

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.

Keywords *Music, ethnomusicology, spectrography, notation, Malaysia*

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 change 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 explores 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:

1. How can an ethnomusicologist describe the sound of a musical instrument?;
2. Can spectrographic analysis and software be used to provide a method for defining and identifying unique qualities of Malay traditional Instruments?; and
3. What parameters of analysis can be defined to provide useful and universally understood symbols using spectrographic software?

Methodology

In conducting this study, various methods were utilised to obtain useful data and information in order to answer the research questions. Generally, methods were 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 analysed and thought through this practice. This approach is also referred to as practice-led research. Three phases have cumulatively documented, analysed, applied and reflected 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 (2014) who discusses this extensively in several publications, particularly from within the Malaysian context.

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).

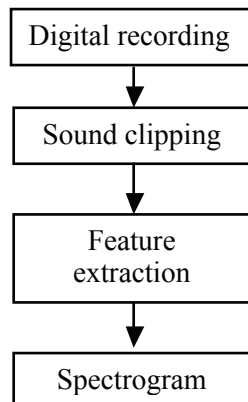


Figure 1 Flowchart of processes

Recording 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.

A series of recordings were made of a solo *gedombak*. After discussion and receiving further clarification from the expert player, it was ascertained that the sound he preferred could be described and then defined by a simple analysis of the colours and density of sound which were visually observable in the spectrogram. (These spectrograms can be viewed at <http://andrewblackburn.weebly.com/article-figures-spectromorphological-timbral-notation.html>) The preferred sound has the following characteristics: a strong attack (onset) followed by a rapid decay – the most rapid decay of all the recorded samples; the fundamental tone is indicated by the brightest colours in the spectrogram (red, yellow, green and blue); the decay (length of the sound before it is finished) is the shortest of all the samples made; the harmonic overtone series, as indicated by the height of the vertical, was at least as rich as any in the samples. Although the specific instrumental sound (preferred by our expert performer) has similar fundamental tone and overtone characteristics to other recorded examples, the ideal timbral characteristic 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.

By applying different spectrogram filters to the one recording of the *gedombak*, different characteristics of the sound of this one instrument became apparent. Using various peak level indicators, the recorded waveform may also be taken as suggestive of the sound envelope (Attack, Sustain, Decay, Release – ASDR) over periodic time. As noted above, the perception of timbre is affected by many elements, and Smalley's suggestions of these sonic characteristics are important. The characteristics identified by Smalley include the harmonic series, spatialisation, amplitude, and onset and release. In combination with the harmonic (overtone) spectral information provided by the spectrograms, it becomes possible to identify the preferred sound and performance approach of the player: the player's preferred sound 'looks like this'.

A recording and spectrogram of a smaller *gedombak* 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 authors catalogue the Malay traditional instruments of the *Wayang Kulit*.

In our final recording, a spectrogram of an entire *Wayang Kulit* ensemble was created. Though the microphone was focused on the *gedombak*, the very pungent, strong sounds of the other instruments, particularly the *serunai*, were clearly evident. In this spectrogram, we also observed long red horizontal lines that represent the melodic lines of the *serunai*. The pitch variations and arabesque ornamentation so characteristic of the instrument were also visible. In this way, a specific interpretation of pitch and duration is possible. The musical activity and function of the *gedombak* was evident in the sharp vertical columns of sound.

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 thank the Ministry of Education, Malaysia for awarding a research grant under the Fundamental Research Grant Scheme. We also wish to thank 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 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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