Pertanika J. Sci. & Technol. 31 (1): 17 - 31 (2023)

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

A Study on Features of Different Tone Quality in a Kenong Set

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ABSTRACT

This work discusses how to distinguish kenong frequencies in a signal and the time-localized frequency content for each tone at a given time using an audio-based approach to tuning retrieval where the fundamental and overtone pitch is shown at all frequencies at a given time. The method of temporal localization on the dominant frequency at its unique time for each tone allows for the detection of frequencies present in the signal. Two approaches used in retrieving the harmonic, pitch, and timbre of kenong are Picoscope and Melda analyzer. The audio recording was done using an At4050 microphone and Ur22 audio interface in mono at 24-bit resolution and 48 kHz sampling rate. PicoScope produces the spectrum while the Melda analyzer produces changes in the spectra with time. Kenong D, E, G, A, and C displayed their near overtones at (2:2.8:4.0), (2:3.0:3.9), (2:2.9:3.9), (2:2.6:3.9), and (2:2.6:3.9). Kenong D had a strong fundamental peak at 295Hz. Kenong G keeps the fundamental frequency constant until t=5s. The basic peak was maintained by Kenong C. The results reveal that the kenong was properly tuned, although the tuner solely tuned it based on hearing, passed down from generation to generation. The maker's intuition permits him to create a specific 'signature' through sound unique to a given kenong set.

Keywords: Acoustic spectra, fundamental frequency, kenong, overtones frequency, sustain fundamental

ARTICLE INFO

Article history:
Received: 16 February 2022
Accepted: 24 May 2022
Published: 19 August 2022

DOI: https://doi.org/10.47836/pjst.31.1.02

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ISSN: 0128-7680
e-ISSN: 2231-8526

INTRODUCTION

The Motivations of the Studies

It is relatively easy to grasp the theory of gamelan tuning but very hazardous to put it into practice (Sorrell, 1990). It appears to be common practice to copy the tuning of some well-known gamelan. The maker answers the question of what to tune to (since there is no pitch or intervallic structure standardization in Java) in consultation with the purchaser.

Figure 1 shows a typical kenong kettle used in this study. The metallophones produce various and complex shimmering and sparkling timbres. The in-harmonic instruments are tuned to either the pelog (seven-tone) or the slendro (five-tone) scales, which differ from the diatonic scale. The tunings are not exactly in the 2:1 octave and can be slightly larger or smaller than 2:1. The octave of one kenong is unlike the octaves of another kenong. An extensive set of measurements of actual gamelan tunings is given in Sudarjana et al. (1993), which studied more than 30 complete gamelans. They used an analog electronic system. This technique filtered out all higher partials and recorded only the fundamentals. The measurement of the tunings is completely adequate because the fundamentals determined the pitches. Unfortunately, all information regarding timbre (spectra) has been lost. An average slendro tuning (numerically average of all the slendro gamelans) is 0, 231, 474, 717, 955, 1208 (in cents), which has a pseudo-octave stretched by 8 cents. This tuning is close to 5-tet. Some gamelans may deviate from this. An average pelog scale is 0, 120, 258, 539, 675, 785, 943, 1206, which is an unequal tuning (stretched by 6 cents).

This study is conducted to identify the sound produced by a set of kenong by making scales and all aspects of sonic as research data. Accordingly, this study considers the configuration procedures of audio equipment, software, and the workflow required for frequency extraction from a kenong set that serves as a musical instrument. This study aims to encourage and expand the approach to working with a variety of approaches in obtaining harmonic contents of metallophones, namely the kenong set through audio signal retrieval via workflows, technologies, and historically as well as culturally recognized music traditions. This research is based on a deep interest in overcoming a kenong set's traditional way of recognizing tunings and scales through a sound recording using various technological and qualitative

Figure 1. A typical kenong kettle

methods. That may finally lead to a comprehensive approach to identifying sound characteristics of a kenong set through retrieving tunings by kenong set through tools, devices, and workflow traditionally played in a communal setting representing a local identity. Gamelan music is in *pelog* or *slendro*, and no matter how evocative the piece, the piano cannot reproduce these tunings. These may help discourage the confusion of general orientalism in Western music with specifically Javanese gamelan elements (Sorrell, 1990). The research on retrieving tunings by the kenong set can serve as a pioneering approach to recognition of sound characteristics, perception of tunings through harmonic differences, and construction of audio signal retrieval through workflows. It will enhance information on factors that might have an impact on the characteristics of each kenong instrument, as well as granting useful data on factors that might have contributed to the differences from one set to another. The way of the functioning (a process of sound production from diverse perspectives) and a sound culture within a community allows for the enrichment of a theory based on facts.

