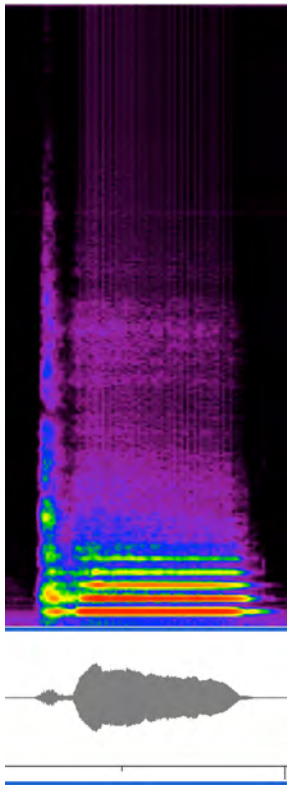
Figure 11: tajwid - deil - flute spectrogram (from eAnalysis) In this figure, the 'd' gives a hard, quite quick attack after which the note tapers off in the voiced vowel, and quickly decays as the 'l' sound is made. something the composer can work with - either over long notes, or strings of notes in a musical phrase.



This part of the project focussed on developing notational ideas that highlighted the significance of sonorities (eg. tonal flexibility, resonance, the effects of articulation, sound envelope matching), the connective experience of aesthetic and cultural blend, and new understandings emerging through Bakhtins' premise that meaning is a process of bringing together different perspectives and … forging understandings that lead to creative understanding (McC and W). These elements support the theory of the score as a cultural marker - demonstrated with the intertwining of *Uthmani* recitation and flute sounds, opening up a stream of enquiry based on the meaning and impact of this fusion and flux of techniques.

The intercultural premise of the work underscored the intension to develop new paths towards notation that impart timbral information for the performer. These experimental sessions of creating flute timbres that incorporate *Uthmani* vocalisation characteristics impelled thinking about the position of notation as a cultural artefact. If a timbral language theoretically relates performance to cultural sound (for example, Arabic recitation) will a composition that uses these sonic artefacts actually have a unique sound quality that in part represents an Arabic soundscape? Is it recognisable as such if transferred to another medium (ie. flute)? Can the composition be located within that culturally specific timbral sphere? Is it universalised? Do the transferrals of sonic

Figure 12 :zor - airy middle (flute spectrogram eAnalysis



inflections create new meaning through an altered timbral language? The outcomes could certainly be seen as inherently cultural - as voice and instruments are never culturally neutral - and representative of symbiotic engagement. The translation attempted here was not literal, but was founded on seeking new ways of thinking about interchange within a sonic framework. Taking a cultural perspective has enriched and broadened the research, and set up myriad avenues for further work in the field.

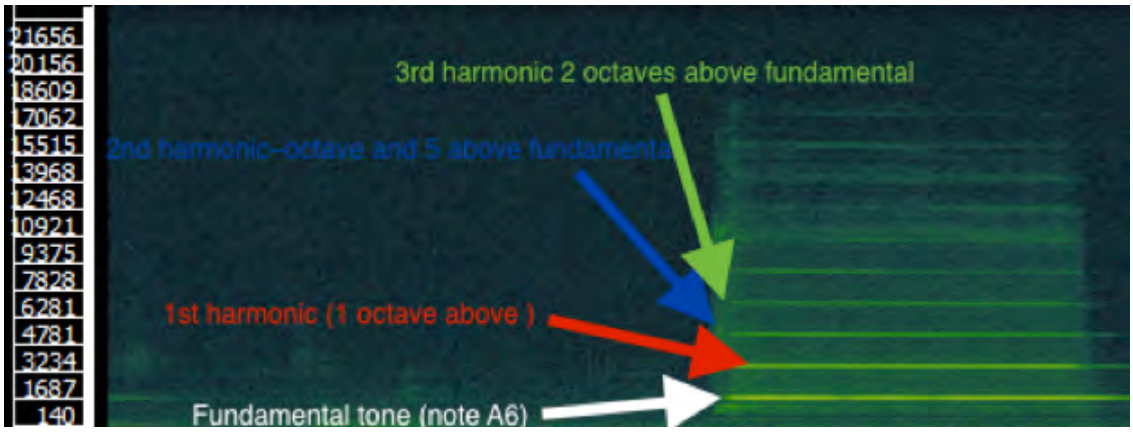
In the research for this project, we acknowledge the breadth of knowledge imparted to the investigation relating to Arabic and *Uthmani* recitation passed on to us verbally by Prof Hasnizam Wahid.

5.6.2 Spectrographic Colour and Harmonics: Structuring a colour based notation

The purpose of this work was the transformation of spectrograms into timbrally expressive colour structures for performative notation. People speak of timbral richness, hue, saturation, etc, in relation to spectrograms – but what does this mean for notation? Do pictures of intensity, of colours, represent the sound characteristics embedded in them, and how are these extrapolated out into readable notation? In the composition for this part of the project, *Timbral Shades* by Valerie Ross (see Appendix 5.1), existing flute techniques were re-worked through new modes of representation -

that is, colour streams. The flute harmonics created a timbral sound scape that was further enriched with alternative fingerings and the distinct colouration effect of microtones. The process of isolating colours based on the harmonic series was undertaken. The further isolation and choice of colours in Timbral Shades came after a process of score development through technique choice, spectrogram definition (colours) and composition. The composer's choices of the colour streams of red, blue and green represent a reduction of the idea of the spectrogram. In our discussions we focused on the first 3 overtones above the fundamental tone for the acoustic instrument. It is felt that for practical performance purposes, this was a reasonable limit to require for the project. (see Fig 7 below)

Fig 13 Spectrogram of flute note (top octave) note A with fundamental, and 1st, 2nd and 3rd harmonics (overtones) highlighted with suggested colours (flute: Jean Penny. Spectrogram: Sonic Visualiser)



The aim was to produce a score with 5 'staves:' from the bottom up, a Common Notation line; red; blue; green; then a graphic/text line for DSP/electronics. Score development occurred through technique choice (harmonics), spectrogram definition (colours) and notation of the composition.

Research Framework and Processes

Identification of instrumental tonal characteristics and variance

Tonal colouration - alternative fingerings / timbre explorations
Recording and spectrographing of timbral flute techniques;

Analysis of recordings / spectrograms

Composer development of timbral scores (red blue green)

Notation ideas and trials

The following flute techniques were recorded and spectrographed:

Percussion

Open key clicks [single, patterns (rain)]*; Fingered key clicks; Added tongue articulations; Added breath sounds; Added tone

Articulation

Voice - consonants [b, k, d, f*, g, h, j*, l*, m, n, p*,q*, r*, s*, t*, v*, w*, y,

z*, ka*, cha*, shh*, th…]

Strong breath accent without tongue; Pizzicato (tongue)

Aspirated

Vocalised (interrupting trill – strvtsvt…), Tongue rams, Tongue with closed embouchure hole; Flutter; poco flutter

Embouchure

Lips well apart, wide apart, moderately apart, slightly apart, closed; Oral cavity shapes, Vowel shapes; Jet whistles*; Modified lip pressure; lateral tensions; fingerings (bisbigliando); Buzz (tpt); Closed embouchure tonguing – part open (combined (pizz) with key clicks)

Breath

Breath/air tone, Inhale, Exhale, Under pressure (weak), Over pressure (extreme), Combined breath/normal sound/flutter residual tone; (unfocussed)/harmonics; Roar (inhale), Roar (exhale) and flz; Air pressure behind lips, Air stream horizontal movement, Saliva (in/out)

Fingerings

Diffuse, Bright, Bamboo, Trills (timbral) – normal/alternative fingerings (eg. Ab+RH3),

Hollow – alternative fingerings, Multiphonics, Thumbless scales with wind

Others

Pure, Pure + vibrato, Trumpet – flute without headjoint; buzz to flutter transition, Mouthpiece only – free, hand blocked, finger block, finger move

Phonemes (a single unit of sound from language), Voice and language

Imitative, Whistles – solid/noise, interrupted, Glissandi, Whistle tones

Harmonics with voice – unison, flute upper harmonics, voice holding fundamental pitch;

Multiphonics, Diffuse Ab, Trill/glissando

Recordings and Spectrograms

The following spectrograms with sound files (which may be downloaded from the Spectronotation[15] web-site and spectrograms show visual/audio examples to demonstrate the points above

This part of the project investigated the creation of timbrally expressive scores through spectrogram related colour scores. The functionality of the score relies upon performer understanding of the significance of the colours and how to translate this into instrumental sonic techniques. Whilst the colours can be evocative and suggestive to a performer, communication of timbral elements in this score remained intuitive and open to interpretation. Codification, therefore, requires further application and direction.

5.7 Concluding remarks

The two exemplars formulated as frameworks for this research have afforded ways to discover new ideas, new practices, and pathways for the future codification of timbre in notation of contemporary music. Differing perspectives and disciplines have been activated in this work, providing a plurality of response and a range of possible solutions and approaches. This sub-project has shown that "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" (Leman 2010), 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; as new dimensions evolve, new ways of thinking and living (and performing) result. These questions engage us with discovering the meaning of the music as new dimensions of musical practice open up.

Evolving questions for future research include:

How do these scores "activate the musician's ability to imagine and translate notation into a temporal unfolding of new knowledge and experience."

How do these scores represent "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."

[15] http://spectronotation.weebly.com/project-2-files.html Please note that these are eAnalysis files, and require the application to be installed and configured on your computer.

Chapter 6: Project 3 - Notating the timbre of Electroacoustic Scores

Researchers:

Dr Andrew Blackburn (UPSI) - leader

Participants:

Associate Professor Dr Pierre Couprie (Sorbonne University, Paris France)

Associate Professor Dr Hasnizam Abdul Wahid

6.1 Introduction

This project is in many ways, the most problematic of all the sub-projects. For a long time there has been argument about the best ways to notate electroacoustic music. …

Initially a definition of 'electroacoustic' music was required, for even the term itself has some elusiveness of meaning. Other writers in the English language find it has considerable 'value-loading': merely using the word 'electroacoustic' is a statement of attitude and approach. The research group decided to accept the definition of the term which is to be found at the Electroacoustic Research online site.[16] Its many and varied meanings are explored, and given here as the basis of the definition and understanding accepted by the researchers.

> This somewhat elusive term has evolved since the late 1950s, and attempts to define it have provoked much-heated debate amongst academics and practitioners. …
>
> The term saw early usage in the United Kingdom and Canada, and during the 1970s tended (amongst other terms) to be used in the French language (électroacoustique)…
>
> Some argue that the term is so elusive as to be unhelpful,…[while others] opt for the most general possible use of the word as an umbrella term (see 1 below)….
>
> In an attempt to illustrate nuance, the following four established definitions are offered below.
>
> > 1. Electroacoustic music refers to any music in which electricity has had some involvement in sound registration and/or production other than that of simple microphone recording or amplification. (Source - Leigh Landy (1999). Reviewing the Musicology of Electroacoustic Music. Organised Sound Vol. 4, No. 1. Cambridge: Cambridge University Press: 61-70)
> > 2. An adjective describing any process involving the transfer of a signal from acoustic to electrical form, or vice versa. Most commonly transducers, such as the microphone or loudspeaker are examples of this process.
> > Although the term most precisely refers to a signal transfer from electrical to acoustic form or vice versa, it also is often used more loosely to refer to any process for the electronic generation and/or manipulation of sound signals, including techniques of sound synthesis for the electronic or digital generation of such signals. When the purpose of such manipulation is artistic, the result is commonly called electroacoustic music. (Source: Barry Truax - Handbook for Acoustic Ecology CD-ROM Edition. Cambridge Street Publishing, 1999 - CSR-CDR 9901)

[16] http://www.ears.dmu.ac.uk

> 3. Music in which electronic technology, now primarily computer-based, is used to access, generate, explore and configure sound materials, and in which loudspeakers are the prime medium of transmission. There are two main genres. Acousmatic music is intended for loudspeaker listening and exists only in recorded tape form (tape, compact disk, computer storage). In live electronic music the technology is used to generate, transform or trigger sounds (or a combination of these) in the act of performance; this may include generating sound with voices and traditional instruments, electroacoustic instruments, or other devices and controls linked to computer-based systems. Both genres depend on loudspeaker transmission, and an electroacoustic work can combine acousmatic and live elements. (Source - Simon Emmerson, Denis Smalley (2001). The New Grove Dictionary of Music and Musicians - Second Edition. Ed. Stanley Sadie.)
> 4. (Electroacoustics) The use of electricity for the conception, ideation, creation, storage, production, interpretation, distribution, reproduction, perception, cognition, visualization, analysis, comprehension and/or conceptualization of sound.[17]

It was agreed that points 1 and 2 above relate most strongly to our needs in this project but, as Pierre Couprie eloquently states there is both a need for and inherent problems deciding on a notation for electroacoustic music when he writes:

> As primary and secondary sources, pieces of music (and their documentation) on a wide variety of media, and electroacoustic instruments, devices and technologies age, their archiving, preservation, digitisation, cataloguing and public accessibility become crucial issues for electroacoustic music studies (Couprie, P., 2007)

It is recognized within the wider academic community that the problem of notating electronic music is both pressing and significant. As the research group came to terms with this issue, another arose: in electroacoustic music, what is a score; what is a composition; and if the music is of a fixed type (defined in French by Michel Chion as l'Art de Sons Fixés[18]) or tape based, when is it performed? As many of the sounds are based on processing in some form, and then combined electronically on tape/cd, or computer disc, is it valid to say that when the tape is switched on, the work has been performed? In addition to these issues, the question also arises when attempting to archive, or notate electroacoustic music which is in the form of an application or a patch from within an application (such as Max/MSP, or Plogue): Is the notation the patch?; is it the sound output which is created when the patch is played/ or operated by a technologist?

French musicologist, Bruno Bossis observes:

> The intrinsic characteristics of the electroacoustic parts and their scoring create serious limitations. Furthermore, many sources remain inaccessible or are already lost. Thus the preoccupation with documentary sources related to the acts of creation, interpretation, and technological context becomes more and more pressing. It is now essential to formulate a synthetic vision of this music, which has existed for half a century, and to pursue the search for invariants. (Bossis B 2006 P101)

It is the pursuit of invariants which have directed the flow of this research, and the scale of the issues which are raised by this exploration which move the significance beyond the scope of this research project. The issues and attempts to scope what is required for the creation of a 'synthetic vision of this music' are the outcomes of the research.

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http://ears.pierrecouprie.fr/spip.php?rubrique125

[18] http://ears.pierrecouprie.fr/spip.php?article109

6.2 Aims of Research

The objectives of this sub-project are to investigate how a timbral notation system for electroacoustic music might be modelled through spectrography in novel ways. The major components of sound are pitch, amplitude, timbre, rhythm and space. Investigating and articulating the ontology of sound both theoretically, and present in the range of electroacoustic works, including Malaysian compositions, will suggest the parameters and requirements of a timbral notation model. It is intended that such a notation system will be independent of software and hardware which historically have a very short currency. It must also be universal, able to operate semiotically across time, culture and language. Inherent in this sub-project (as in all the sub projects of this study) is the development of optimal techniques and conditions for creating and assessing spectrograms of electroacoustic music.

6.3 Research Questions

1. What are, and how effective are, current notational styles used in electroacoustic composition?
2. What parameters and symbols of spectrographic analysis can be defined to provide useful and universally 'understood' symbols in notation using spectrographic softwares?
3. Can spectrographic analysis and software be used to provide a method for defining and identifying unique and individual qualities of an electroacoustic composition so that it can be accurately interpreted from such notation?
4. What are the elements that composers and performers require from a timbrel notation system, and how can these be represented?

6.4 Methodology

Drawing on the outcomes and definitions established in the opening symposium, the ontology and semiotics of a timbral notation system were refined through discussion and debate with the selected practitioners who are also researchers and participants in this study.

Experimentation of the optimal collection of sounds of electroacoustic music will be undertaken using extant compositions and newly composed works in a software context. The selected work will be performed through loudspeakers, and spectrograms created from within the playback of the software, but without playing back through speakers.

Through analyses of spectrograms, and discussion with project and sub-project participants and researchers, it has been hoped to identify and quantify ontological timbrel elements common in electroacoustic sound. An outcome of this step in the methodology will be to assess the uniqueness and individual characteristics that mark a sound (spectrogram) as electroacoustic (acousmatique).

In working with composers and performers of electroacoustic music, the specific and characteristic timbrel elements which allow communication of the composer's ideas in a performance or installation context will be established. Identifying how these elements operate in conjunction with each other is essential to the creation of a model for electroacoustic notation that can operate across culture, language, and time.

6.5 Findings

A number of works were analyzed for their potential as models. The works included electroacoustic compositions from French, Australian and Malaysian composers. The results were variable in their application to this project, highlighting issues that are explained in greater detail a little later in this section.

In a presentation to the Second Research Symposium, sponsored by this project and held at the University Education Research Laboratory at Sultan Idris Education University in December 2015, Prof Marc Battier (Université de Paris, Sorbonne) made the following observations:

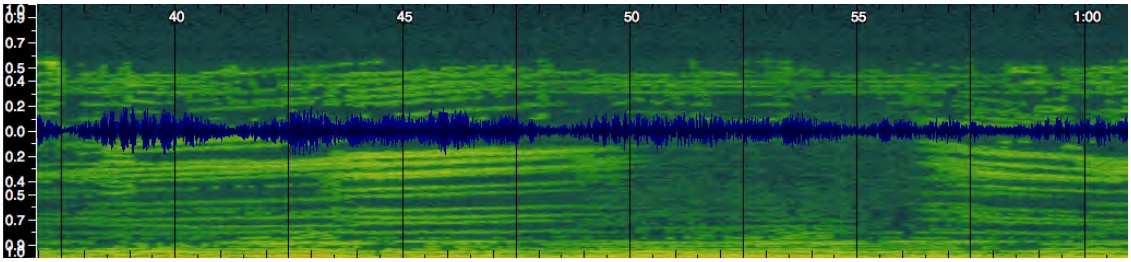
- When dealing with spectrograms, we are creating what is termed 'Visual sound' - but we must question – is it notation or representation? Spectrograms represent a sound that has existed and been detected and mapped by a software. Notation documents what needs to be done in order to recreate a sound - it is an object of 'infinite potential'.
- Visual sounds - part of EMS musicology [19]. Visual music is a larger set to which spectrograms belong
    - Very broadly, this is an area of audio-visual creation that is concerned with technological, metaphorical, analogical and imaginative mappings between visual images and music (and vice versa).Couprie 2007
- The usual function of a Spectrogram is as 'a point of embarkation' - it enables us to know what is happening [has happened] in a score
- Semiotics from many measurements.
- E.G. Software generated scores that are hard to read. Music III partial score is essentially a technical tool
- Space as a localisation system - external **Sound in Space** (Fr. le sons dans l'espace) - of use to engineers and developers
- Space as a component of sound: **space within sound** (Fr l'espace du son) - of use to composers and performers.
- Ideally the best tools and graphics will represent both types of space.

[19] Couprie P 2007 http://ears.pierrecouprie.fr/spip.php?rubrique1402

For the purpose of this report, researchers elected to focus on a single work by Malaysian composer Hasnizam bin Wahid *Solemn.* [20]

The spectrograms all belong to the category of 'Visual Music' elaborated earlier, and in particular remain 'analogical and imaginative' representations of what is occurring in the music at this moment. The spectrograms below are all of the same segment from *Solemn (*37.24 sec to 1.01.32) – a fragment of about 24.5 seconds duration from a work with a duration of over 17 minutes. The first example (Figure 14 below) is a full spectrogram, containing all the pitches – both fundamental and all the overtones or harmonics – detected by the application, with the wave form of the file superimposed in deep blue. The green and yellow chroma tones indicate various pitches (the brighter the colour, the more predominant the tone). The horizontal time scale is present in the white numbers and black vertical lines.

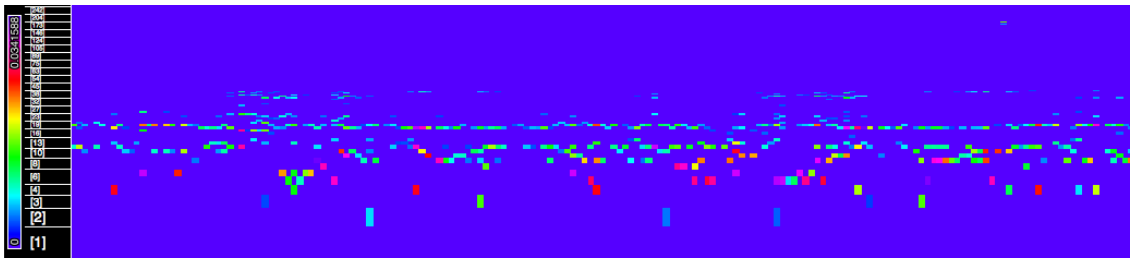
Figure 14 Wahid H Solemn Wahid H Solemn Wave form (in blue) and harmonic overtone series



Although this example contains much information, interpreting it as a score, even in conjunction with other information, does not reveal the actual detail of the sound itself. *Solemn* is composed for tape with a 12 channel playback system, so implicit in the reception of the work is the spatial quality and relationship between the sounds, none of which information is present in this, or any other, spectrogram.

The next spectrogram (Figure 15 below) indicates the onset, duration and amplitude of musical events. It does not indicate their duration, though through reference to the first, and other spectrograms this information can be elicited. Collectively, there is much information which can be discovered about the musical content and character of the fragment from these two examples, and the information is further extended by the next two spectrograms.

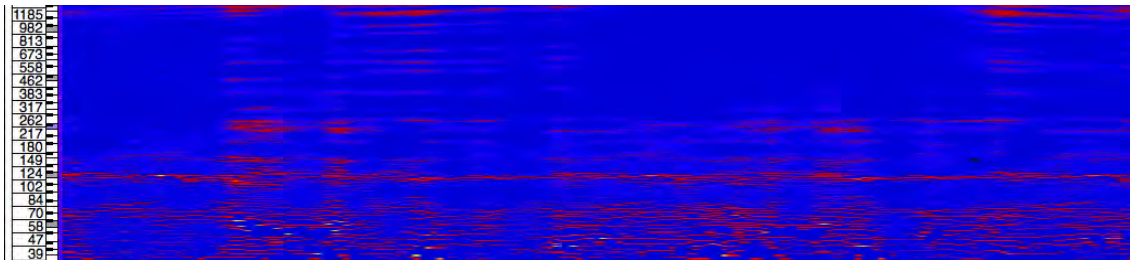
Figure 15 Wahid H Solemn Pitch and musical events



[20] The full spectrogram of the work is available online at http://spectronotation.weebly.com/project-3-files.html, and requires Sonic Visualiser Spectrogram software to be installed on your computer.

In the next figure below (Figure 16 the predominant fundamental tones are highlighted (mostly red, but the louder the tone, the brighter the colour, so there are some organge, yellow and green flecks that indicate the most dominant fundamental sounds at those moments), or a form of amplitude. What is not indicated in this spectrogram is the timbral quality of each fundamental tone, so this needs to be read in conjunction with (or overlaid on) the first example (Figure 14 above) which shows all the harmonics which are present.

Figure 16:Wahid H Solemn Predominant fundamental tones



Responses to Research Questions of Project 3

1. What are, and how effective are, current notational styles used in electroacoustic composition?

There has been some work undertaken in this realm, especially using the applications eAnalysis and Sonic Visualiser. The applications are capable of recording and mapping musical events, pitch shapes, and harmonic overtones. In practice electroacoustic works are commonly created and documented by creating a software patch and using that, combined with descriptive text documents, create a possible performance context. This process is effective and creates the possibility of skilled technologists recreating authentic performances of works. A disadvantage of the reliance on software or specific hardware devices is that in many instances, after several years the software or device may disappear. Unless the parameters of a historic device can be found and reproduced with whatever is then available, the work, if not preserved in this way, is lost forever. The research group identified that most electroacoustic creators use the method described above. Blackburn (2011) describes how four different composers approach the notation of the electronic part (live signal processing of a pipe organ) in their works. These are:

(i) a Software patch (SuperCollider) with event tracking and scene control by a technologist;

(ii) a Software/hardware system (Kyema) who's settings are manipulated by a technologist during the performance;

(iii) a text-based document that describes scene setups by precise parameter, making a system that is software independent, requiring major setup and then operation by the technologist during the performance and;

(iv) a gestural and graphic score for 2 technologists, within the organ score, allowing the technologist and organists to participate in a 'chamber music' style ensemble.

Each of these score environments offer similar information by providing the technologist with sufficient information to recreate the sound processing in real time, and both invariant qualities - the same signal process settings between performances, yet the flexibility of the difference between pipe organ sounds and the spaces in which the instrument exists. Developing a model which provides similar conditions for an electroacoustic and fixed music compositional environment is the essence of the challenge here.

2. What parameters and symbols of spectrographic analysis can be defined to provide useful and universally 'understood' symbols using spectrographic softwares?

A spectrogram is capable of providing a considerable quantity of visual information, making it a potential tool for the provision of symbols using a notation software. Tools within the software packages eAnalysis and Sonic Visualiser are available to visually map the musical structure, pitch profile, event onsets and more. These all provide powerful tools of analysis to provide 'a point of embarkation' - it enables us to know what is happening [has happened] in a score (Battier, M 2015). Both applications have drawing and text tools which enable the musicologist to insert additional marks and comments within the spectrogram. In a potential notation setting, these could be used to provide additional information to a spectrogram as score.

3. Can spectrographic analysis and software be used to provide a method for defining and identifying unique and individual qualities of an electroacoustic composition?

There is little doubt that a spectrogram is an ideal visual tool to create either a fixed or interactive video environment that analyses the salient musical features of any composition. It can allow the viewer to 'read' what is happening in the composition, and has the superficial appearance of a musical score. Changing from the analysis of a performance analysis to the potential of a score –a performance that is yet to happen– requires different levels of information.

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

This question follows on from the previous research: taking the identification of the features of an electroacoustic composition and converting this information to a visual representation that can be read and interpreted to independently recreate the same composition.

Detail which is sufficient for the interpretation of a score has one invariant that a visual spectrographic analysis does not usually provide: a level of detail which is sufficient to supply the interpreter with the information to reproduce the work, yet not so much detail that the score is only legible as a scrolling movie, and with so many layers of information. In Blackburn, A., (2011) *The pipe organ and real time digital signal processing,* considerable discussion is given regarding different and

idiosyncratic forms of notating the electronic processing of sound in a musique-mixte environment.

6.6 Reflection

During the research process for this, the last of the sub-projects of this overall project, a number of existential issues arose regarding the ontology of electroacoustic compositions and scores. Just what is an electroacoustic composition and how it can be articulated and defined was, and remains a clear problem. Some clarity of this is required before it is possible to consider before being able to assess the components of a notation system. What information is required in a score that might enable a performer to re-create the work without direct reference to the original version.

As noted earlier, these issues are recognized in the wider academic community and definitions have a fluidity about them- initially in deciding precisely what electroacoustic music is, and then deciding how to document it. The writings of Battier, Bossis and Couprie all attested to the issues that were confronting the researchers in this project It was realised very early on in the planning stages for this project that the research aims for this project were substantial, and with the limitations of scope of this project, were greater than could be achieved. It was hoped that the spectrogram might provide a vehicle to record the pitch shape, musical structure or events map, overtones and textures that would enable a technologist to rebuild a work from such a tool. Spectrograms are indeed able to indicate such information over a time period, but the complexity of most electroacoustic works - with their layers of complex sound that interact with each other, as well as in a spatial environment means that a spectrogram can only carry a part of the information required to achieve this.

The interaction of sound in space is a complexity in notation, and Battier (2015) points out that :

- Space as a localisation system - external **Sound in Space** (Fr. le sons dans l'espace) - is of use to engineers and developers

but in contrast

- Space as a component of sound: **space within sound** (Fr l'espace du son) - of use to composers and performers. (Battier 2015)

The difference of purpose here is important in the consideration of a notation system for electroacoustic music using spectrograms. The location of le sons dans l'espace, while there philosophical relationships that are beyond the purview of this project, are a question of the setup provided by engineers for a musical performance. A fluidity of the sound within the acoustic space is an extension of this, which composers will have some concern for: but related to the sound within the space, is the compositional concern of l'espace du son which is a musical textural element and, as we have demonstrated, even more difficult to notate through spectrogram. In a graphic musical score, it may be possible to indicate something of this textural quality with the composer perhaps indicating this by contrasting blocks or gestures and relying on the interpretative imagination of the performer to complete the instruction.

Whilst the other projects have yielded potentially functional models, this project and musical genre requires information too complex for a spectrogram to carry in a

visually accessible form. A practical way that the researchers consider that one could create a notational model for electroacoustic music is by using a combination of text and graphic forms. Such a combination would involve individual spectrograms showing pitch, musical events, texture, harmonics and all the information relating to sound elements, then be matched with a map for the spatialization of the sound output in a room, and finally access to a software that would automate the actions, events and processing of sound during the work.

In the next chapter, the models which are proposed for further development are elaborated, but this project, though it aims for worthy outcomes, it has not been sufficiently developed to propose such a model. The research group however emphasise that the project has been a very valid exercise as experience and knowledge gained has been applied in the models for the ethnographic and performance projects and proposed models.

Chapter 7: Conclusions & Models

7.1 Introduction.

This project has opened several possible directions for the development of timbral notation in each of the three areas (projects) of investigation: Timbral notation of acoustic music; Timbral notation of Musique-mixte; and the timbral notation of electroacoustic music composition. Each project has highlighted different issues pertaining to the overall issue of timbre discussed in the literature review. Indeed, determining the components of timbre itself has been, and remains, one of the major issues of the whole project. As the literature review itself reveals, the discussion is not new, and the research project has adopted something of the differing stances which have been highlighted in various literature approaches

7.2 Literature Review findings

This project has undertaken a very extensive survey of literature pertaining to notation (what is it, and what is being notated?) timbre (what organological musical features contribute to the knowledge, perception and understanding of timbre?). The survey has revealed recent theoretical, academic and philosophical understandings of these terms, tools and characteristics, allowing some conclusions of the whole field to be drawn. This scope and range of the literature survey has provided new understandings of what timbre is, its harmonic, spatial, and acoustic components, and how these all interact in complex ways to create the impression of tone (timbre). In turn, this knowledge has allowed the project's researchers to undertake the research required for each project and draw new knowledge that in turn allows for the creation of the models that are outlined later in this chapter.

We highlight the transdisciplinary, and intertextual findings which may be applied between sub-projects, and their relation to the findings of the literature review. Together, these lead to our understanding of timbre. From this understanding of the organology of timbre, we have developed models of timbral notation that have the potential for semiotic richness across cultures and communities.

7.3 Responses to Research Questions in each project

Project 1

1. How effective are current notational styles in representing the sound of Malaysian indigenous instruments?

The notation of traditional Malaysian music is largely based around forms of recording and recalling rhythm and pitch. There may also be some description of instrumental technique. This is useful at one level, but as is noted in the problem statement it does not define the timbre of the instruments to which it refers. It was observed that ethnographic researchers usually will describe the sound of an instrument using text. This is often done using metaphors or descriptive language or a local terminology to

describe what a sound is like. The current practice in Malaysia is that a sound is given a description based on the ethnomusicologist's understanding. Such descriptions are verbal and as such are likely to be perceived differently by others. In this respect, spectrograms have been used to objectively describe the organology of instruments of other cultures but not in Malaysia. It is suggested that a further study be undertaken to create a catalogue of traditional Malaysian instruments, which can be used as a reference point for future and other studies.

2. What organological elements within each sub-project are common or exclusive to each instrument, and how can they best be identified and analysed?

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

Spectrograms have their own language and terminologies which allows interpretation and description across a variety of application. In other disciplines, such as speech therapy. Bullock (2011) asserts "… acoustics tools are not just useful in university research labs. Spectrograms provide valuable biofeedback information that clinicians can use to remediate tough speech errors …."[21] We found that the spectrogram provided objective descriptors of the sound qualities of Malaysian indigenous instruments that were valuable to the needs of ethnomusicologists. The objective quality of a spectrogram, when used to reveal the overtone/harmonic quality of an instrument, was found to be helpful to the ethnographic researcher. Being able to be configured to the needs of the user/recipient, means that spectrograms have a potential functionality in research lexicon of the ethnographer. The project is also open-ended as, in Malaysia, little work has been undertaken to map the sound of Malaysian traditional instruments. The opportunity afforded by this research, and highlighted in the Malaysian Music Journal article (see Appendix 3.2) suggests it is an area that is ripe for additional research.

4. 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?

To become a notation system that is applicable to performers in this ethnographic context, as well as other applications of interest in this research (and which is the research goal of the other sub-projects), any notation system needs to provide additional information.

Pierre Couprie (2016) [22] very pertinently to this sub-project (and the other sub-projects) writes

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[21] Bullock, J. 2011 p.2.

[22] Couprie, P. 2016 p 175.

…we need to create suitable representations: sound representation, line and form/ structure charts, graphic representation of units or moments. These representations need also to integrate images or other representations of performance … [It] is not only a graphic representation with beautiful shapes in various colours, each of them representing a sound. Representation can also include sonograms, curve charts of audio descriptors, …

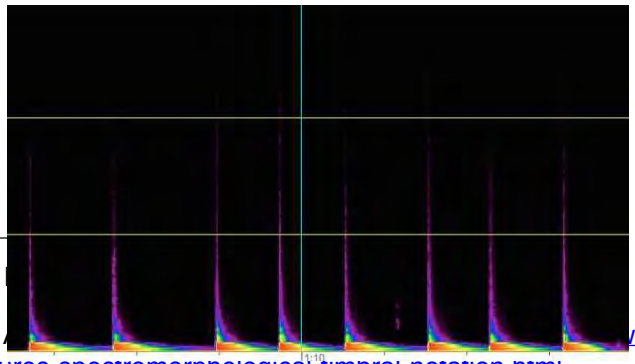
Notation, being the representation, and transmission of a composer's musical ideas to a performer (or other receiver), must be capable of being able to communicate itself in ways that have semiotic and perhaps an aesthetic immediacy. So, just what is being represented will depend on the circumstances of the notation (in this instance, Couprie is describing musical analysis). There are a variety of tools which the ethnomusicologist has at their disposal, but the spectrogram is one that can provide a reproducible sound image, which as we have demonstrated, has validity and value for the ethnomusicologist, in addition to the performer and instrument maker. The spectrogram can therefore be used as a form of timbral notation, perhaps in combination with other time-based tools available in software such as EAnalysis.

5. What parameters of analysis can be defined to provide useful and universally 'understood' symbols using spectrographic softwares?

In studying the spectrogram of various recorded sounds of a gedombak, we noted the following in reference to the preferred sound of our Wayang Kulit performer having these characteristics:

> a strong attack (onset) that is followed by the most rapid decay of all the samples shown in the spectrogram (See Figure 17) ; the fundamental tone, indicated by the brightest colours (red, yellow, green and blue) is also the most evident in this sample; the decay (length of the sound before it is finished) is the shortest of all the samples in the spectrogram; the harmonic overtone series, as indicated by (especially) the height of the purple column, is at least as rich as any in the samples. Although the 4th beat sound (preferred by our expert performer) has quite similar fundamental tone and overtone characteristics to the 8th beat (the last) the 4th beat has a significantly faster decay. (Abdullah H and Blackburn A. (2015) [23]

Figure 17: Spectrogram of a gedombak [24]



23

24 ww.andrewblackburn.org/article-figures-spectromorphological-timbral-notation.html

So, visually we have a set of analytical parameters that can be reproduced by a performer drawn from a spectrogram. One could develop this as a model or 'shape' of a sound. Though not developed as a model in the outcomes of this research, such a graphic form of notation, with, or without the addition of some colour element for harmonics emphasis, is a possibility for further exploration. The concept was reflected upon and explored by the researchers, and it became the genesis of the colour model which is presented below as a 'colour notation' model.

> How can this notational system help scholars, musicians, instrument makers and others in identifying a preferred timbre for any particular Malay traditional instrument?

Our research has demonstrated a process by which a preferred timbre (either by instrument or performance technique) can be objectively and reproducibly identified. With further development, as recommended above, it follows that in having such a tool, interested parties can use it to identify and create a notation system for this purpose.

This initial sub-project was always intended to open the larger research project. It's objectives in this research was twofold: first as a means of creating a symbiotic graphic notation that would objectively enable Malaysian traditional musicians, instrument makers and scholars to identify an 'ideal' sound or preferred sound for the instruments; secondly, the sub-project was intended to act as a springboard for the development of possible notation and composition/performance models in the second and third projects. In both these objectives, the outcomes have been successful.

Project 2

The three main objectives were met through recordings of flute and voice, spectrograms of the recordings, and notation experimentation deriving from these. Each of the prototypes for notation sprang directly from performance practice (contemporary extended techniques and Arabic recitation), creating a basis for composition and evaluation. New ways of approaching the issues of timbral notation were activated, particularly through culturally distinct sound artefacts, and these in turn provoked new ways of playing and producing sound.

Research Questions

1. How effective are current notational styles in representing and articulating the sounds of instruments?

It was agreed that current notational styles for timbre are imprecise and open to wide interpretation. The purpose of this research was to address this problem through spectrogram based notation.

2. What information about instrumental sound do spectrograms give us?

A significant amount of research has been done in the domain of creating and digitally analysing instrumental sound through spectrograms, including the pioneering work of

Jean-Claude Risset (1978/99). Visual information about spectral density, texture, shape, and so on does not necessarily translate to readable notation, however, and the difficulties of transforming time based spectrograms into notation is well known, calling for great innovation in research. The information taken from the spectrograms for this project lead to the notation approaches taken by the composers, and has opened up specific pathways for further research.

3. How is timbre captured by spectrographic representation? How can this be notated?

In this sub-project, two major timbre worlds were explored: the blend of *Uthmani* recitation sounds with flute, and the harmonic series. The timbral elements of these captured by the spectrographs lead to the two different foci. In the first example, spectrograms were initially used for comparison of sound, blending of sounds, and ideas of how these might progress to notation. In the second example, the spectral colours of the harmonic series shown in the spectrograms of flute sounds were used to create a score that attempted to articulate timbral information through colour and intensity. This score was accompanied by a significant amount of annotated explanation of the meaning of the colours.

4. How can spectrographs work as performative scores? How can they be read? Is this functional in a real-time setting?

As notation has a major real-time function in music performance, the ability to read a score *in situ* is vitally important. Spectrograms are pictures of sound that has already sounded; scores create the potential for the realisation of the sound. In this project spectrograms were used in the exploration processes rather than as a score outcome. This question therefore remains, as the fundamental research moves towards the production of performance-ready scores in the future. Evaluations can then occur regarding the efficiency and clarity of the notations.

6. Are the visual representations of timbral characteristics dependent on vast arrays of instructions (eg. pages of explanations, recording or video demonstrations in the score)? Is there a code that we can develop?

It appears, from the two projects undertaken here that a significant amount of accompanying explanation is necessary with this notation. Whilst this may not present as a problem, the codification of notation will ideally become more universal and recognisable in this respect.