Hence, the study will stimulate discussion and generate greater awareness among practitioners and social scientists on the importance of having a working method of identifying sound characteristics of a kenong set through retrieving tunings by kenong set as a framework consisting of effective tools and workflow. This study can therefore also be seen as a model that compensates for limitations in more abstract findings. It can benefit cultural supporters in a broader sense and from a diversity of backgrounds, both internal and external musicians, anthropologists, and social scientists.

Statement of the Problem

Sound analysis and re-synthesis became available for investigating tone systems and tunings of non-Western music cultures (Schneider & Andreas, 1990; Schneider & Beurmann, 1993). The tunings in kenong are different from the Western systems and were difficult to explain in terms of their origins regarding relevant perceptual and cognitive issues (Ellis & Hipkins, 1884; Stumpf, 1901; Kunst, 1934). All the work mentioned above measured the fundamental frequency but did not consider the overtone frequency. As a result, their works are unable to determine the harmonics and sub-harmonics as well as the timbre. This work measures the fundamental and overtone frequency, called timbre. Fourier transformation determines fundamentals, harmonics, and sub-harmonics. The different intensity and harmonics or sub-harmonics (overtones) distinguish each instrument's characteristics. Most importantly, this work showed the range of available frequencies at a specific time.

This research is carried out to classify the sonic properties generated through the kenong by making scales, tuning, and other aspects of sonic. Accordingly, this study considers the configuration procedures of audio equipment, software, as well as workflows that are required for frequency extraction from the individual kenong. This extraction process will provide an indicator of what sound is appropriate that contributes to what is the preferred sounding of a kenong set. Furthermore, the data collected, which leads to a knowledge of the transformation process factors within the object itself, is important in the production of the kenong set. Therefore, it contributed to the facts of what is preferred sounding kenong.

Objectives of the Study

The main objective of this study is to contribute to tuning and to all facets of sound as research data on the whole sound community of metallophone musical instruments of their high capacity for establishing an independent sound identity, namely kenong, and from the standpoint of retrieving the tunings of the kenong set in field recordings. This contribution helps to clarify further the role of the musical acoustician and his/her relationship to the tuning of metallophones in general. Musical acoustic studies of sound preservation, including a range of responsive viewpoints, would be of growing interest in research projects. Social scientists, audio and sound forensics, technicians, and decision-makers in Malaysian communities are increasingly aware of intangible cultural attributes—focusing on chosen metallophone instruments kenong as the key objects. This study aims to prove the importance of retrieving metallophone tuning through a musical acoustic approach and diversity in sonic studies, that is, through observation and perceptions in the context presented by these instruments' actual meaning. Studies may concentrate on capturing the principles suggested in other metallophone instruments, namely, questionable xylophones and gongs (Schneider, 1988), while checking the applicability of the techniques, instruments, and theoretical views established in the research.

The specific objectives are:

1. To describe the type of kenong set in Malaysia from the perspective of tuning.
2. To describe the kenong set through literature reviews and sound recordings.
3. To describe the tools and devices in retrieving a comprehensive approach to identifying sound characteristics of the kenong set in Malaysia.