Project 3

1. What are, and how effective are, current notational styles used in electroacoustic composition?

There has been some work undertaken in this realm, especially using the applications eAnalysis and Sonic Visualiser. The applications are capable of recording and mapping musical events, pitch shapes, and harmonic overtones. In practice electroacoustic works are commonly created and documented by creating a software patch and using that, combined with descriptive text documents, create a possible performance context. This process is effective and creates the possibility of skilled technologists recreating authentic performances of works. A disadvantage of the reliance on software or specific hardware devices is that in many instances, after several years the software or device may disappear. Unless the parameters of a historic device can be found and reproduced with whatever is then available, the work, if not preserved in this way, is lost forever. The research group identified that most electroacoustic creators use the method described in Chapter 6 above.

Each of these score environments offer similar information by providing the technologist with sufficient information to recreate the sound processing in real time, and both invariant qualities - the same signal process settings between performances, yet the flexibility of the difference between pipe organ sounds and the spaces in which the instrument exists. Developing a model which provides similar conditions for an electroacoustic and fixed music compositional environment is the essence of the challenge here.

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

A spectrogram is capable of providing a considerable quantity of visual information, making it a potential tool for the provision of symbols using a notation software. Tools within the software packages eAnalysis and Sonic Visualiser are available to visually map the musical structure, pitch profile, event onsets and more. These all provide powerful tools of analysis to provide ‘a point of embarkation’ - it enables us to know what is happening [has happened] in a score (Battier, M 2015). Both applications have drawing and text tools which enable the musicologist to insert additional marks and comments within the spectrogram.

3. Can spectrographic analysis and software be used to provide a method for defining and identifying unique and individual qualities of an electroacoustic composition?

There is little doubt that a spectrogram is an ideal visual tool to create either a fixed or interactive video environment that analyses the salient musical features of any composition. It can allow the viewer to ‘read’ what is happening in the composition, and has the superficial appearance of a musical score. Changing from the analysis of a performance analysis to the potential of a score –a performance that is yet to happen– requires different levels of information.

So, during the course of this project, it became apparent that, though spectrograms are an important component of a possible timbral notation for this genre, the complexity of the music, its cross-over of different technologies, space, and source sound materials

demands a notation system that reflects all these and other possible elements. It was felt that the scope of this facet of our modelling was beyond the self-imposed scope of the project. In a potential notation setting, these could be used to provide additional information to a spectrogram as score.

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

This question follows on from the previous research: taking the identification of the features of an electroacoustic composition and converting this information to a visual representation that can be read and interpreted to independently recreate the same composition.

Detail which is sufficient for the interpretation of a score has one invariant that a visual spectrographic analysis does not usually provide: a level of detail which is sufficient to supply the interpreter with the information to reproduce the work, yet not so much detail that the score is only legible as a scrolling movie, and with so many layers of information. In Blackburn, A., (2011) *The pipe organ and real time digital signal processing*[25], considerable discussion is given regarding different and idiosyncratic forms of notating the electronic processing of sound in a musique-mixte environment.

7.6 Models

Four primary models are proposed for exploration of timbral notation.

7.6.1 Ethnomusicological timbral modelling

The model which was agreed by the researchers is best explained as a practice which can be adopted by researchers, and the target audience of the research (ethnographers, musicians and instrument makers).

For performing musicians and instrument makers, cataloguing all the instruments in a traditional Malaysian ensemble (for example Wayang Kulit (see Abdullah 2004) or gamelan, and decisions on the preferred sounds or tunings made by expert performers in the field. There are some potential disadvantages in that codifying so-called 'ideal' sounds and timbres may lead to a uniformity of instrument making and performance

7.6.2 Colours notation model

The second model explored in this research is a form of notation which proposes that colour be used to highlight the combination of harmonics to a given 'pure' note. In its original iteration, this model is intended as a form of timbral notation that can be applied in acoustic/musique-mixe environments. It was first proposed but the project's

[25] http://www.hutes.com.au/PipeOrgan/wp-content/uploads/2011/08/Andrew-Blackburn-Organ-and-Realtime-DSP-print-version-a-.pdf

lead researcher (Dr Andrew Blackburn) and researcher (Dr Jean Penny) at the TENOR 2015 conference in Paris.

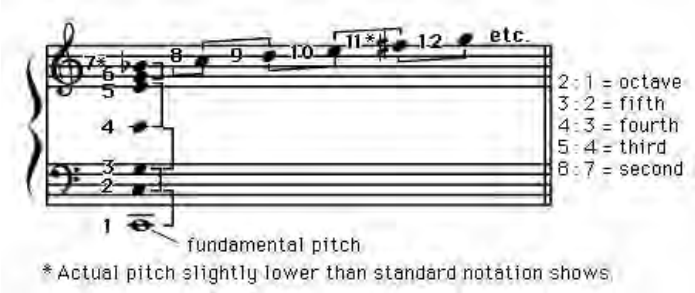
Sound and Overtones (harmonics) are produced when molecules in the air are disturbed by some type of motion. When a finger picks a guitar string, the entire string starts to move back and forth at a certain rate. This rate is called the frequency of the vibration. Because a single back and forth motion is called a cycle, we use a measure of frequency called cycles per second, or cps. This measure is also known as Hertz, abbreviated Hz.produced by a vibrating object.

If the simple back-and-forth motion of the string was the only phenomenon involved in creating a sound, then all stringed instruments would probably sound much the same. We know this is not true, of course; the laws of physics are not quite so simple. In fact, the string vibrates not only at its entire length, but at one-half its length, one-third, one-fourth, one-fifth, and so on. These additional vibrations (harmonics) occur at a rate faster than the rate of the original vibration (the fundamental frequency), but are usually weaker in strength. Our ear doesn't hear each frequency of vibration individually, however. If it if did, we would hear a multinote chord every time a single string were played. Rather, all these vibrations are added together to form a complex or composite sound that our ear perceives as a single tone.

The combinations and relative strengths of the harmonics of any sound determine the 'timbre' of the sound. Of course, there are many other factors at play here, such as acoustics, diffusion, locations and so on. For the purposes of this Project we are developing a notation that encourages the creator/performer to actively consider the characteristics of the harmonics which are present in their instrument, and emphasize (or reduce) the presence of specific harmonics.

This will require players to develop new performance techniques, and creators to be aware of the possibilities of each instrument. For this project the instrument being used as an exemplar is the flute (Jean Penny).

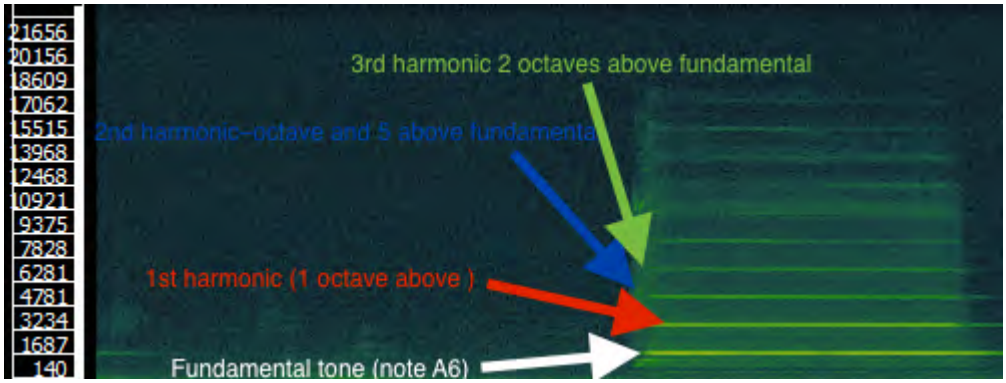
Figure 18: The overtone series is shown here (from Encyclopedia Britannica and a more complete explanation is available here)[26]



In our discussions we have focused on the first 3 overtones above the fundamental tone for the acoustic instrument. It is felt that for practical performance purposes, this is a reasonable limit to require of instrumentalists. (see Figure 19 below)

[26] http://global.britannica.com/science/overtone-series

Figure 19: Spectrogram of flute note (top octave) note A with fundamental, and 1st, 2nd and 3rd harmonics (overtones) highlighted with suggested colours (flute: Jean Penny. Spectrogram: eAnalysis)



The second project uses musique mixte as the genre of its exemplars, so the DSP and live processing can use the other (higher) notes of the harmonic series given in Figure 19.

The concept of tone colour is not at all new, and, for example, a well developed concept in flute performance practice. Since at least the time of Varese, flautists have fully exploited varieties of colour and colourlessness, and this has transferred into the flute and electronics sphere with great success and with many compositional outcomes.

Pedagogical texts, such as Trevor Wye's Practice Book for the Flute series, present ideas of tone colour and variation to the student with an urging to "play in technicolour". As in the ethnomusicology sub-project, we are challenging metaphorical descriptors that these texts and compositions might proffer - such as "hollow tone", "pure tone", or "deep dark green" (as we find in the Wye books) or suggestions of mood and colour from such terms as 'schivo', 'altrove' or 'vorace' (as we find in the score of Marco Stroppa).

These evocative words may stimulate the individual imagination of the performer, but what do they actually mean? - and how can we discover just what a particular colour might sound like? The process of drawing semiotics from a spectrograph opens up an opportunity to explore colours and their relation to sound, and in the process create a newly informative element of score.

The spectrogram of embouchure disruption tone on a concert flute (Figure 19 shows: A relative richness of the first 4 notes of overtone series - then fades away after that.

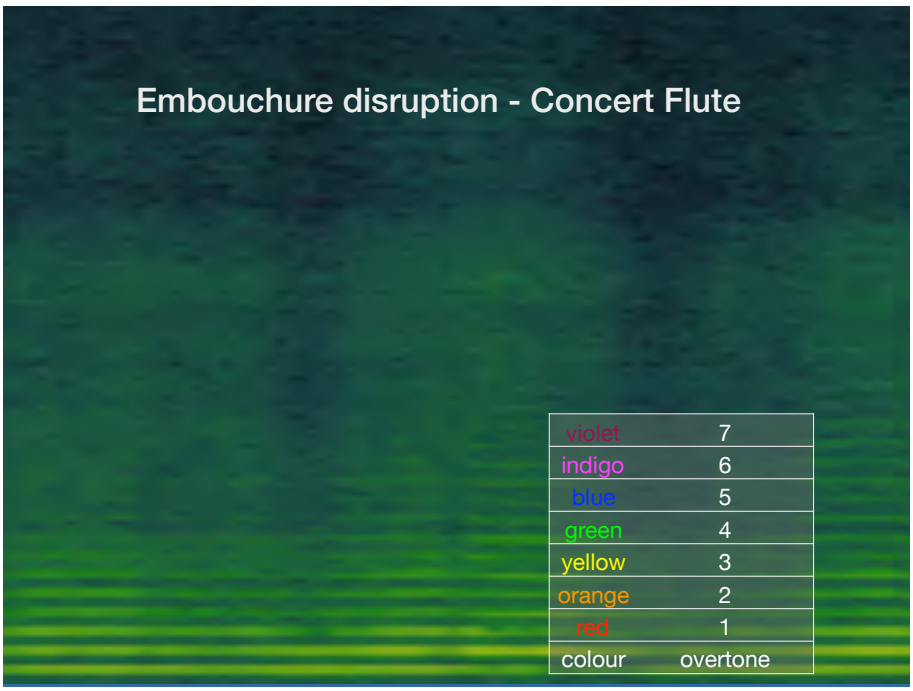
Using the Rainbow colour spectrum as a way of assisting the performer to create the desired timbral quality: ROY G. BIV. R=red, O=orange, Y=yellow, G=green, B=blue, I = indigo, and V=violet. Red being at the top edge of the rainbow and violet is at the bottom edge, with the other colors in between. See Figure 14 above.

How this will be represented in the score is something which requires additional research in subsequent projects. A major requirement for notation based on this system is the need for the graphic quality of the notation must provide a semiotic richness to the performer. Instrumentally, the performance techniques required to create the given timbre quality will need to be developed for each instrument. Equally, the characteristic instrumental tone will not be 'lost' however the player can apply performance

techniques which emphasise the specific tones within the overtone series can be indicated.

Can this information be verbally represented - while leaving much to the performer's imagination. Where acoustic and electronic sounds merge, it may be that the notational indications of timbre, in general become the 'property' of the software or mixing desk - the programmed effect - rather than the instrumentalist.

Figure 20 Embouchure disruption - Concert Flute Showing the flute basic tone = 'pure' sound - a sine wave with strong 1st, 2nd and 3rd (red, orange, yellow) overtones.



Central to this project is the score – what is it, and what relationships do various music 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. 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".

Yolande Harris (214) argues that sound "binds people together in space in a contextual manner" . 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 2008).

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, 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 (Penny 2015)

These are well-understood concepts, which confirm our (Western) cultural understandings of the ontology of a musical score.

What does the score (as artifact or 'thing') mean within non-Western, oral-based cultures?

So, How can spectrograms be used to create a performing score?…

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

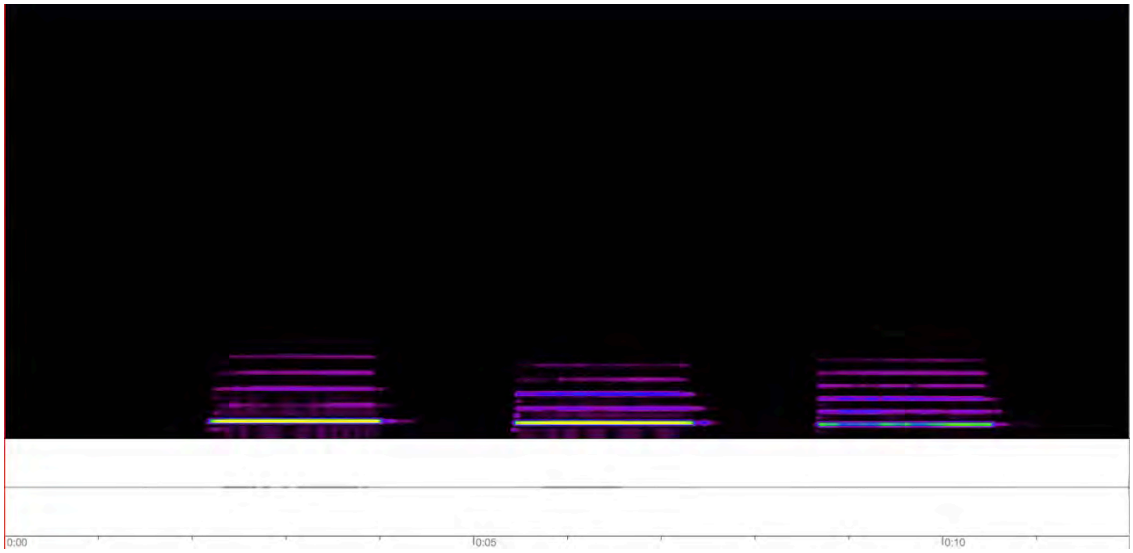
[sound and notation - "both constitute inseparable entity" (Cage 1958).]

We have begun by taking spectrograms of a flute, and examining the characteristics and possible

This spectrogram in Figure 21 (below) is of 3 'normal' middle octave flute tones.(B–A–G) The 2nd note has a dominant 2nd harmonic (bright purple)

If we 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 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.

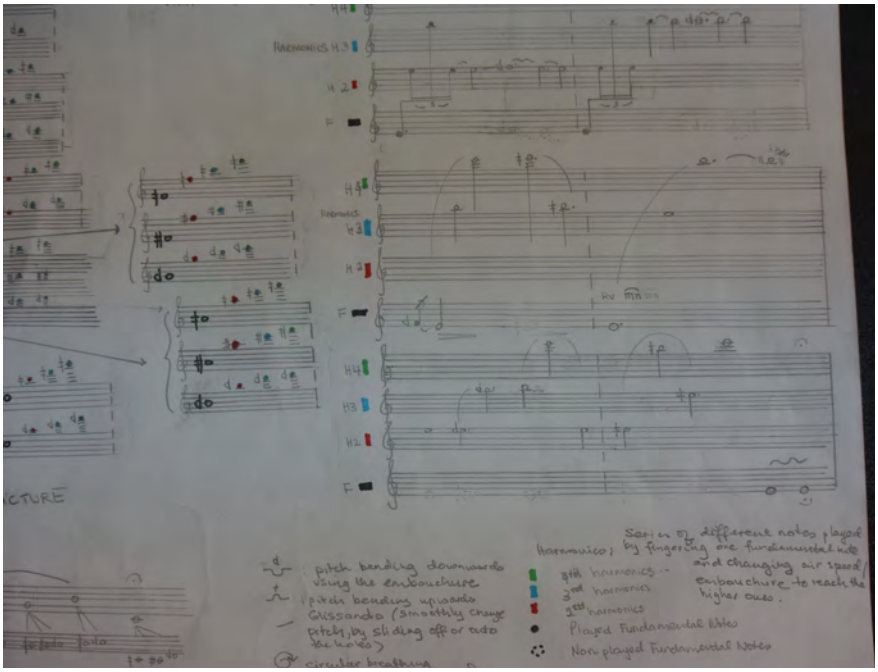
Figure 21: Spectrogram of flute Middle Octave B - A - G.

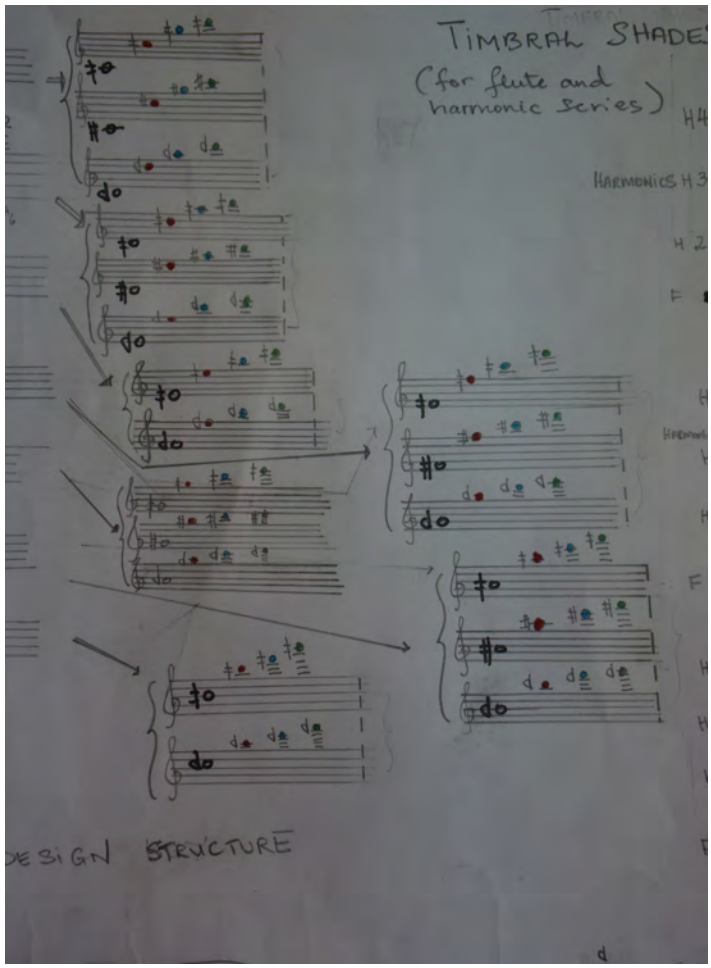


7.6.3 Harmonic series notation model

The detail of this model in the previous section. Below (Figure 22) are two detail images from the score of *Timbral Shades* which is the exemplar work for this model.

Figure 22: Annotated instructions in Valerie Ross composition, Timbral Shades.





Constraints During Research.

The project contains a number of research threads which were explored through a series of projects that are outlined below. The research directions of these projects were beginning to provide fruitful outcomes and models for further exploration. These models remain valuable as a basis for future research projects and direction.

Timbral notation for instrumental performance model is potentially a very rich vein for research. The intention of the *Developing Timbral Notation for Performance* project is to create additional chroma-based notation, which the composer/creator could indicate to the instrumentalist which partials they should emphasise in performance. It is realised that this will require the individual performer to develop new performance techniques and capabilities which simultaneously provide the composer with an additional tonal palette to work with. It is also anticipated that such a notation could have considerable effect in works that combine acoustic instruments with electronic processing (both fixed and live digital signal processing).To explore this further, a number of the collaborative researchers offered to compose new works that experimented with the idea. The Principal researcher (Dr Jean Penny) worked with both collaborator researchers Associate Professor Dr Valerie Ross (UiTM) and Associate Professor Dr Hasnizam Wahid (UniMAS) in researching and extending this concept. Sadly, neither composer completed works that could be presented and performed in any of the research symposia, so this remains another area for extended research..

As this final modelling phase was being reached in this project, the lead researcher (Dr Andrew Blackburn) and a Principal Researcher (Dr Jean Penny) both returned to Australia for critical health treatment. For about a year the project largely ground to a halt, and now (in June 2017) the final report has been prepared from Australia. It is to be hoped that further research will be undertaken to further develop and apply the models that have been proposed in this document.

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Appendix 1 Seminar 1 report

Appendix 2 Seminar Report 2

Appendix 3 - Conference Presentations

TENOR2015 Dr Andrew Blackburn & Dr Jean Penny

TENOR2015 - Assoc. Prof Dr Hassan Abdullah & Dr Andrew Blackburn

5 Publication List

Appendix 7 Scores

1. Valerie Ross *Timbral Shades*
2. Hasnizam Abd Wahid *Piece for Jeannie*

Appendix 1 Seminar 1 Report - June 2014

Date: 26 - 27 June 2014

Location: Universiti Pendidikan Sultan Idris, Tanjong Malim, Perak, Malaysia.

Researchers:

Dr Andrew Blackburn (Project leader) - UPSI; Prof Dr Marc Battier (Université Paris-Sorbonne); Associate Professor Dr Mohd. Hassan Abdullah (UPSI); Associate Professor Dr Valerie Ross (Universiti Teknologi MARA); Dr Jean Penny (UPSI); Associate Professor Hasnizam Wahid (Universiti Malaysia, Sarawak).

Student Assistant - Oskar Musaev (UPSI). Hafifi….

Notes from researcher presentations

Andrew Blackburn (Project Leader)

Methods are grounded in practice (ie. Practice-led): Thinking through practice; analysing through practice. Each project is grounded in the practice of the researchers - we believe this is a point of differentiation to other projects. Can we use new works/ performances to model a new timbral notation?

Is it possible to take a sonogram and turn it back to sound?

Look at forms of timbre notation being developed (Paris EMSAN Music Notation Group, Adelaide {Coaldrake})

Performance notation should include timbre, phrasing, duration, timbre and pitches.

This research project aims to create a model for a timbral notation system that addresses a need for usability in performance, analysis, and providing a clarity of communication and longevity of technological scores. An ethnomusicological and electroacoustic music focus will be taken, and model(s) of timbral notation proposed.

Existing music notation systems allow musical ideas to be communicated across time and geography. Notation and analysis of timbre, however, does not exist. This is significant in several fields that are important in Malaysia and Europe:

> Ethnomusicology (Cultural Musicology)–a lack of quantifiable ethnomusicological knowledge of traditional musical sounds and instruments,
>
> Electroacoustic and Musique-Mixte–the inability to reproduce electronic sound due to the demise and obsolescence of software, hardware and electronic storage systems.

The project will utilize timbral analysis through spectography to investigate the organology and ontology of sounds. The notational needs of music practitioners, composers and researchers will be assessed and, in the light of this knowledge, we aim to propose a system of musical notation which is independent of music creation software.

Three phases will cumulatively document, analyse, apply and reflect on project activities and outcomes. Critical reflection is a key criterion of the research, supported by textual analysis. We will articulate how practice is an integral part of the research, and the creative and/or performative aspects of the research will be made explicit in relation to research questions, issues or problems, outputs and outcomes, research methods and approaches.

Prof Dr Marc Battier

Preservation of score is a big issue - has issues for notation

Multi-dimensional approach needed to analyse sound

Spectrogram provides a ‘point of embarkation’ - know what is happening in a score

Malt - Interpretation of the criteria of sound and analysis

a knowledge ‘problem’ - our knowledge as ‘performer’ composer’ of the sound\/ acoustic criteria - but which criteria are meaningful for the musical environment?

How do we perceive sounds? - WHAT we hear and the NATURE of sounds

> There is a huge list of sound descriptors. It is developed by acousticians and psychoacousticians.

Composers/researchers need to talk with sound engineers using their 'audio' terms in order to make their requests more precise.

Dr Clare Chan (Sub Project 1 - Cultural Musicology)

No notes presented

Associate Prof Dr Valerie Ross (Sub Project 2 Electroacoustic composition)

It is suggested to replace the term 'ethnomusicology' with 'cultural musicology' to avoid the idea of 'Westerners' studying 'Orientals'

The approach to question 2 and 3 is to 'talk to other people'.

Some scores are meant for technicians, which puts them almost in the place of a performer.

Question: In which case will this notation be useful.

What kind of information would you expect from such a score? Spatial Density?

Project 3:

1st question is a “Literature Review” type of question.

Best software could be Spears rather than Eanalysis.

Comparison between Western and Quranic ‘Classical Arabic’ form of notation. Can something useful be developed from this?

Similar symbolic systems - Indian Raga, Gamelan Nemonic, Arabic, Raga, Melismatic Chants, Cantonese Operas and Japanese symbolic systems

How to apply this for instrumentalists?

Take similarities between Arabic, Raga, Melismatic Chants, Cantonese Operas and Japanese symbolic systems.

Collect the sounds into a 'timbre bank' aka. 'Sample Bank'

Try this out for a single flute piece to see the outcome.

Perhaps along with the sample bank, sonographic images can be added.

Mouthshapes can be photographed and recorded (Anatomy & Linguistics) ie. Cantonese Opera and Arabic. - aka“Notation from languages & Anatomies”

Question 3: It is not recommended to capture spectograms from the acoustic environment of a performance.

Spectograms should be created from a software environment.

Question 4:

We are trying to look for a 'form' of notation of sounds, not simply sounds.

Present systems are approaching this issue by providing instructions on what to do, but the resulting sound is not known.

What do you have to have in a sonogram to have it useful and what do you have to leave out?

There is a problem with the lower range being compressed and difficult to read in a sonogram.

There is a need to notate the pitch, timbre and at the same time a time scale.

There is a need for a balance between the pitch definition and the time definition.

A need for a creation for some set of symbols from Arabic, Cantonese & Indian languages, anatomy of mouth shapes (from Cantonese opera) and hand signals from the Indian Raga. Also to draw from the indigenous instruments of Malaysia.

Vocalization- Valery will get the best people of these languages into the recording studio by the end of August and September.

Need for budget allocations to pay for recording and performers

Notation of process rather than the results.

Technology constantly evolves so results always change.

Good idea to have some sort of representation of results

Associate Prof Dr Mohd. Hassan Abdullah (Sub Project 1 - Cultural Musicology)

Q1. How effective are current notational styles in representing the sound of Malaysian indigenous instruments?

Nobat, Gamelan are examples of a Malaysian notation system however instead of precise notational systems they are ‘guides lines’

If the answer is not ‘effective’, then Why?

We should ask why.

“What do we (ethnomusicologists) want out of it?” (notation)

The focus should be drawn on one instrument and its construction, environment etc. should be analyzed.

Another thing to consider is instruments that are similar but from different regions and the material they are made of.

It should be noted that indigenous instruments are not standardized even among the indigenous population.

So which examples should be chosen for the study?

When researchers go into the field, the samples given to them by villagers might differ from the ones that they use, but do not present to visitors.

Associate Professor Dr Hasnizam Wahid (Sub Project 2 Electroacoustic composition)

Figure 23:

Problem Statement	1. There some tools ready 'commercially' available for analysis of timbre, in which need to be further explored and try to identify what are the limitations and problems with these available tools. How useful are these tools for the purpose of timbre analysis?
Objective	If this project intended to use timbral properties through spectography to investigate the organology and ontology of sounds, it will also require some level of **knowledge on acoustic** of a particular musical instrument, as well as some level of knowledge in digital signal processing. Perhaps references (books) from Rossing such as in the Science of musical sounds, Music, physics and engineering by Harry F.Olson , etc, would be useful.

1. To explore the '*Uthmani*' notation used in Quran recitation. Not the content but in the context of how it was written and recite 'through sound'.

Dr Jean Penny (Sub Project 3 - performance)

PRELIMINARY QUESTIONS

How effective are current notational styles in representing the sound of instruments, computer generated sound and combinations of these?

How has and can spectrographic notation be used to define and articulate instrumental and electronic sound?

To what extent can organological differences be analysed through spectrographs? What new information does this give us?

What differences of instrumental timbre can be captured by spectrographic representation, and how effective and informative is this as notation?

What spectrographic changes occur with the use of electronic manipulation of instrumental sound? What does this reveal?

How can spectrographs work as performative scores? Is this possible?

a few more performative questions…

Timbral notation - how can this be incorporated into the performance score Different streams of representation? Timbre ++?

What are the semiotic implications of sound codification? Are these rigid, or a point of departure for the performer?

How does the performer relate/interact to/with the score?

What freedom/responsibility/interpretation is left for the performer, the reader of the score?

What information might come from specifically Malaysian performance contexts/instruments

Notation and Performance significance - a few points

Score as an 'infinite substance' -

Barenboim *Everything Is Connected: The Power of Music* (2007), calls the score an 'infinite substance'. From this, he says, comes the performer's inner hearing of the work – the internalisation of the music – the ability to analyse and to imagine the sounds and interpretations, then to return to an instinctive unfolding of the piece as new knowledge, self-knowledge or metaphysical understanding of the score and one's relationship to it.

Score as mediator -

Marc Leman (*Embodied music cognition and mediation technology* 2008): The score … provides mental access to sound energy by offering a set of

instructions on how to generate the music. Therefore, the score can be seen as a mediator between mind and sound.

Score/instrumentalist as correspondence -

Tim Ingold talks about the musical instrument 'corresponding with sound', the instrument as transducer, that 'converts ductus into material flux' (Ingold 2013: 128). He contends that musical instruments correspond with the sound in the way that materials correspond with the maker of objects; that correspondence is a dialogue, carried forward through gestures and traces – a 'telling' that can occur through making. This analogy transfers into a music performance narrative, as the music becomes a way of thinking and telling. The score might create the impulse …. or setting for this thinking and telling.

Score as documentation - of structures and processes, of interactions and human ways of living and thinking.

Notation - vocabularies, annotations

The performer's notational needs and interaction

Metaphor (Stroppa - *little i*)

Visualisation (Lavista - *Canto dal alba*)

Individual interpretation (Cage)

Can a spectrograph be as revealing or evocative as these scores? and does that matter?

Notating timbre - creating the model through analysis and functionality

Challenging existing models

Articulating significant aspects of artistic practice

Readability / functionality

Analysis

Technology - what is it revealing? …..what can we learn about performance?
Components: sound shapes; morphology; intensity; perception of distance; texture.

What do these tell us?

Organologies

Instruments

Materials

Techniques

Physical behaviours

Similarities and differences

Cultural practices

What influences do organologies have on sound spectography and performance knowledge?

Multiple layers; multiple meanings

Structures and Processes:

Layers responding to different interpretations - instrumental, networked instrumental, computer signal, video (visualisation, sonification), networked computer synthesis layer.

Experiential knowledge - relational knowledge, a comprehension; moving from intuition to the cognitive.

Interaction and modes of listening.

Spectrographs

measuring

documenting

reading

describing

learning

applying

advancing??

Digital media tends to handle music as encoded physical energy, while the human way of dealing with music is based on beliefs, intentions, interpretations, experiences, evaluations, and significations (Leman, 2010).

Is that measurable? Documentable?

[end of project 3 summary report]

Forward planning (as discussed)

Develop compositions to explore and evaluate spectrographic notation

Evaluate functionality of spectography as notated performance score

Explore answers to all above questions through new compositions created for this project.

Composers on the team - Marc, Hasnizam and Valerie - agreed to develop new works - yippee!

Marc : a work for flute and electronics;

Haznizam: a work exploring Qu'ran chant annotations;

Valerie: a work including collection of 'sonic units' and elements of Cantonese Opera.

Figure 24: Seminar Schedule

Spectromorphological Notation Research Project - Initial Project, Conference

Day	Time		Venue	Notes
Jun 2	**08.30 - 0.900**	Conference delegates arrive	FMSP	
	9.00	Welcoming Speech Dekan & Project Leader (Introductory Conference comments	FMSP Bilik Mesyuarat	Dekan & TNCPI. (TBC) AB
	09.30 - 11	Prof Marc Battier - research comments and discussion	FMSP Bilik Mesyuarat	What is happening elsewhere/SWOT of research/ issues being encountered. 45 min + 45 min discussion + Q & A
	11.00 - 11.30	Morning Tea/coffee	FMSP cafe	Provided
	11.30 - 13.00	Individual researcher presentations x 3	FMSP Bilik Wayang Kulit & Bilik Mesyuarat	Outlining main aims and objectives - Ethnomusicology group
	13.00 - 1415	Lunch	FMSP cafe	
	1415 - 1545	Individual researcher presentations x 3	FMSP Bilik Mesyuarat	AP Dr Valerie Ross (Composition), AP Dr Hasnizam Wahid (Composition) Dr Jean Penny (Performance)
	1545 - 1615	Afternoon Tea	FMSP cafe	

Day	Time		Venue	Notes
	16.15 - 17.30	Sub-project group meeting #1.	Bilik Mesyuarat	Refinement of main research questions (maintaining drive towards research outcomes as specified in proposal) and emerging approaches
	17.30 - 18.00	10 minute presentation from each sub-group	FMSP Bilik Mesyuarat	
	1800	End of sessions		
	2030	Dinner with all delegates	TBC	
Jun 2	**8.30 - 10.00**	Sub-project group meeting #2.	FMSP Bilik Mesyuarat	Finalise research questions and methods. Forward planning, publication and other outputs.
	10.00-11.00	Prof Marc Battier public talk	Bilik Resital	Recent electroacoustic music inspired by traditional instruments.
	11.00-11.20	Morning Tea/coffee	Cafe/ TBA	
	11.20-12.00	Publication discussions (sub project groups and major project)	FMSP Bilik Mesyuarat	Outline of forward plan of action for each group including outputs.
	12.00 - 12.30	Conference wrap up and close	FMSP Bilik Mesyuarat	Final research questions for major projects and all sub projects. - Next conference 2015 Feb/March
	Afternoon	Lunch	Restaurant (not provided)	

Day	Time		Venue	Notes
	16.00	Prof Marc to KLIA for return flight to Paris Thai FI 418 (to Bangkok, then Paris(depart KLIA 20.55)		

Appendix 2 Seminar 2 Report - December 2015

Fundamental Research Grant Scheme *Spectromorphological Notation-Notating the unNotatable*

Report of SpectroSeminar 2, including notes from reports, presented by co-researchers.

Introductory comments - Dr Andrew Blackburn (Project Research Leader)

Seminar Presentation1

Introduction - morning session arrangements topics of Marc Battier and Pierre Couprie

Music notation of timbre (sound quality) is an outcome–what does this mean and imply?

Timbre - new understandings and meanings - beginning with the commonly used Smalley definition:

> 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 Un-notatable? 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.
>
> D. Smalley (1994) "Defining Timbre - Refining Timbre" in Contemporary Music Review 10 (2) pp.35 – 48.

But what of other definitions:

> Lasse Thoresen's asserts 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. Our - Jean and me– 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, 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. (L. Thoresen (2001/4) Spectromorphological Analysis of Sound Objects. An Adaptation of Pierre Schaeffer's Typomorphology. The Norwegian Academy of Music p.2.)

We may develop our own definition of timbre, particularly as it relates to ways of representing sound visually - perhaps from spectrograms themselves (and we have the creator of a superb spectrographic software package present with us Prof Dr Pierre Couprie): through understanding more of the musicological concept of what is, and potentially might be, represented within music notation: how we can use technology to assist us in reaching such knowledge. (Prof Marc Battier), who will open our seminar and discussion.

What we have found is that timbre is many things, and has many meanings. These meanings are not only definitional, but also cultural. If I, a western trained musician, hear a sound which does not fall within my previous experience, I will (psychologically) attempt to give it meaning, based on prior aural experience. However, a Malaysian trained musician hearing the same sound, and having fall outside their aural experience, will likely define and understand that sound from within their own cultural landscape.

Other things which influence timbre may include the location of the sound source, relative to the hearer, or the acoustic properties of the performance/ sound projection space. Are these things we *want* to notate and define? … and who wants to do so?

New notations

Importance of semiotics of a new notation, and its ontology;

It is reasonable to say that common music notation (stave and stick) has a highly developed semiotic ontology, which, within a tonal or 12 note system, quite effectively manages to convey pitch and duration. There is an allowance

for timbre in that 'this stave is played by this instrument' and the characteristics of that instrument will provide this timbre. We can speak of composers' ability to mix instrumental sounds creating a 'new' timbre or something like this - E.G. Ravel Bolero use of solo instrument with piccolo doubling 1 octave and fifth above, which creates a more nasal sound. <EX> Again here, I am constrained using descriptive words, which remain very open to interpretation.

Other measurable factors which influence timbral quality are for example:the shape of the ADSR envelope: the interaction between a sound and the space into which it is projected - both acoustic and electronically: which will be raised in other presentations.

So, for new models of notation to be effective and widely acceptable–or additions to existing notation–need to demonstrate an ontology which is recognisable and can readily develop symbols and signage that have semiotic potential. What we are finding as both problems and potentials of timbral notation in performative contexts are what we can reasonably expect from a notation development (its *affordances*) and what is not going to be possible to expect (*constraints*). Jean will speak of this in greater detail in her presentation later in the seminar.

A timbral notation is our objective - our models add to–not replace as such.

Welcome to Marc Battier

Introductory Biography

Prof Dr Marc Battier is a composer and musicologist.

He is known as a cofounder with Leigh Landy and Daniel Teruggi of the Electroacoustic Music Studies Network, which established a new field in musicology specifically for the musicological study of electroacoustic music. He is also known for developing the study of electroacoustic music in East Asia.[2] His electroacoustic are widely performed and have been commissioned in several countries.

He teaches at the university of Paris-Sorbonne (1997–present) and has taught at the University of California, San Diego and at UC Irvine. He has been in residence at the Aichi University of Fine Arts and Music in Nagoya (Aichi gedai, Japan), and was invited professor at the Université de Montréal (Canada). He was DAAD Varese Guestprofessor in Berlin (April–July 2012) and then in residence at Aichi Prefectural University of Fine Arts and Music (July 2012, Japan). As a full professor, he is the head of a research team, MINT (Musicologie, informatique et nouvelles technologies) which spearhead the field of electroacoustic music studies. This new field became formed when

Battier and Leigh Landy, professor at De Montfort University, joined forces to found an international conference, first held in 2003 at Centre Georges Pompidou in Paris with the support of IRCAM. With Daniel Teruggi, composer and head of Groupe de recherches musicales, INA-GRM, they formed the electroacoustic music studies network, a non-profit association which since then helps organize an annual conference (2005, Montreal, Canada; 2006: Beijing, China; 2007: Leicester, UK; 2008: Paris, France; 2009: Buenos Aires; 2010: Shanghai, China; 2011: New York, USA; 2012: Stockholm; 2013: Lisbon; 2014: Berlin; 2015: Sheffield). Battier is one of the main experts on electroacoustic music and computer music history. He has written many articles on that topic and has published several books. He is the co-founder, with professor Leigh Landy (De Montfort University) and later Daniel Teruggi (INA-GRM) of the Electroacoustic Music Studies (EMS) movement (founded, 2003), which led to the creation of the annual EMS conference. He is also a leader of the musicology of electroacoustic music in East Asia (EMSAN project), which led to the creation of databases of electroacoustic music in East Asia. In 2015, he wåas asked by the Suzhou Academy of Music (China) to help develop its electroacoustic music program. He is also Supervisor for the Planetary Collegium (Plymouth University) doctoral program for the DeTao-node in Shanghai.