Several Related Works Similar to this Research. In Indonesia, the instruments are not all tuned to a single standard reference scale, producing many different gamelan tunings (Surjodiningrat et al., 1993). Each instrument is tuned and timbrally adjusted for its orchestral context, where it is created for a single ensemble. Therefore, one gamelan inevitably differs in intonation, tone, and feelings from another. Western diatonic scales are connected to sounds with harmonic spectra. A similar relationship exists between the pelog and slendro scales and the overtone sounds of the saron, bonang, gender, or kenong. The differences between the tunings of various gamelans can be explained by the differences between the spectra of the various instruments. The relation between the spectra and the tunings of the gamelans presents an intriguing challenge. Rossing and Shepherd published details of the spectra of any gamelan instruments, but this was not a complete study, even of the one gamelan (Rossing & Shepherd, 1982). Only the *jegongan* (a Balinese gender) and the gong are studied, requiring more data.

The metallophones of the gamelan have in-harmonic spectra. Gamelan music scales and tunings are unfamiliar, with the timbre of the instruments unusually bright and harsh. Both the tunings and the timbres are easily quantifiable. The kenong with a larger rim makes a clear and sustained sound. Hence it serves as a primarily rhythmic function. Despite the differences in shape, the spectra of the kenong are like those of the bonang. Figure 2 shows the spectra of 3 typical bonang from Sethares (2005).

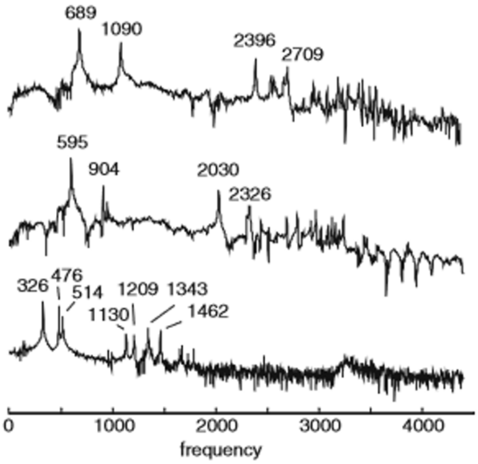


Figure 2. Spectra of 3 typical bonang (Sethares, 2005)

Gamelan has a strong sense of rhythm as it is traditionally played by ear rather as opposed to reading from written musical scores. The beats are clearly audible so that the musical piece can be passed down orally through generations. The significance of beat features shows Gamelan classification compared to Western musical instruments. The first feature of vibration of the kenong is the extraction process, where the whole audio is characterized by a frequency representation (using the Fast Fourier Transform-FFT). This FFT feature clearly showed the whole frequency range after the first beating. With audio data, several studies are also done using the Melda analyzer in Cubase version 9. The significance of Melda analyzer data features that display the spectra changes with time was investigated, and the characters of the features are discussed. Hamdan et al. (2019) offer a comprehensive discussion on the feature.

METHODOLOGY

Two approaches suggested in retrieving tunings of kenong via tools, device, and its workflow are shown in Figure 3.

The cast bronze kenong set was chosen from a range of gamelan ensembles available at the Faculty of Applied and Creative Art, Universiti Malaysia Sarawak. The acoustic spectra of the measured sets of 5 just-tuned cast bronze kenong (kenong D, E, G, A, and C), which were made in Indonesia, were captured using PicoScope oscilloscopes and Melda analyzer to investigate the fundamental and the overtone frequencies. Excitation was done

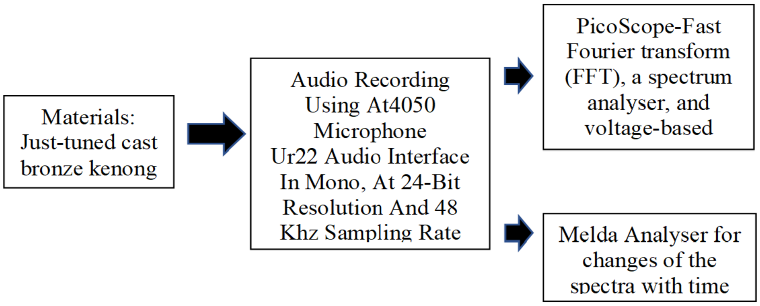


Figure 3. Workflow showing the tools and device for retrieving tunings of kenong

by beating the kenong with padded mallets by an expert kenong player. The Melda analyzer records the sound and plots the intensity versus frequency over time. Various frequencies with differing intensities are presented at any given time. This study gives the intensity versus frequency at 0, 0.5, 1, 2, 3, 4, and 5 seconds. At t=0 s, the fundamental frequency has the highest intensity. This fundamental frequency can no longer be sustained after t=0 s. The analyzer can display how the intensity of the frequency changes over time.