Morning Tea

Welcome to Pierre Couprie

Introductory Biography

å He is a lecturer and teaches information and communications technology for education at the University of Paris-Sorbonne.

Pierre studied at the conservatories of Bordeaux, Boulogne-Billancourt, Orsay and participated in the composition courses at Darmstatd. He has won a number of important prizes for his compositions including the Internationnal Electroacoustic Music Competition in Bourges.

Pierre’s musical language explores the notion of soundscape through the creation of virtual musical landscapes, the interaction between concrete sounds raw and electronic textures, as well as extensive work on space.

With the collective Phonogénistes, he turned to improvisation and electroacoustic environment combining flute, didgeridoo, a laptop and a MIDI interface.

Pierre holds a PhD in musicology (2003), postdoctoral fellow (2004-2006) in Music Technology and Innovation Research Centre at De Montfort University in Leicester (UK), member of the French Society for Music Analysis, researcher at the Laboratory Musicology, Informatics and New Technologies of OMF (University of Paris-Sorbonne), member of the Organizing Committee of the Electroacoustic Music Studies Network and the editorial board of the journal Musimédiane hypermedia, he focuses his research on electroacoustic music and the development of interactive tools for analysis and musical performance.

Pierre is an enthusiast multimedia and software development. He develops CD-ROMs, software adapted to musicological research, virtual musical instruments and interactive environments musical production adapted his game for improvisation.

Of particular importance to this project is the spectrographic software eAnalysis, which has allowed many of the findings and concepts we are developing to occur.

Seminar presentation 2

Seminar aims - for researchers

> Present research report/paper in each project
>
> How to most effectively disseminate? A discussion and presentation by Dr Azhari on Tuesday before lunch will help us locate possible publication and dissemination
>
> This presentation is to present something of how all three projects connect to each other. Understandings gained in one project feed to and inform the others. This is a back and forward process. For example, the use of colour as a way of notating timbre

A Timbral Music notation is an outcome

> what does this mean and imply?
>
> Outcome of ideas and a means of informing performative practice. In this project we are focussed on *timbre* and all that is implied by this.

Repeat and remind from Seminar 1 and research questions. Are the lists of questions we began with still relevant? If not, what are?

Fundamental Research Grant Scheme *Spectromorphological Notation-Notating the unNotatable*

Starting point of whole project ethnographic - why- justify: beginning point and then moved to contemporary musical notation issues - connection to intercultural and so on through *Uthmani* models

Shape of potential models - colour and *Uthmani*.

Colour coding - from TENOR2015 paper

Electroacoustic/Electronic model of notation - not yet addressed - a query for later in the seminar.

Philosophical and musicological basis' of research. Explain the philosophy of musical representation in detail:

connection of ideas – composer to score: score to performer: performer to listener: Other agencies within might include recording, improvisation etc.. but all involve the transmission of musical ideas. Is this still a valid paradigm, especially in non-western cultures?

Spaces - between participants: performative: spatial. How these are related to timbre. How we are approaching representing them? Spatial timbre - how is this represented? refer to papers on spat in electroacoustic, but what about acoustic music?

Cultural/Intercultural significances of timbre and notation - reconcile between written and oral culture transmission

We are observing two compositions (still being developed) from both compositional - Valerie and hasnizam, and performative perspectives - Jean.

Music representation –> meaning–> notation (expand on this)

We see common and many graphic notations having both ontological (metaphysical - nature of being) and semiotic (symbolic signs and interpretation) significance and meaning. So how can spectrography and timbral notation add to this.

An initial question has been '…can spectrography evolve the ontological significance as common notation? If yes, how might this process (develop

ontological and semiotic significance) be achieved? Educational implications? Software?

Research process has been moving 'back and forwards'. Philosophical underpinning leads to practical application and discovery - leads back to philosophy … etc. Practice-led research model. One action is generating and driving the next action and response.

eg *Uthmani*- from an old form of text but being adapted and re-purposed which is leading to new extended flute techniques, leading to new timbres. Relationship

Colour coding

Report notes from Co-Researcher Presentations.

Dr Prof Dr Marc Battier (IreMus Université Paris-Sorbonne (Paris IV))

Sound Considerations on visual sounds and performance

Visual sound - notation or representation?

Spectrogram - 'a point of embarkation' - know what is happening in a score

What are the criteria for a 'new notation'?

Semiotics from many measurements.

Visual sounds - part of EMS musicology.

E.G. Software generated scores that are hard to read. Music III partial score is essentially a technical tool

Space as a localisation system - external Sound in Space (Fr. le sons dans l'espace) - of use to engineers and developers

Space as a component of sound: space within sound (Fr l'espace du son) - of use to composers and performers.

Ideally the best tools and graphics will represent **both** types of space.

Considerations

Representing artificial sounds

dexterity in their use

What is retained by perceptions?

Realisations score Acousmograph

François Bayle Toupie de la ciel

Sonogram - short events - but all different form - indicated by the sonogram, but not indicated HOW it is done.

Associate Prof Dr Pierre Couprie (IreMus Université Paris-Sorbonne (Paris IV))

eAnalysis

for musical analysis

go beyond transcriptions

new forms of representations

a software for different types of use

Music Education - representation to introduce and work on musical analysis

Music presentations: eA can counter cultural obsolescence - a starting point.

eAnalysis attempts to combine the main features of the following softwares:

Audio manipulation software

Audiosculpt

SPEAR (free)

Extract data from Sound

PRAAT

Audiosculpt

Good for spectral analysis

Sonic Visualiser

Granular Synthesis

CATART

Annotation software

Sonic Visualiser

Acousmographie

eAnalysis allows for a 'timbre scope'

Coloured waveform allows for general timbral structural analysis

Acousmoscribe - Scrime de LaBri (free)

Lasse Thoresen - recent book published in Canada

Aural Sinology Plugin for Acousmographe. - Can correlate the difference/correlation of sound between L/R speakers

Look at Similarity Matrix - to measure the distance between values. This is interesting for structural analysis

PC Suggestion - it could be helpful to notate the difference **between** timbres - not to try to notate the **exact** timbre.

Associate Professor Dr Hasnizam (UNIMAS)

Notating the *Un*notated – Thought, Potential and Possibilities Studied from the *Uthmani*'s.

The paper will discuss possible approach on notating sound particularly in representing sound domain composition such as in electroacoustic music.

In general, the *Uthmani*'s text reading, requires readers on how to recite, pronounce and articulate right articulation. It is primarily focused on sound and timbre characteristics as well as the duration on dictions of Arabic words. The Arabic with particular reference to the Quranic reading, as like many other languages has always been vocal oriented and above all, it also requires extensive knowledge of the rules of *makhraj* and *tajweed*.

Discussion will explore and articulate the idea of referring to how *makhraj* as well as the rudiments on *tajweed,* as a case study for possible timbre notation approach.

Works with Sound

? Should we proceed with this way to create notation?

Proper syllable - when you read the text you know how pronounce it correctly. There are other ways - e.g. IPA

Makraj - very similar looking syllables, but can mean very dissimilar sounds

Aims to create a flute piece - and still working on it. Has/is teaching Jean to pronounce it on the flute.

A newer version of '*uthmani*' called '*tajiell* - which uses colour

Intends to have a score (common notation?) with *uthmani* included.

Emphasise that the *uthmani* is not Q'ran but a way of explaining how to pronounce the text. It can be applied (found) in any Arabic text. For this reason it is not a problem to incorporate and adapt it in this musical context.

Dr Jean Penny

This presentation will focus on performative perspectives of timbral notation models that have been developed in the project. Timbral notation is posited here as a stream of representation opening up new dimensions of musical practice and cultural understandings. The collaborative journey towards developing the models will be documented and evaluations of each as vehicles for sonic expressivity and performance functionality given. The relationship of the new scores with spectrography begins with definition of the flute sound – components of sound shapes, morphology, intensity, perception, texture – and how this can be transferred into timbre-based notation. Models include the transformation of spectrographic elements into timbrally expressive colour structures and notation related to a blend of *Uthmani* recitation and flute sound.

Focus on performative elements

Still in early stage of work - extant works and phenomenology of collaboration and development

Problem - Spectro - implies a visual representation of sound.

Also exploring spaces - - performative heterotopia - (need definitions from Slide 4 of JP presentation)

Bourriard ?

Foucault - - resemblance and connection link'Ingold - 'thing' is a going on - or several 'goings on'.

Intertextuality - Kriseva quote…

Can think of notation as text - a transposition of one sign system.

Notation as transformation of all previous notations

Parallel spectrogram - as per a score - ‘infinite substance.

define.

Now we are trying to pin down what is notation and what we are trying to achieve

Risset - reflection

Alternative notations

2 different approaches being explored

Colour based notation

VR - affordances of flute technique - this is leading to a reductive version of spectromorphology

Uthmani

Meaning is a process

a cultural marker

Intercultural Understandings

East West

In this Jean’s experience has included:

Learning what YOU want to do with the sound

Fl/Serunai - made a conscious effort to take on the ‘characteristics of “the other”

Discussion ensued on Empirical musicology - UK - US, but not France

France - organisations who gather researchers together

Include developers as well as artists - ICMC

PC - in UK there are many more composers driving the ideas then researchers.

Where to now - Discussion points

Fundamental Research Grant Scheme *Spectromorphological Notation-Notating the unNotatable*

Project 3

Email discussion - AB to set it up.

Project 2

Composition and performances - agreed to have pieces ready for performance in UERL in late January - need time to prepare and rehearse.

Project 1

Look at ways of gestural measurement - see video from iPhone/iCloud

Introduction - morning session arrangements topics of Marc and Pierre

Welcome to other travelling researchers and any VIP's

Introduction to FRGS project (brief)

> *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, encompassing a range of intercultural, performance and sonic representation issues, which were flagged in our discussions during the SpectroSeminar 1 held in June 2014, and which we hope to really come to terms with in this seminar.

Music notation of timbre (sound quality) is an outcome–what does this mean and imply?

Timbre - new understandings and meanings - beginning with the commonly used Smalley definition:

> 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 Un-notatable? 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.

D. Smalley (1994) ”Defining Timbre - Refining Timbre” in Contemporary Music Review 10 (2) pp.35 – 48.

But what of other definitions:

Lasse Thoresen’s asserts 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. Our - Jean and me– 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, 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. (L. Thoresen (2001/4) Spectromorphological Analysis of Sound Objects. An Adaptation of Pierre Schaeffer’s Typomorphology. The Norwegian Academy of Music p.2.)

We may develop our own definition of timbre, particularly as it relates to ways of representing sound visually - perhaps from spectrograms themselves (and we have the creator of a superb spectrographic software package present with us Prof Dr Pierre Couprie): through understanding more of the musicological concept of what is, and potentially might be, represented within music notation: how we can use technology to assist us in reaching such knowledge. (Prof Marc Battier), who will open our seminar and discussion.

What we have found is that timbre is many things, and has many meanings. These meanings are not only definitional, but also cultural. If I, a western trained musician, hear a sound which does not fall within my previous experience, I will (psychologically) attempt to give it meaning, based on prior aural experience. However, a Malaysian trained musician hearing the same sound, and having fall outside their aural experience, will likely define and understand that sound from within their own cultural landscape.

Other things which influence timbre may include the location of the sound source, relative to the hearer, or the acoustic properties of the performance/ sound projection space. Are these things we *want* to notate and define? … and who wants to do so?

New notations

Importance of semiotics of a new notation, and its ontology;

It is reasonable to say that common music notation (stave and stick) has a highly developed semiotic ontology, which, within a tonal or 12 note system, quite effectively manages to convey pitch and duration. There is an allowance for timbre in that 'this stave is played by this instrument' and the characteristics of that instrument will provide this timbre. We can speak of composers' ability to mix instrumental sounds creating a 'new' timbre or something like this - E.G. Ravel Bolero use of solo instrument with piccolo doubling 1 octave and fifth above, which creates a more nasal sound. <EX> Again here, I am constrained using descriptive words, which remain very open to interpretation.

Other measurable factors which influence timbral quality are for example:the shape of the ADSR envelope: the interaction between a sound and the space into which it is projected - both acoustic and electronically: which will be raised in other presentations.

So, for new models of notation to be effective and widely acceptable–or additions to existing notation–need to demonstrate an ontology which is recognisable and can readily develop symbols and signage that have semiotic potential. What we are finding as both problems and potentials of timbral notation in performative contexts are what we can reasonably expect from a notation development (its *affordances*) and what is not going to be possible to expect (*constraints*). Jean will speak of this in greater detail in her presentation later in the seminar.

A timbral notation is our objective - our models add to–not replace as such.

Welcome to Marc Battier

Introductory Biography

Prof Dr Marc Battier is a composer and musicologist.

He is known as a cofounder with Leigh Landy and Daniel Teruggi of the Electroacoustic Music Studies Network, which established a new field in musicology specifically for the musicological study of electroacoustic music. He is also known for developing the study of electroacoustic music in East Asia.[2] His electroacoustic are widely performed and have been commissioned in several countries.

He teaches at the university of Paris-Sorbonne (1997–present) and has taught at the University of California, San Diego and at UC Irvine. He has been in residence at the Aichi University of Fine Arts and Music in Nagoya (Aichi gedai, Japan), and was invited professor at the Université de Montréal (Canada). He was DAAD Varese Guestprofessor in Berlin (April–July 2012) and then in residence at Aichi Prefectural University of Fine Arts and Music (July 2012, Japan). As a full professor, he is the head of a research team, MINT (Musicologie, informatique et nouvelles technologies) which spearhead the field of electroacoustic music studies. This new field became formed when Battier and Leigh Landy, professor at De Montfort University, joined forces to found an international conference, first held in 2003 at Centre Georges Pompidou in Paris with the support of IRCAM. With Daniel Teruggi, composer and head of Groupe de recherches musicales, INA-GRM, they formed the electroacoustic music studies network, a non-profit association which since then helps organize an annual conference (2005, Montreal, Canada; 2006: Beijing, China; 2007: Leicester, UK; 2008: Paris, France; 2009: Buenos Aires; 2010: Shanghai, China; 2011: New York, USA; 2012: Stockholm; 2013: Lisbon; 2014: Berlin; 2015: Sheffield). Battier is one of the main experts on electroacoustic music and computer music history. He has written many articles on that topic and has published several books. He is the co-founder, with professor Leigh Landy (De Montfort University) and later Daniel Teruggi (INA-GRM) of the Electroacoustic Music Studies (EMS) movement (founded, 2003), which led to the creation of the annual EMS conference. He is also a leader of the musicology of electroacoustic music in East Asia (EMSAN project), which led to the creation of databases of electroacoustic music in East Asia. In 2015, he wåas asked by the Suzhou Academy of Music (China) to help develop its electroacoustic music program. He is also Supervisor for the Planetary Collegium (Plymouth University) doctoral program for the DeTao-node in Shanghai.

Welcome to Pierre Couprie

Introductory Biography

å He is a lecturer and teaches information and communications technology for education at the University of Paris-Sorbonne.

Pierre studied at the conservatories of Bordeaux, Boulogne-Billancourt, Orsay and participated in the composition courses at Darmstatd. He has won a number of important prizes for his compositions including the Internationnal Electroacoustic Music Competition in Bourges.

Pierre's musical language explores the notion of soundscape through the creation of virtual musical landscapes, the interaction between concrete sounds raw and electronic textures, as well as extensive work on space.

With the collective Phonogénistes, he turned to improvisation and electroacoustic environment combining flute, didgeridoo, a laptop and a MIDI interface.

Pierre holds a PhD in musicology (2003), postdoctoral fellow (2004-2006) in Music Technology and Innovation Research Centre at De Montfort University in Leicester (UK), member of the French Society for Music Analysis, researcher at the Laboratory Musicology, Informatics and New Technologies of OMF (University of Paris-Sorbonne), member of the Organizing Committee of the Electroacoustic Music Studies Network and the editorial board of the journal Musimédiane hypermedia, he focuses his research on electroacoustic music and the development of interactive tools for analysis and musical performance.

Pierre is an enthusiast multimedia and software development. He develops CD-ROMs, software adapted to musicological research, virtual musical instruments and interactive environments musical production adapted his game for improvisation.

Of particular importance to this project is the spectrographic software eAnalysis, which has allowed many of the findings and concepts we are developing to occur.

Seminar presentation 2

Seminar aims - for researchers

Present research report/paper in each project

How to most effectively disseminate? A discussion and presentation by Dr Azhari on Tuesday before lunch will help us locate possible publication and dissemination

This presentation is to present something of how all three projects connect to each other. Understandings gained in one project feed to and inform the others.

This is a back and forward process. For example, the use of colour as a way of notating timbre

A Timbral Music notation is an outcome

what does this mean and imply?

Outcome of ideas and a means of informing performative practice. In this project we are focussed on *timbre* and all that is implied by this.

Repeat and remind from Seminar 1 and research questions. Are the lists of questions we began with still relevant? If not, what are?

Starting point of whole project ethnographic - why- justify: beginning point and then moved to contemporary musical notation issues - connection to intercultural and so on through *Uthmani* models

Shape of potential models - colour and *Uthmani*.

Colour coding - from TENOR2015 paper

Electroacoustic/Electronic model of notation - not yet addressed - a query for later in the seminar.

Philosophical and musicological basis' of research.

Detail:

connection of ideas – composer to score: score to performer: performer to listener: Other agencies within might include recording, improvisation etc.. but all involve the transmission of musical ideas. Is this still a valid paradigm, especially in non-western cultures?

Spaces - between participants: performative: spatial. How these are related to timbre. How we are approaching representing them? Spatial timbre - how is this represented? refer to papers on spat in electroacoustic, but what about acoustic music?

Cultural/Intercultural significances of timbre and notation - reconcile between written and oral culture transmission

We are observing two compositions (still being developed) from both compositional - Valerie and hasnizam, and performative perspectives - Jean.

Music representation –> meaning–> notation (expand on this)

We see common and many graphic notations having both ontological (metaphysical - nature of being) and semiotic (symbolic signs and interpretation) significance and meaning. So how can spectrography and timbral notation add to this.

An initial question has been '…can spectrography evolve the ontological significance as common notation? If yes, how might this process (develop ontological and semiotic significance) be achieved? Educational implications? Software?

Research process has been moving 'back and forwards'. Philosophical underpinning leads to practical application and discovery - leads back to philosophy … etc. Practice-led research model. One action is generating and driving the next action and response.

eg *Uthmani*- from an old form of text but being adapted and re-purposed which is leading to new extended flute techniques, leading to new timbres. Relationship

Colour coding

Appendix 3 - Conference Presentations:

3.1 TENOR2015 - Dr Andrew Blackburn and Dr Jean Penny

TIMBRAL NOTATION FROM SPECTROGRAMS : NOTATING THE UN-NOTATABLE? Andrew Blackburn

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ABSTRACT

This paper outlines a research project currently underway in Malaysia that, through spectography, 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, andcontextualized in the wider project. The paper includes a discussion of the score as artifact or 'thing' the relationships that are im- plicit 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 ethnomusicologi- cal, musique-mixte and electroacoustic music composi- tions. The focus of this fundamental research is broad,

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 develop- ment 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 no- tation and music representation questions within three sub-projects that focus on, respectively, ethnomusicolo- gy, musique-mixte and electroacoustic music. Crucial to the first and second sub-projects is our interest in devel- oping ways of representing timbre that can be understood from both Malaysian and Western perspectives of per- formance, 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 con- clude 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 ex- panding the assumed notions of timbre based on acoustic sound and the trouble of refining and standardizing re- sponses to such a complex element or identity. Within Spectromorphological Notation: Notating the Un- notatable? we are addressing both the acoustic and elec- troacoustic, aiming to create an investigative continuum that proceeds and informs from one to another. Elements of the study and documentation of the timbral characteris- tics of both traditional and modern instruments occurring in the initial stages of the research will lead to experimen- tation 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 recog- nition of Lasse Thoresen's assertion that we need to de- velop 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 accom- modate the multiplicity of meanings of 'timbre': structur- al, 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 indica- tions. 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 tech- niques) 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 com- poser's intentions, rather than technical instructions, could be more effectively enabled with semiotically rele- vant timbral representation. In organ works, timbre is often suggested through assumed knowledge of historical performance practice1, or specific stop indications com- bined with an understanding and knowledge of the in- strument 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 tech- nical set up according to the performance space.

Investigations of timbral descriptions of traditional in- struments 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,

1 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 in- struments: “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, per- haps 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 communi- cate sound quality in all its complexity to a literate ob- server.

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 dif- ferent in literate cultures, though. Through the very in- vention 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 seeming- ly so because the accomplishments of such a transfor- mation are limited and can at times be deceiving” [4].

Combined with the other informal explorations and con- siderations 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 poten- tial. 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 work- ing with traditional instruments, then within contempo- rary Western Art Music research through the creation and performance of new musique-mixte and electroacoustic

compositions using these possible models and systems.”2 The overall project consists of two conferences, bookend- ing three sub-projects that, taken together, provide oppor- tunities 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, electroacous- tic and musique-mixte as academics, creators and per- formers.

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 spectro- morphological representation?

2. What are the elements that composers, musicolo- gists, 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 no- tate 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 pro- vide useful and universally 'understood' symbols using spectrographic softwares?

2.1 Issues Arising – a problem statement?

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

2 Blackburn (2014),

http://spectronotation.upsi.edu.my

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 per- formance. Further, it encompasses oral and rote learning, common notation scores to software, and works depend- ent 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 sepa- rate 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 ‘correspond- ence’ [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].

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 is- sues that have arisen in our individual and collective deliberations. Rob Weale3 in the EARS Glossary of terms, Spectromorphology notes there is both interde- pendence and dynamism in the word spectromorphology. Whist not reducing the historic quality of a spectrogram, this is helpful to this project for the conceptual develop- ment of a timbral score, as he describes spectromorphol- ogy 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 spectrogra- phy, will probably contain graphics that also have semiot- ic 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".

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. 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. 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 and Sonic Visualiser.

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 Wayang Kulit artform, which is presently in a difficult phase. In parts of Malay- sia, including one of its places of origin, Kelantan, it is banned. University programmes, such as those main- tained by UPSI, are important in the continued artistic viability and vibrancy of Wayang Kulit (Director of Kelan- tan 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 musi- cians who play and perform.

The first process within this sub-project has been to record the sound of, then create spectrograms of, tradi- tional Malaysian Wayang 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 percus- sion instruments.

The orchestra of the Wayang 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

Figure 1. Testing the Gedumbak

bowed instrument – rebab. The instruments, while indi- vidually important, gain their true significance in an en- semble 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

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

A second strand in this project investigates a 'Western' facet – the creation of a recorded catalogued 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 electroa- coustic 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 musi- cian'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 para- digms that reflect and drive new expressions and activi- ties evolve. Timbral notation as a context of change mo- tivates explorations of shifting performative relationships, new ways of thinking and performing, and a reconceptu- alization of the score/performer relationship.

This part of the project will create models for spectro- graphic notation as performance scores. Analyses of notation, timbre and organology associated with chosen instruments and electronics (musique mixte) will be un- dertaken to develop a framework for

investigating spec- trographic analyses, evaluations and outcomes. New works will generate performance analyses through phe- nomenologically based studies, following the sound spec- trum 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 per- former'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 beauti- ful 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-

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 of so traditional stories) means that the players are more interested in their collective role than the individu- al, so the recordings were made to reflect this. The ge- dumbak 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 con- text. Spectrograms further show us that by using different modes of playing, different timbral qualities can be em- phasized in the same instrument – brighter or more mel- low 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

ories, or sonic energies? What is the need for this as nota- tion?

Investigating the recordings and single frame spectro- graphs of the Western flute extended techniques will allow us to experiment with the flautist to see how effec- tive this is in the re-creation of timbres. The form of tim- bral representation on which we will focus does not con- sider 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 spectro- graphic series (see Figure 3) as a research process model provides some ways forward to link timbral representa- tions to scores in a musique-mixte environment.

Recorded note

Spectrogram of technique / sound

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). FundamentalFrequency;

(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 to- gether in space in a contextual manner" [18]. This con- cept 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 Malaysia4, 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 perfor- mance, a symbiosis of elements of the cultures, collabora- tions and connections that occur [19].

Digital media tends to handle music as encoded physi- cal 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 con- tained in a spectrogram is useful in determining the tim- bral quality of a sound at a given moment and dynamical- ly 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 rain- bow 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 in- strumentalist would need to acquire knowledge of the possible harmonic series for their instrument, and the instrumental technique required to produce such combi- nations of sound. Timbre indications could then be read as coloured dashes above musical phrases or individual

4 The Imaginary Space: Developing models for an emergent Malaysian/Western electroacoustic music (2012-14). Funda- mental Research Grant Scheme, Ministry of Education, Malay- sia.

Flute

Extended techniques

Features FO and characteristics

significant harmonic series highlighted

Representation of timbre as musical element in score

as adjunct to common musical notation?

Colour range (rainbow spectrum)

notes. This approach allows the retention of score rela- tionships 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 ampli- tude and the ASDR envelope. These could be incorpo- rated into a form of notation that may resemble a colour- ised 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 pro- cess currently being examined in our pieces. This ap- proach 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 spec- trograms to create a form of timbral notation, which could be used in electroacoustic compositions as a way of preserving the music independently of the soft- ware/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 estab- lished. 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 cur- rently 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 artefact 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 elec- troacoustic/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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3.3 TENOR Proceedings Spectromorphological Timbral Notation as a tool for Malaysian Ethnomusicology

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Abstract

Ethnomusicologists often face the problem of precisely and objectively describing the characteristics of a sound recorded in fieldwork activities. In the absence of any other means, written explanations normally use metaphoric words to represent the timbral characteristics of a sound produced by ethnic musical instruments. But to what extent will the reader understand and perceive the sound based on the writer's explanation? This study is part of a wider research project *Spectromorphological Notation-Notating the unNotatable? - Modelling a New System of Timbral and Performance Notation for Ethnomusicological, Musique-mixte and Electroacoustic Music Compositions.* This article will explore some of the possibilities of using timbral visualisation in the recognition of the characteristics of Malaysian traditional musical instruments with a view of providing a more objective description of the sound of these instruments. Such analysis of Malay traditional instruments is new. As part of a wider cataloguing and analysis of this group of instruments, we focus on the timbre of one instrument in particular, the *gedombak* (goblet drum). We introduce an instrument recognition process from our solo recordings of a set of Malay traditional instruments, which in the examples provided, are yielding a high recognition rate. A large sound profile is used in order to encompass the different sound characteristics of each instrument and evaluate the generalisation abilities of the recognition process. Our approach is to then use understanding gained by this process to visualise the sound qualities preferred by an experienced and professional Wayang Kulit performer when selecting specific instruments for a given dramatic story or context.

Ethnomusicology is a field of music that deals with any musical activities and perspectives related to the specific music in a certain ethnic group. One of the perspectives of the study in this field is the organology of traditional instruments, and an evaluation of the sound produced by the instrument. Researchers who study this field will, as part of their research, describe the sound and music performed by any particular instrument in a community. Such descriptions will include descriptions of the

instruments' organology, social significance or context for performance and often a verbal description of its sound characteristics.

In printed text documents, researchers have tried to describe the characteristics of a sound and to make the reader understand the sound quality without the reader having listened to, or accessed the original recording materials. Though partly addressed by making recordings available online, readers are likely to misunderstand the sound quality and perceive it differently from the understanding of the researcher. In short, a sound that is described in writing may be perceived differently from the actual sound that the readers listen to. One example of this lack of precision – or perhaps a poetic approach to the description of sound – is given by Ngabut in Kenyah Bakung oral literature: here the author describes several traditional instruments from the Borneo Kalimantan region, including detailed descriptions of their construction (dimension, materials, and decoration), mode of playing, social function and many other cultural features, but makes only one reference to the actual sound quality of any of the instruments: "The sound produced resembles that of a frog" (Ngabut, 2004, p.272). Assuming one knows what species of frog giving what call is being referred to by the author, perhaps this is a helpful description. This article suggests a mode of timbral description that is useful to readers who do not have a familiarity with the "frog", by referring to the quality of sound – identifying its spectral content, sonic identity and recognition of source.

Though not descriptive (like a frog) the spectrogram provides a quantitative analysis of the sound of a given instrument. Combined with the characteristics of the sound envelope (Attack, Sustain, Decay Release – ASDR – as discussed in Figure 2 below), musicologists and ethnomusicologists have a highly objective sound descriptor. This project is a part of a larger research project (*Spectromorphological Notation: Notating the UnNotatable*) exploring the creation of possible models of timbral notation using the qualities of the tools just discussed. Using spectrograms to allow specific quantitative information of the timbre of traditional Malaysian instruments, relating them to the instruments' organology has not been undertaken. Other ethnomusicologists have explored the approach of using spectrograms for various forms of analysis. This paper focuses on one aspect of this larger project, namely understanding the instrumental sound, selected by a highly skilled professional Wayang Kulit performer for specific purposes, and what instrumental timbral qualities can be understood through the spectrogram.

Literature Review

In addition to the Ngabut text referred to earlier, the literature reviewed by the authors for this paper has focused on the use of spectrography in ethnomusicological contexts, and how timbre may be defined theoretically using this tool. One example, of many, is the 1994 study of lamentation practices in rural Russia by Margarita Mazo. In this study the author uses spectrograms to investigate and compare the vocal production in laments with that in normal speech and singing. This ties in with another common and early use of spectrograms by speech therapists for the diagnosis and treatment of speech or vocal problems. In Mazo's study, the author is looking at the difference between the quality of the singing voice used in funerary laments, and compares it with the voice quality in other contexts. The musical application in a specific social context

is apparent and central to Mazo's study, and though limited there to vocal intonations, can be effectively applied to (pitched and un-pitched) instruments as in the present research. The concept of spectromorphology is concerned with the notion of how sounds changes over periodic time (ASDR) as a characteristic of timbre, and this leads us to consider the theoretical and applied texts of Denis Smalley.

Understanding the meaning of timbre is essential before its usefulness as a descriptor, and the elements which together comprise it, can be discussed. Although Denis Smalley's writings and theories on timbre and spectromorphology pertain to acousmatic music, we have found that they are effective and helpful in the description of timbre in this ethnomusicological context. Smalley (1986) divides spectromorphology into its temporal unfolding (the changes in a sound over time) and the shaping of sound spectra. As our focus in this article is towards finding a way of using spectrograms to identify the instrumental sound quality preferred by an expert Wayang Kulit performer for different theatrical or cultural contexts, Smalley's theories are helpful. They allow us to consider the contextual and cultural environments from which we are creating our spectrograms and assessments. Smalley discusses a multitude of definitions of timbres in his 1986 and 1994 articles, and these will be outlined a little later. David Hirst (2003) observes that the French word itself – *timbre* identifies the object that creates the sound. He proposes that the German *Klangfarbenmelodie* – sound colour– is more abstract, and so has validity in many contexts, including this. However, for the sake of general consistency we shall continue to use the conventional terminology – *timbre.* Denis Smalley presents four different understandings of the term:

> The American National Standards Institute: "... that attribute of auditory sensation in terms of which a listener can judge that two sounds similarly presented and having the same loudness and pitch are dissimilar (Smalley, 1994, p.36).
> The instrumental composer: timbre is an extension of harmony, or vice versa. The composer uses spectral analysis as a basis for conceptualising the relationship between pitch and sound qualities, and attempts to negotiate fluent border crossings between the two. (Smalley, 1994, p.36)
> The researcher: Through research and through electroacoustic compositional experience we have become very aware of the multiple variables which determine timbral identity. And we have also become concerned to differentiate what is acoustically present in sounds from what is psychoacoustically pertinent.
>
> Everyone: The everyday language of qualitative description is accessible to everyone. It is closely allied to the "matter" of sound. Terms like bright/dull, compact/spread, hollow, dense... (Smalley, 1994, p.36, as cited in Hirst, 2003).

From these understandings we may conclude that a definition of timbre in this context, and for ethnomusicological purposes – the organology of traditional instruments and the impact this has on the sound of the instrument – may perhaps be enunciated by judging … "two sounds similarly presented and having the same loudness and pitch are dissimilar", and for our Wayang Kulit performers who conceptualise "… the relationship between pitch and sound qualities" (Smalley, 1994, p.36). They then form musical or dramatic opinions as to what is the most appropriate timbre for the given situation.

Problem Statement

For the past few decades, many ethnomusicologists have been trying to precisely describe the sound of any musical activities in many different ways. Some of them describe the sound of music in a narrative way, while some of them give some meaning and use metaphor or other type of sound representation to describe the characteristics of a sound. Ethnomusicologists also face difficulty in describing a sound of music or an instrument from their fieldwork. The current practice in Malaysia is that a sound is given a description based on the ethnomusicologist's understanding. The description is verbal and as such may be perceived differently by other people. How can this situation be overcome or addressed? Spectrograms have been used to objectively to describe the organology of instruments of other cultures but not in Malaysia.

In the field of ethnomusicology, researchers normally describe the sound based on their perception or use a local terminology to describe a particular sound. Most indigenous musical instruments are not constructed to any standard pitch, size or measurements. One may note that almost all ethnic musical instruments – even from the same general regions or makers, have different sound quality and pitches. For example, in the Kompang (frame drum) ensemble of the Malay people, the sound of the kompang depends on the tautness and thickness of a skinhead as well as the size of the instrument. However, the kompang must be tuned to the "*Bunyi yang diterima*" (acceptable sound) before being played. A kompang ensemble normally consists of 15 to 25 players who perform on similar instruments in interlocking rhythmic patterns to celebrate joyful occasions in the Malay community.

The individual kompangs used in an ensemble are all tuned to a certain pitch, made as close as possible to one another. However, even though there is no standard tuning set for the kompang, an experienced kompang player is able to tell the 'acceptable sound' of a kompang. The 'acceptable sound' of a kompang to the players is described as (*kuat*) loud, (*gemersik*) penetrating, (*tajam*) sharp and (*tegang*) taut. How can one precisely understand and perceive the sound of a kompang as loud, penetrating, sharp and taut? Can one precisely describe the 'sharp' sound of the kompang? Given that the sound of any indigenous musical instrument is mostly not standardised in nature, there is a need to find ways of identifying and recognising the "acceptable sound" of any particular musical instrument, not only for researchers, but especially for beginners and those who are not expert in that field.

Moreover, contemporary Western arts and traditional music notation is usually linked to an analysis and the semiotic representation of the musical elements of melody and harmony (vertical and horizontal pitches) using common music notation. Precise pitch indications are 'rounded out' into the twelve semitones of this system, unable to further accommodate the precise subtleties of sound which are inherent in all music traditions. Further, musical performance parameters such as articulation (attack, decay, sustain and release) and dynamics (volume or intensity) are loosely indicated through the use of staccato or phrase markings for articulations, or dynamic marks (forte, piano, crescendo, diminuendo, and so on).

Representation of other significant musical elements such as tone and colour (timbre) are largely limited to instrumental naming or specific performance techniques (*sul ponticello* – play near the bridge for string instruments). This weakness, along with the

difficulties brought about by the multitude of definitions and understandings of timbre are increasingly recognised within both new music and traditional music fields.

Aims of Research

This project will explore the creation of a model for the timbral and performance notation of acoustic music that notates more content details of the various elements of sound. Of significance for ethnomusicologists who are working in this field, will be the use of spectrographic notation leading to the creation of an authentic and precise transcription library and catalogue inclusive of all musical elements. Such a catalogue will lead to a greater understanding of the individual and unique spectral and tuning characteristics of traditional Malay musical instruments. This method will be applied to instruments such as kompang, gedombak, gendang, serunai, and rebab. Knowledge and experience of creating spectrograms of the Malay traditional instruments will then be applied into the forefront of music making using these possible models and systems. Whilst the research and research questions suggest an on-going and complete cataloguing of instruments from traditional ensembles, this article will focus on the research and understandings gained through the consideration of one instrument – the gedombak.

Research Questions

In exploring the possibilities of using the spectrographic features in ethnomusicological study, there are many related questions that can be addressed.

How can an ethnomusicologist describe the sound of a musical instrument?

What are the elements that ethnomusicologists require from a notation system and how can these be represented?

What kind of notational/transcription system can possibly precisely describe the musical sound of traditional instrument?

What organological elements are common or exclusive to each instrument and how can they best be identified and analysed?

Can spectrographic analysis and software be used to provide a method for defining and identifying unique qualities of Malay traditional instruments?

Can this information be used to describe and notate the specific individuality of sound materials and performance methods in ways that expand the range and musical vocabulary of the ethnomusicologist?

What parameters of analysis can be defined to provide useful and universally understood symbols using spectrographic software?

How can this notational system help scholars, musicians, instrument makers and others in identifying a preferred timbre for any particular Malay traditional instrument?

What other knowledge can be drawn from this?

In the present paper, we do not attempt to answer all of the research questions from the larger sub-project, but focus on three questions: (i) How can an ethnomusicologist describe the sound of a musical instrument?; (v) Can spectrographic analysis and software be used to provide a method for defining and identifying unique qualities of Malay traditional Instruments?; and (vii) What parameters of analysis can be defined to provide useful and universally understood symbols using spectrographic software?

Methodology

In conducting this study, various methods will be utilised in getting useful data and information in order to answer the research question. Generally, methods will be grounded in the performance practice of the Wayang Kulit ensemble. While exploring all the possibilities of using spectrographic as a tool to describe the characteristic of a sound, researchers will analyse and think through this practice. This method is also always referred to as practice-led research. Three phases will cumulatively document, analyse, apply and reflect on project activities and outcomes. Critical reflection is a key criterion of the research, supported by textual analysis.

The Importance of Practice-led Research in this Paper

Practice-led research uses the practice of the researcher as ethnomusicologist, acknowledging the knowledge they bring to the research, both as an individual and experienced ethnomusicologist as starting points. In particular, the variety of perspectives this methodology allows has been most advantageous in the research project. The 'insider-outsider' knowledge paradigm in particular, has assisted the authors in coming to understand what is occurring as the Wayang Kulit performer made his instrumental deliberations. This 'insider-outsider' reflection is the basis of the research approach described in the 1980s by Donald Schon (1996), requiring the researcher/practitioner to consider their professional practice, and consider what is, and how this knowledge might be used to improve or develop what occurs in the researcher's practice. This reflective process is not to confirm the status quo, but to open the researcher to look for new ways and processes to create positive change in their practice. Central to this reflective process is the knowledge the researcher has both from an awareness or mindfulness while they are playing, teaching or whatever (insider knowledge), and a subsequent process of reflection after the event, perhaps also observed by a knowledgeable other (outsider knowledge). A full discussion of this research methodology is beyond the scope of this paper, but attention is drawn to Penny (2011) who discusses this extensively in several publications.