The microphone was held above the top surface along the axis of symmetry of the kenong at about 20 cm (Figure 4). The PicoScope computer software (Pico Technology, 3000 series, Eaton Socon, UK) was used to view and analyze the time signals from PicoScope oscilloscopes (Pico Technology, 3000 series, Eaton Socon, UK) and data loggers for real-time signal acquisition. PicoScope software enables analysis using FFT, a spectrum analyzer, voltage-based triggers, and the ability to save/load waveforms to a disk. Figure 4 shows the schematic diagram of the experimental setup. The kenong was placed where the sound could be captured with minimum interference. The amplifier (Behringer Powerplay Pro XL, Behringer, China) ensured the signal converter's sound capture was loud enough to be detected.

The kenong spectra were also digitally recorded using the Melda analyzer. In this study, the audio signal derived from the striking of the kenong played by an expert kenong player is recorded. The audio signal is recorded in mono, at 24-bit resolution, at a 48 kHz sampling rate. The audio signal is recorded with the aid of a digital audio interface in a .WAV format. Audio signal calibration of the recording system is carried out to ensure the recorded audio signal of the striking of the kenong is at the optimum level. A 1 kHz sine wave test tone is used to calibrate the recording system. Here the 'unity' calibration level is at +4dBu or -10dBV and is read by the recording device at '0 VU'. In this regard, the EBU recommended that the digital equivalent of 0VU is that the test tone generated to the recording device of the experimentation is recorded at -18 dBFS (Digital) or +4dBu (Analog), which is equivalent to 0VU. The amplitude scale of the vertical ruler waveform display is in decibels mode. In this mode, amplitude ranges from -infinity to zero dBFS on a decibel scale. 'FS' stands for 'Full Scale', and 0 dBFS is the highest signal level achieved in a digital audio WAV file.

Higher levels are possible within digital audio workstation software, but 0 dBFS is the highest level in the files that are recorded on the disk. As the signal is either an electronic or digital representation of that sound, variations in signal or sound levels are measured in decibels (dB). In their dB form, decibels do not describe the absolute level of a signal or sound, only any comparison or change in level. 0 dB means no difference in the level or no change in level. Decibels are used to describe differences or changes in level. 0 dB means ‘no change’. Values in dBFS are used to describe signal levels in comparison with the highest level a WAV file can handle. In this thorough calibration procedure, no devices unknowingly boost or attenuate its amplitude in the signal chain when the recording is carried out. The recording apparatus was the Steinberg UR22 mkII audio interface, Audio-Technica AT4050 microphone, XLR cable (balance), with microphone position on axis (<20 cm), and microphone setting with low cut (flat) 0dB.

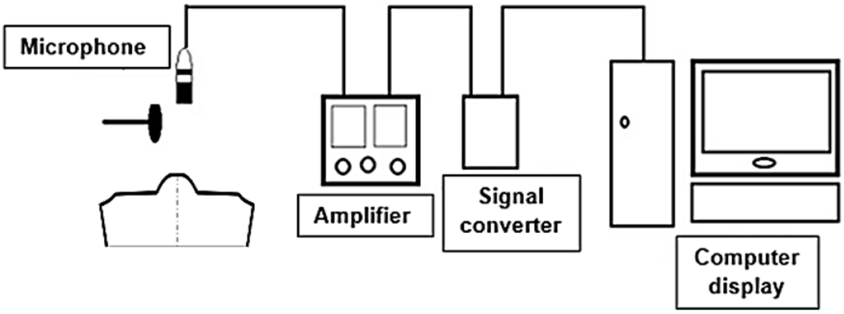


Figure 4. Schematic diagram of the experimental setup

For this investigation, the acoustic signal generated by an experience kenong player striking the kenong was captured. The kenong was struck at a steady rate since the performance was assessed on the rhythm and physiological synchronization of the left and right hands.