Our initial research activities include identifying the sound characteristics of a few selected Malay traditional musical instruments such as *gedombak* (goblet drum),

gendang (cylindrical drum), *kompang* (frame drum), *serunai* (double-reed oboe type instrument), and *rebab* (spike-fiddle). Expert players were selected to play the instruments for the purpose of recording. A number of software packages were utilised to visualise the sound characteristics of each instrument. From the spectrograms, the researchers then considered how the spectrograms may inform our knowledge of the sound, and how this may be applied in the performance of ethnomusicological works.

Findings

A number of samples of Malay traditional instruments were recorded (as wave files) both in an ensemble and solo context. The instruments included the *gedombak*, *gendang, serunai, geduk and gong* and were played by expert musicians in both solo and ensemble music for the purpose of recording. The recordings used uni-directional microphones, and focused on the desired instrument. As noted, the recordings of the instruments were made in two contexts – solo, in which the selected instrument played alone, and in an ensemble, where the selected instrument was recorded (close miked) within the ensemble. The 'spillage' of sounds from the other instruments in the ensemble provided a musical context for the highlighted instrument, and this helped to demonstrate its role within the ensemble. The various recordings were then converted to spectrograms with a variety of filters and perspectives. These are outlined below. Three software packages – eAnalyse, Sonic Visualier and Praat - were used to create the spectrograms, which provide a visual representation of the recorded clips used in this paper.

The process that has been followed is shown in the following flowchart (Figure 1).

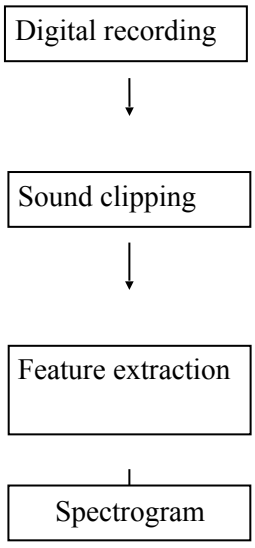

Figure 1. Flowchart of processes

A series of recordings of the instruments demonstrated that the underlying phonetic representation of an unknown utterance can be recovered almost entirely from a visual examination of the spectrogram. The most common format is a graph with two geometric dimensions: The horizontal axis represents time; as we move right along the x-axis we shift forward in time, traversing one spectrum after another; the vertical axis is frequency and the colours represent the most important acoustic peaks for a given time frame, with red representing the highest energies, then in decreasing order of importance, orange, yellow, green, cyan, blue, and magenta, with grey areas having even less energy, and white areas below a threshold decibel level.

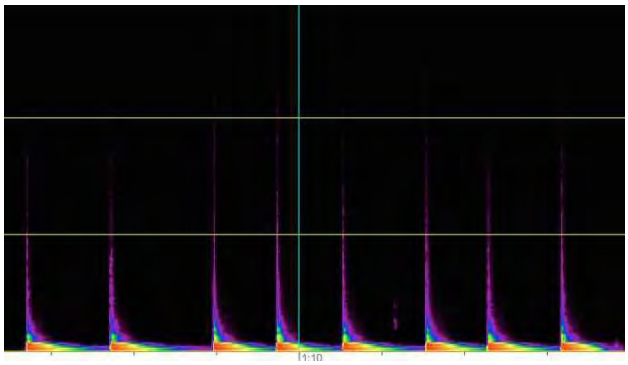

Figure 2. Spectrogram of a gedombak

In Figure 2 we can see the spectrogram of a gedombak beaten in a series of single taps in the middle of the skinhead. What can we learn from this spectrogram? After discussion and receiving further clarification from the expert player, it has been ascertained that the fourth beat of the sound in Figure 2 is the sound preferred by the expert player. One can tell the characteristics of the preferred sound by simple analysis of the colours and density of sound as shown in the spectrogram. Here, we see the preferred sound has the following characteristics: a strong attack (onset) that is followed by the most rapid decay of all the samples shown here; the fundamental tone, which is indicated by the brightest colours (red, yellow, green and blue) is also the most evident in this beat; the decay (length of the sound before it is finished) is the shortest of all the samples; the harmonic overtone series, as indicated by (especially) the height of the purple column, is at least as rich as any in the samples. Although the 4th beat sound (preferred by our expert performer) has a quite similar fundamental tone and overtone characteristics to the 8th beat (the last,) the 4th beat has a significantly faster decay. In addition to the instrument being a preferred one for the player, the performance technique that provides this most desirable sound should also be identified. This will be undertaken in subsequent studies.

Different filters have been applied to the one recording of the gedombak. The results show different features of the sound performed on the same instrument. Below are the examples of different spectrograms showing different features and characteristics of a sound performed on this Malay traditional instrument.

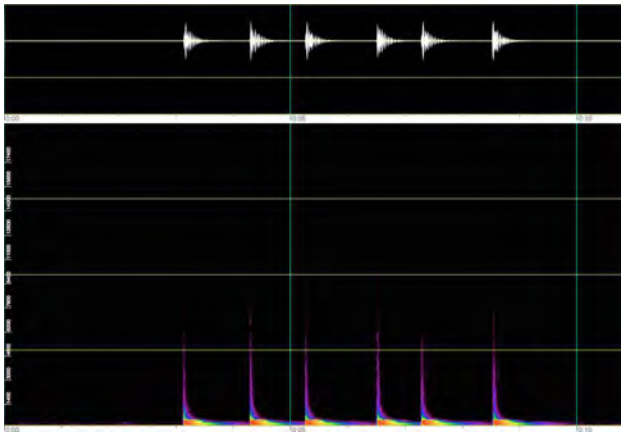

Figure 3. Spectrogram of a Gedombak with the waveform at the top.

In Figure 3, the waveform is an indicator of the sound envelope (Attack, Sustain, Decay, Release – ASDR) over periodic time, and one of the ways Smalley suggests consideration of sonic characteristics. In combination with the harmonic spectral information provided in the spectrogram below, it becomes possible to identify the preferred sound and performance approach of the player. The player's preferred sound 'looks like this'.

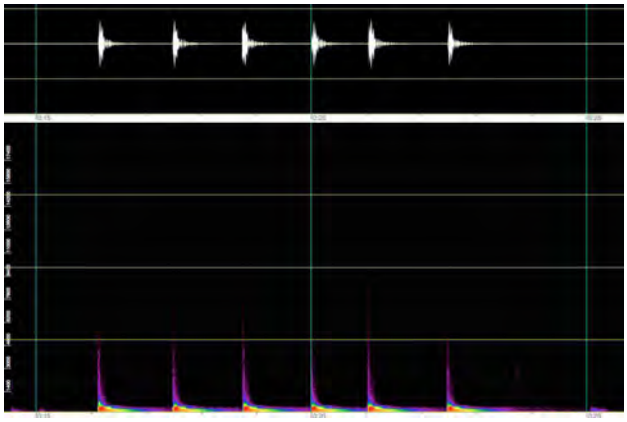

Figure 4. Spectrogram of a smaller sized Gedombak – waveform also at top.

The smaller gedombak (Figure 4) shows slight, but significant differences to the larger instrument discussed above, in both its sound envelope (ASDR) suggested by the wave form, and its harmonic overtone structure. This aspect is an area that will be followed

up in subsequent research as the author catalogues the Malay traditional instruments of the Wayang Kulit. The gedombak is indicated as the large regularly spaced columns of Figure 5.

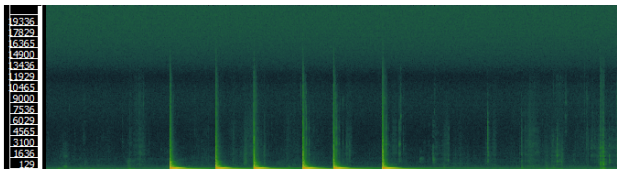

Figure 5. Zoom in Spectrogram of a Gedombak

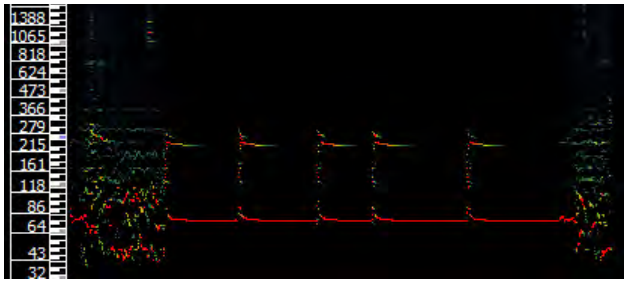

Figure 6. Spectrogram of a Wayang Kulit ensemble

In Figure 6, we see a spectrogram of the entire Wayang Kulit ensemble, recorded in the manner noted earlier. The microphone is focused on the gedombak, but the very strong sounds of the other instruments, particularly the serunai, are clearly evident. In this spectrogram, the higher partials of the sound have been filtered out, indicating only the fundamental tones of the various instruments. The long red horizontal lines represent the melodic lines of the serunai. The pitch variations and arabesque ornamentation so characteristic of the instrument is also visible. The gedombak pitch is visible in the five vertical columns of sound, while the smaller, higher pitched horizontal lines at the top of these columns.

Discussion and Suggestions

The spectrograms of gedombak (goblet drum) in the Wayang Kulit ensemble (Shadow puppet play) above are preliminary attempts to explore the potential of a spectrogram as the basis for a performative notation that includes useful timbral information. This begins the plan to use spectrograms of individual instruments to identify preferred timbral quality of instruments for use in specific musical/dramatic contexts – why a Wayang Kulit 'master' selects one instrument over another in a given performance? In identifying the specific timbre 'preferred' by our 'Wayang Kulit' master, we are also

able to appropriate artifacts that an ethnomusicologist can use to objectively describe the timbre of the instrument, using a combination of overtone and onset qualities. This approach has also allowed our identification of the unique timbral qualities of both an individual instrument (gedombak) and performance techniques that lead to its selection. In achieving this level of specificity in this small component of the paper, we are also in a position to begin to assess the potential of a spectrogram as a precursor to a score timbral representation in performance.

Just what is timbral notation - gestural, purely tonal, semiotic, and so on, and how might timbre be meaningfully represented? The representation of timbre from an historic document – a spectrogram is a diagram of a sound that has already occurred – to one which offers the performative potential inherently extant in a common or graphic musical score is yet to be realised. This creates the opportunity for different forms and styles of score. It might be that in the ethnomusicological project, we can develop the opportunities for varieties of scores and purpose, and in so doing, begin to open the door to new types of performance score which will apply to the wider research project. In the ethnomusicological context, instrumental profiling of timbre linked to the organology of the instrument is applicable in Malaysia and opens ideas that appear to inform concepts and practices in the other sub-projects of the overall research project.

Conclusion

In this paper, we dealt with recognition of sound samples and presented several methods to improve recognition results. Tones were extracted from a database of Malaysian traditional musical instruments (gedombak, gendang, serunai, and so on). We have used two different parameters in this analysis – sound analysis through spectral mapping, and morphology over time. From the experiments, we could observe evident results for spectrogram and autocorrelation. Maximum and minimum values of amplitude for autocorrelation for all musical instruments have different ranges. The harmonic range indicated through the spectrograms of gedombak is much wider than those of gendang and serunai. Our results suggest that the estimation of spectrogram and autocorrelation more effectively reflects the timbral difference in these musical instruments. From the gedombak spectrograms we are also finding that it is possible to objectively demonstrate an experienced performer’s preferences of tonal characteristics for the instrument.

Acknowledgements

We would like to thanks the Ministry of Education, Malaysia for awarding a research grant under the Fundamental Research Grant Scheme. We also wish to thanks the Sultan Idris Education University through their Research Management and Innovation Centre who coordinated all of the research activities. We also would like to express our gratitude to the deans and management teams in the Faculty of Music and Performing

Fundamental Research Grant Scheme *Spectromorphological Notation-Notating the unNotatable*

Arts and the Faculty of Creative Computing Industry at the same university for providing all of the facilities used in this research. Lastly, we offer thanks to all of the people who, either directly or indirectly, have been involved in this research. Without their involvement, this study would not have been possible.

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3.4 Article for UPSI 'Discover' Magazine

Spectromorphological Notation - Notating the unNotatable? Modeling a new system of timbral and performance notation for ethnomusicological, musique-mixte and electroacoustic music compositions. (author) Dr Andrew Blackburn

Research Team

Dr Andrew Blackburn (leader)

Associate Professor Dr Mohd Hassan Abdullah

Dr Jean Penny

Associate Professor Dr Hasnizam Wahid

Associate Professor Dr Valerie Ross

Professor Dr Marc Battier (Université de Paris- Sorbonne)

Associate Professor Dr Pierre Couprie (Université de Paris Paris IV)

GRA. En Hafifi Mokhtar

The Spectromorphological Notation project aims to create a model for a timbral notation system that addresses the need for analysis, clarity of communication, and longevity of technological music scores. An ethnomusicological and electroacoustic music focus is being taken. Existing notation systems allow musical ideas to be communicated across centuries and geographical locations. Notation and analysis of timbre, however, does not exist. This results in a lack of quantifiable enthomusicological knowledge of traditional musical sound, and the inability to reproduce electronic sound due to the demise and obsolescence of software, hardware and electronic storage systems.

This research has caught the attention of researchers worldwide, and has been joined by renowned scholars from the Sorbonne University, Paris: Professor Marc Battier and Professor Pierre Couprie. In June 2014, Professor Battier joined the research team in Tanjong Malim as a connection between this group and the IReMus (Institut de Recherche en Musicologie), France, who are conducting other forms of research in musical representation. Both Prof Battier and Couprie are being funded by IReMUS to come to Malaysia as part of the project in December 2015. In May, 2015 Dr Andrew, Dr Jean and Dr Hassan held research meetings in Paris with various French researchers, and also presented aspects of the research at the First International Conference on Technologies for Music Notation and Representation (TENOR), in Paris.

This project is utilizing timbral analysis through spectography to investigate the organology and ontology of sounds, assessing the needs of music practitioners and researchers, and proposing systems of notation independent of music creation software. Three sub-projects based within ethnomusicology, musique-mixte and electroacoustic

music are investigating the timbral mapping and spectography of traditional Malaysian instruments, Western acoustic instruments, electroacoustic music, and the performance ontologies of these.

Goals of the research include: new insights into Malaysian music making and new techniques for composition, performance and research; new methods of analysis using spectography; quantifiable measurement and description of timbral qualities of music – particularly of traditional Malaysian instruments; identification of instrumental techniques, materials and performance elements and connections; solutions to the problem of obsolescence in music composition; positioning of Malaysian ethnographic studies in ethnomusicology and contemporary art music fields at the forefront of worldwide research.

New musical works are currently being developed in collaboration with Malaysian composers.

The first of these, 'A Piece for Jeanny' by Hasnizam Wahid, contains a flute part coupled with an electronic sound scape; the second is exploring ways to transfer *Usmani* vocal pronunciations into flute playing and to applying various live electronic sound transformations. Both of these works are multichannel works, providing a vehicle to notationally represent timbre in diffusion and space, as well as its morphological characteristics. Another new work is exploring the use of colour in notation to indicate varieties of timbre.

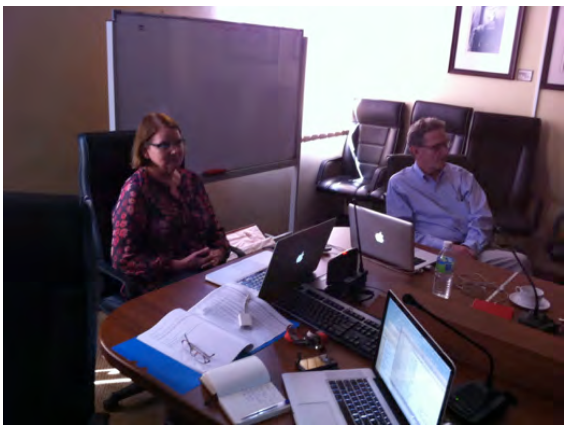
Photos on following pages.

PHOTOS from Discovery Article.

Dr Andrew and Dr Jean presenting at the TENOR conference, Sorbonne University, Paris. May 2015

2. Dr Andrew with Professor Marc Battier visiting UPSI. June 2014

3. Dr Jean and Professor Marc Battier visiting UPSI. June 2014



4. & 5. Working with Prof Hasnizam Wahid at University Malaysia Sarawak. August 2015.

Appendix 4 - Sub-Project proposals

4.1 Sub-Project 1

Spectromorphological Notation – Notating the unNotatable? - Modeling a new system for timbral

notation of ethnomusicological, musique-mixte and electroacoustic music compositions.

- sub-project 1

Spectography and Ethnography : representing the unique Malaysian sound.

Researchers

Dr Andrew Blackburn (UPSI)

Associate Professor Dr Mohd Hassan Bin Abdullah (UPSI)

Dr Clare Suet Chan (UPSI)

Associate Professor Dr Valerie Ross (UiTM)

Participants

As required

Objective of Research

Malaysian musical heritage has many unique instruments, which give it a sound that is, for Malaysians, emotionally important. The instruments have specific physical properties along with cultural meanings, which have been described by many writers. The music has been transcribed using the usual tools available to ethnomusicologists. However, almost no work has been undertaken to map and transcribe the sounds,

identifying the unique qualities which characterize each instrument, and how the instrument sounds differ according to the material from which they are made - or how the different performers from each area create individual or localized timbres. This study aims to address this by creating a series of spectrograms of each of the instruments belonging to the Malay Traditional Orchestra or Wayang Kulit ensemble. Spectrograms of both solo and ensemble groups will be made to contextualize the timbral location of the study, and then some instruments will be investigated at great depth. Within the larger FRGS project, this study will pioneer optimal techniques and conditions for creating and assessing spectrograms for a Malaysian ethnographic environment. These techniques will be refined and applied in the other sub-projects that follow.

An outcome of this study will be a series of spectrograms of instruments from several areas, played in the field and in the studio. These will be compared according to material, (bamboo from Cameron Highlands, wood from Kelantan etc) and, in addition to noting the individual or local performance techniques, from the spectrograms, identify how the timbre differs between them, and the frequency, amplitude and other

variables which might be measured. Finally within this whole project, the knowledge of individual instrumental timbre will contribute to the development a model for the timbral notation of instruments. This timbral notation model will allow ethnographers to more completely notate all the musical characteristics of Malaysian Traditional Music.

Project Research Questions

How effective are current notational styles in representing the sound of Malaysian indigenous instruments?

What are the elements that ethnomusicologists require from a notation system and how can these be

represented?

What organological elements within each sub-project are common or exclusive to each instrument, and how

can they best be identified and analysed?

Can spectrographic analysis and software be used to provide a method for defining and identifying unique

qualities of Malaysian indigenous instruments?

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?

What parameters of analysis can be defined to provide useful and universally 'understood' symbols using spectrographic softwares?

What other knowledge can be drawn from this?

Methods

Using the list below identifies the range of instruments that are normally considered members of the Malay Traditional Orchestra.

Table .<XX> Class MALAY Traditional Orchestra

Winds	Percussion - pitched	Percussion - un-pitched	
Seruling (1)	Bonang (1unit:Bflat	Sarun barung 1	
Bansuri (1)	pentatonic) Sarun peking (1)	Sarun demong 1 Kempul (1 set)	
Serunai Kedah (2)		Gong Agung (1)	
Serunai Kelantan (1)		Gong Suwukan (1)	
		Greteh (2 unitschromatic) * Gambang (1 unit:B flat pentatonic)	

Winds	Percussion - pitched	Percussion - un-pitched	
		Angklung (1 set chromatic)	
		Rebana Ubi (Sets) Jidor Kompang Maruas	
		Rebana Melayu asli ibu & anak (1 each)	
		Gendang Panjang ibu & anak (1 each)	
		Kesi (1)	

Each performer/instrument will be recorded in the field and a neutral studio environment. Language and material differences will be noted in addition to identifying fine performative techniques.

2

Within this process, field and studio recording techniques will be noted and so elements such as microphone characteristics and preferred placements can be collated and published in appropriate technical journals to assist other recording engineers. The characteristics differences of the spectrograms of each instrument will be quantitatively measured and listed, adding to the overall knowledge of these instruments.

New Knowledge

This knowledge will add to the organological understanding of the instruments, by providing a quantifiable and measurable base set of knowledge of the instrumental timbre of Malaysian Traditional Instruments. The timbral knowledge established in this project will allow the researchers to continue their research in the subsequent sub-projects. In creating and analyzing the spectrograms, an understanding of the timbral information which is important to ethnographers will be gleaned, allowing the modeling of a timbral notation system which will gain semiotic universality.

4.2 Sub Project 2 Spectography and Performance: Acoustic and Musique-mixte

Researchers:

Dr Jean Penny (UPSI) - leader

Associate Prof Dr Valerie Ross (UiTM) - researcher

Dr Andrew Blackburn (UPSI) - researcher

Participants:

Associate Prof Dr Michael Edgerton (UM)

Performers as required

Objective of Research

This subproject will create models for spectrographic notation as performance scores. It will investigate intersections of performance and spectography in specific focus

areas.These areas involve acoustic instruments – alone, and in conjunction with electronics (musique-mixte). Analyses of notation, timbre, and organology associated with chosen instruments and electronics will be undertaken to develop a framework for investigating spectographic analyses, evaluations and outcomes. Instruments included in the study are flutes (Malaysian, Western), pipe organ, violin, and a variety of tuned percussion instruments. Live spectography will be applied in studio settings and to music performances, developing new models for investigation and analysis. Inherent in this sub-project (as in all the sub projects of this study) is the development of optimal techniques and conditions for creating and assessing spectrograms for a performance environment. Additionally, performance analyses will be generated through phenomenologically based studies, following the sound spectrum and performer responses to musical works. Performers in this study include instrumentalists and sound technologist / computer musicians.

Project Research Questions

> How effective are current notational styles in representing the sound of instruments, computer generated sound and combinations of these?
>
> How can spectrographic notation be used to define and articulate instrumental and electronics sound?
>
> To what extent can organological differences be analysed through spectrographs? What new information does this give us?
>
> What differences of timbre can be captured by spectrographic representation, and how effective and informative is this as notation?
>
> What spectrographic changes occur with the use of electronic manipulation of instrumental sound?
>
> How can spectrographs work as performative scores? Is this possible?

Methodologies

Notation studies: Daniel Barenboim, in his book Everything Is Connected: The Power of Music (2007), calls the score an ‘infinite substance’. From this, he says, comes the performer’s inner hearing of the work – the internalisation of the music – the ability to analyse and to imagine the sounds and interpretations, then to return to an instinctive unfolding of the piece as new knowledge, self-knowledge or metaphysical understanding of the score and one’s relationship to it. This part of the project will investigate the notated score of both contemporary and traditional music, it’s ability to transfer information and elicit performative response, and the timbrel implications that can be generated. Comparative studies will be generated from this information as models for new spectrographic notations are assessed from the performer’s point of view. Interviews with composers and performers will be conducted.

Timbrel studies: Timbrel studies will relate to the analysis of sounds generated by the notated scores studied. Effectiveness of notational styles will be evaluated as new timbrel studies conducted in this project create comparisons and new knowledge. For example, the sound elements of a traditional Malaysian bamboo flute and a Western silver flute will generate different sound spectra. Electronic techniques will further

manipulate the sound, creating a transformation of the sound spectra. The spectrographic representation of these sounds will be examined for viability as timbre-based notational scores and analysis.

Organological studies: The influence of instrumental properties will be examined – such as materials, playing techniques, and physical behaviours of performers – to determine components of spectrographic notation. Organological similarities and differences between instruments and a variety of digital technologies will be studied, as well as the influence of cultural practices on sound. *Spectography studies*: As the research from the previous three studies creates outcomes, new spectrography investigations can analyse and evaluate this documentation and apply the new knowledge to proposals for notation styles in the performance context.

New Knowledge

New knowledge gained from this project will establish new ways of measuring, documenting, reading and describing sound in music performance.

This knowledge will contribute to the development of models for new forms of score notation.

New organological knowledge, as applied to instrumental and electronic performance, will increase understandings and development of new forms of interactive performance based around spectography. The timbrel knowledge established in this project will allow the researchers to define and continue exploratory research in future projects. In creating and analyzing the spectrograms, an understanding of diverse timbrel information will be gleaned, allowing the modeling of a timbrel notation system which will gain semiotic universality.

4.3 Sub-project 3 Spectography, timbral notation and electroacoustic music.

Researchers:

Dr Andrew Blackburn (UPSI) - leader

Associate Prof Dr Valerie Ross (UiTM) - researcher

Participants:

Associate Professor Dr Pierre Couprie (Sorbonne University, Paris France)

Associate Professor Dr Hasnizam Abdul Wahid

Objective of Research

The objectives of this sub-project are to investigate how a timbral notation system for electroacoustic music might be modeled through spectrography in novel ways. The major components of sound are pitch, amplitude, timbre, rhythm and time. Investigating and articulating the ontological characteristics present in the range of electroacoustic sound(s) used in a selected number of extant works, as well as newly and locally (Malaysian) composed works, will provide the parameters and requirements

of a timbral notation model to be established. It is intended that such a notation system will be independent of software and hardware which historically have a very short currency. It must also be universal, able to operate semiotically across time, culture and language. Inherent in this sub-project (as in all the sub projects of this study) is the development of optimal techniques and conditions for creating and assessing spectrograms of electroacoustic music.

Project Research Questions

1. What are, and how effective are, current notational styles used in electroacoustic composition?

2. What parameters and symbols of spectrographic analysis can be defined to provide useful and universally 'understood' symbols using spectrographic softwares?

3. What are the optimal techniques and conditions required to create spectrograms as the notation of an electroacoustic work? Should such a spectrogram be created from:

    i. Within a software environment;

    ii. Within the acoustic environment of its first performance?

4. Which ontological elements of each sub-project are common, or exclusive, to electroacoustic, and how can they best be identified and analyzed?

5. Can spectrographic analysis and software be used to provide a method for defining and identifying

unique and individual qualities of an electroacoustic composition so that it can be reproduced from such notation?

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

7. Can such information be used to 'describe' and notate a specific individuality of sounds, materials and performance techniques over a temporal scale to allow a performer to re-create an electroacoustic work from such a 'score' independently of the original software used to create the work?

8. What other knowledge can be drawn from this?

Methods

Drawing on the outcomes and definitions established in the opening symposium, the ontology and semiotics of a timbral notation system will be refined through discussion and debate with selected practitioners who are also researchers and participants in this study.

Experimentation of the optimal collection of sounds of electroacoustic music will be undertaken using extant compositions and newly composed works in a studio and software context. In the studio, the selected works will be performed through loudspeakers, and spectrograms created using a variety of recording techniques. Spectrograms of the same works will created from within the playback of the software,

but without playing back through speakers. The spectrograms will then be compared and evaluated for their ability to convey information useful for a timbrel notation model.

Through analyses of spectrograms, and discussion with project and sub-project participants and researchers, it is hoped to identify and quantify ontological timbrel elements common in electroacoustic sound. An outcome of this step in the methodology will be to assess the uniqueness and individual characteristics that mark a sound (spectrogram) as electroacoustic (acousmatique).

In working with composers and performers of electroacoustic music, the specific and characteristic timbrel elements which allow communication of the composer's ideas in a performance or installation context will be established.

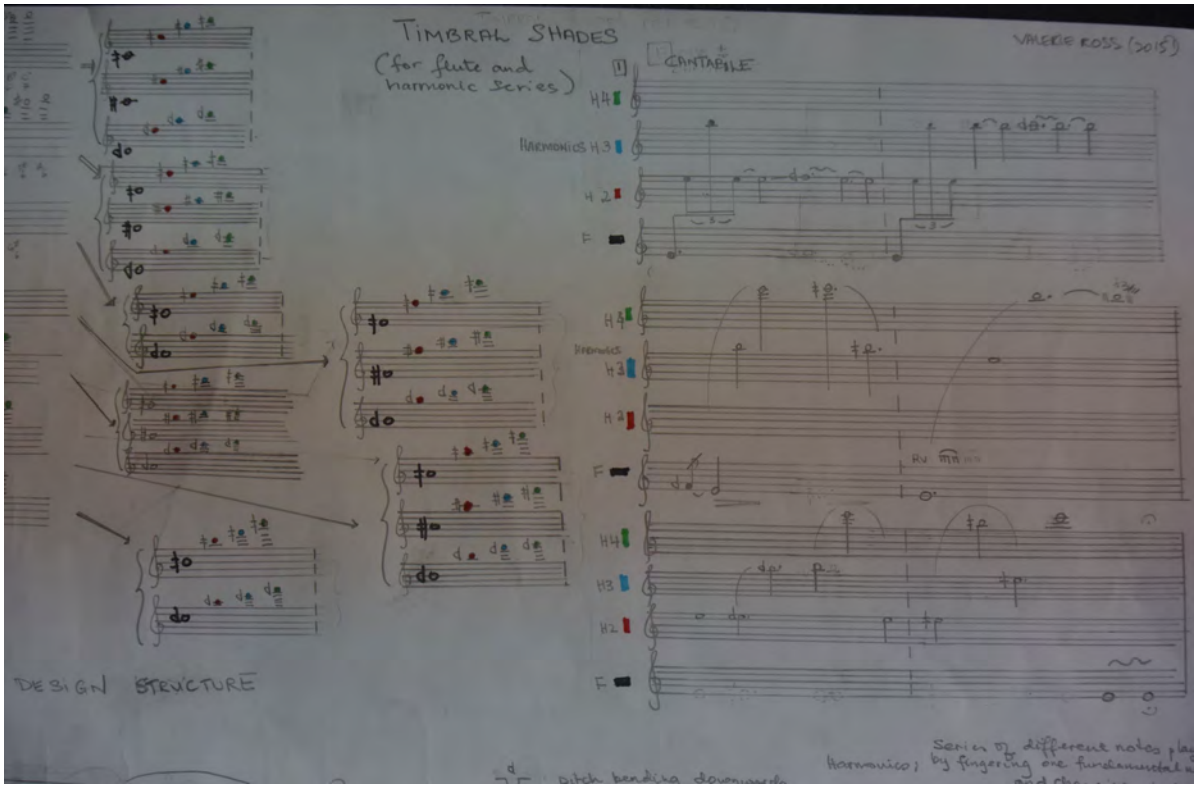
Identifying how these elements operate in conjunction with each other is essential to the creation of a model for electroacoustic notation that can operate across culture, language, and time.

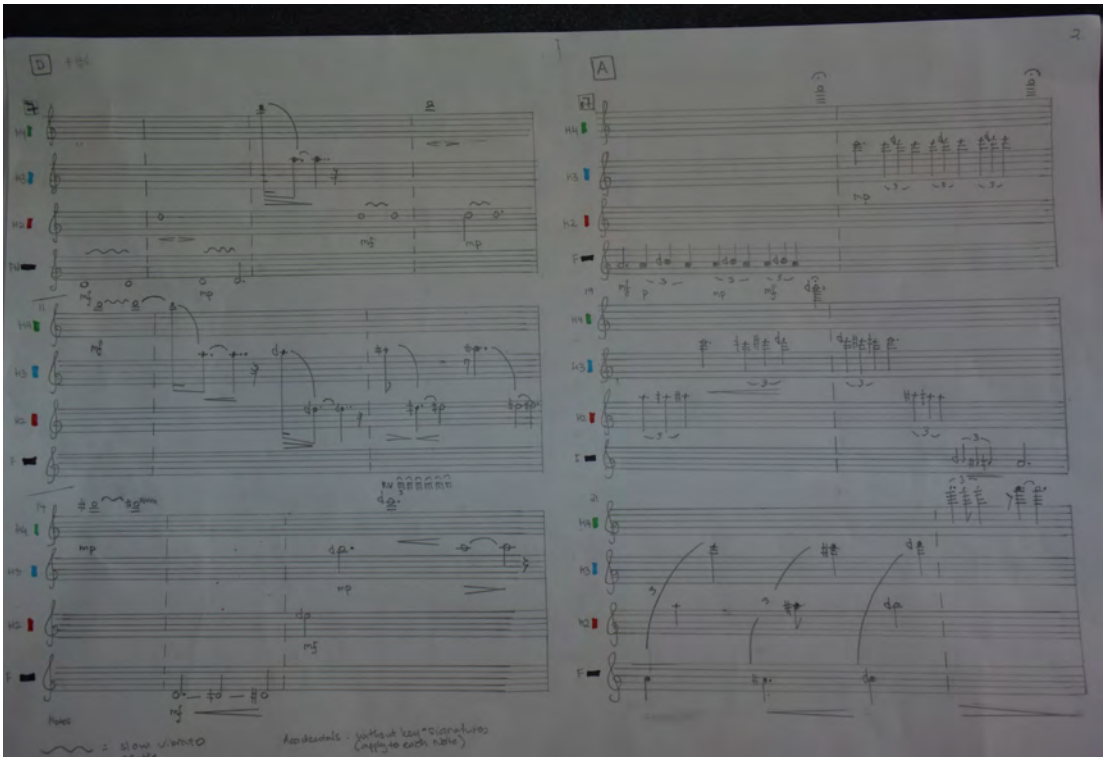
New Knowledge

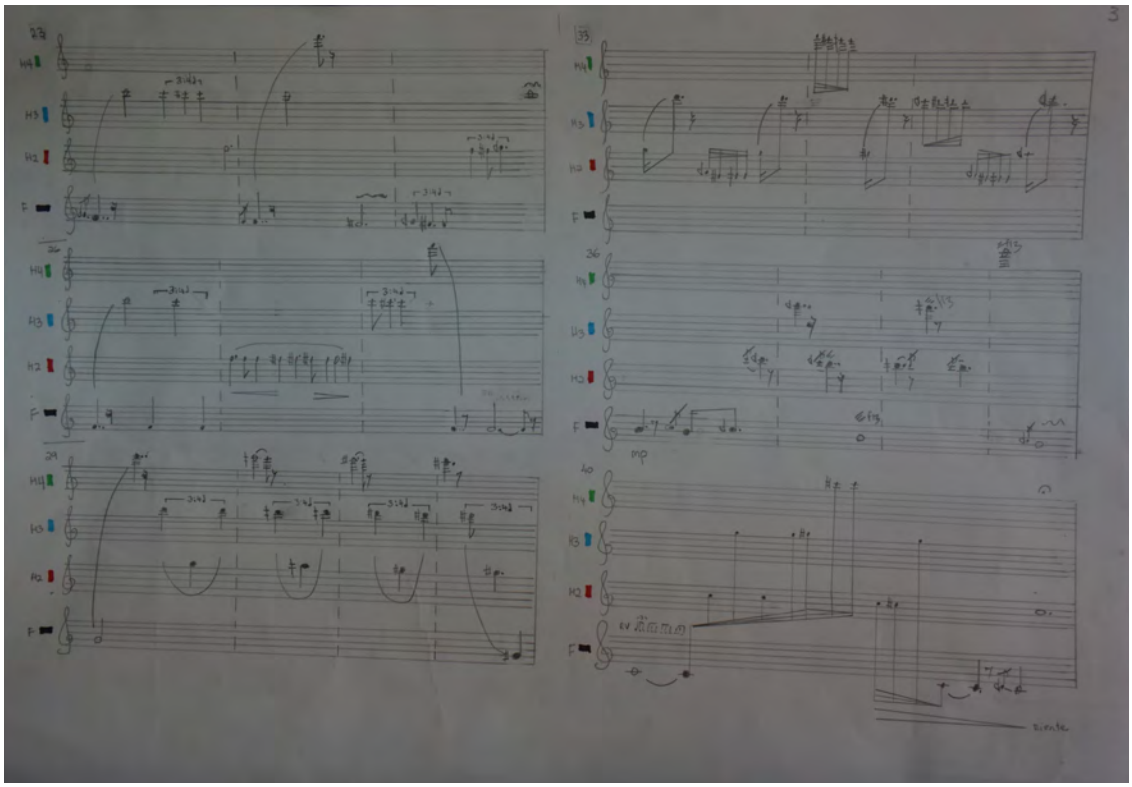
New knowledge gained from this project will establish new ways of measuring, documenting, reading and describing sound in electroacoustic music performance. This knowledge will contribute to the development of models for new forms of score notation and representation. New organological knowledge, as applied to electronic performance, will increase understandings and development of new forms of interactive performance based around spectography. The timbrel knowledge established in this project will allow the researchers to define and continue exploratory research in future projects. In creating and analyzing the spectrograms, an understanding of diverse timbrel information will be gleaned, allowing the modeling of a timbrel notation system which will gain semiotic universality.

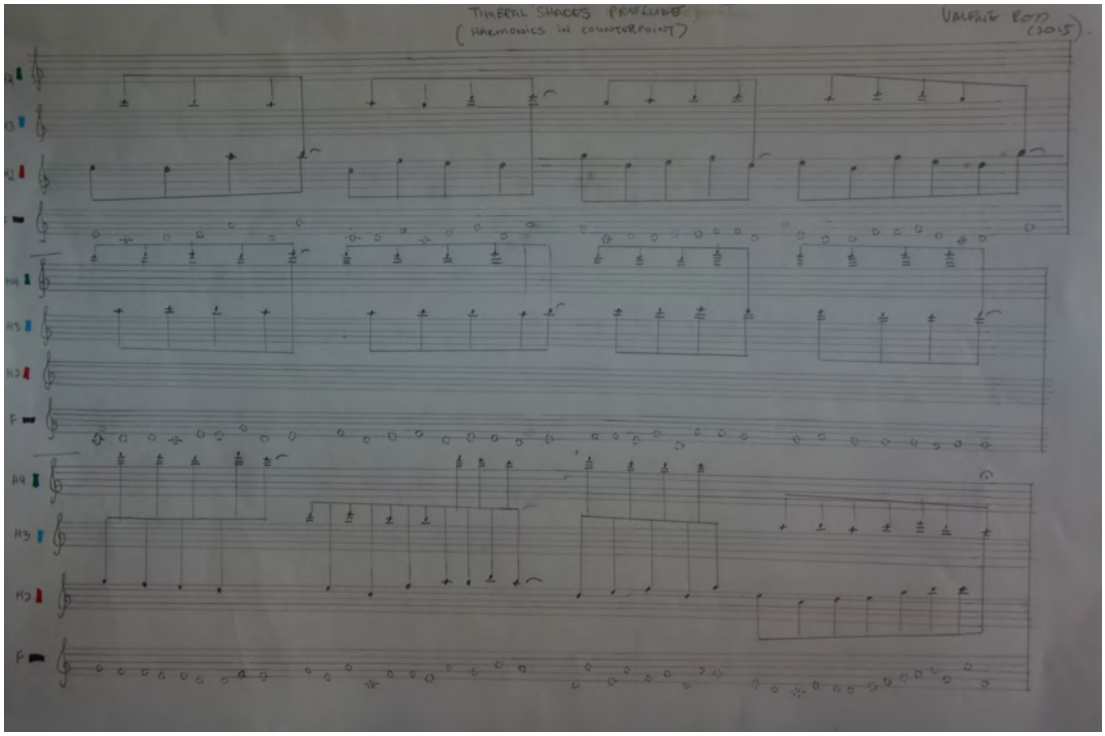
Appendix 5 - Scores

5.1 *Timbral Shades* Valerie Ross








TIMBRAL SHADES PRELUDE
(HARMONICS in COUNTERPOINT)
VALERIE ROTT (2015)

5.2 Piece for Jeannie Hasnizam Wahid

A recording of this work (with the electronics part) is available at

http://spectronotation.weebly.com/project-3-files.html