RESULT AND DISCUSSION

Acoustical recordings of metallophones being struck were used to examine ratios of overtone frequencies to the fundamental. Results showed variability in the number and ratios of overtones present. The acoustic spectra for the kenong vary substantially due to variation in shape, size, and dimensional irregularities created during manufacture and while tuning by hand grinding. Figure 5 shows the typical acoustic spectra recorded after excitation of kenong D captured using PicoScope oscilloscopes. The spectrum in Figure 5 is very noisy because the PicoScope captures the whole range of the signal. The peak picking is not chosen randomly here but based on the highest amplitude. So, the frequencies given in Table 1 are not arbitrarily chosen. Knowing the fundamental frequency of each kenong gives an indicator of the overtone peaks. The spectrum in Figure 6 is captured using the Melda analyzer and displays the signal at t=0, 0.5, 1, 2, 3, 4, and 5 seconds. At one time, such as at t=0s, the analyzer only displays three significant frequencies 296, 424, and 1213Hz. The signal looks cleaner because the duration of the display is at one time. Although the spectra still depend on the strike, the frequency obtained does not depend on the strike; only the amplitude depends on the strike. Although there is only one example of many possible spectra from one instrument, the author employed a professional player to strike the instrument, and the frequencies are reproducible and repetitive.

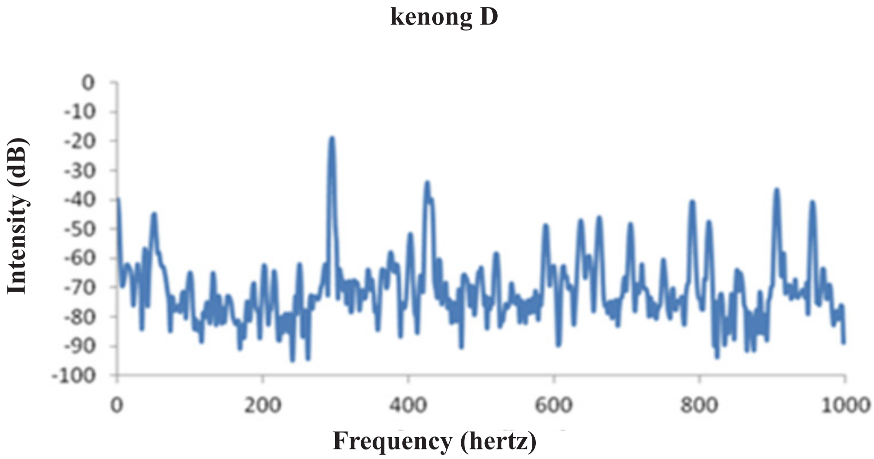


Figure 5. A typical spectrum (kenong D) from PicoScope Oscilloscope

Table 1 shows the fundamental frequency (f_0), first overtones (f_1), and second overtones (f_2) for kenong D, E, G, A, and C. The values in the bracket at the last column based on the equal-tempered scale (ETS) are shown as a reference only. The tuning of kenong cannot be interpreted in a framework of an ETS harmonic or even in the framework of the harmonics of 4 basic waveforms of the square, saw-tooth, triangle, and pulse. These define precisely to decrease amplitude over time. Square wave will have a set of odd-order harmonics determined by the harmonic order and decibel loss per harmonic over time (1, 3, 5, 7, & 9). Saw-tooth is made of odd and even number harmonics 1, 2, 3,4,5, and 6. So kenong is not of these harmonics, and its structure is made of a variety of non-harmonic partials, so the kenong partials were (2:2.89:4.01), (2:3.03:3.90), (2:2.92:3.99), (2:2.67:3.98) and (2:3.12:3.69) for kenong D, E, G, A and C respectively.

Table 1

Fundamental frequency and overtones for Kenong D, E, G, A and C, Kenong Swastigitha (Sw) and Kenong Kyai KadukManis (Kk) (Hamdan et al., 2019) with the Equal Tempered Scale (ETS) frequencies as a reference

	f_o	f_1	f_2	f_o: f_1: f_2	f_o (Sw)	f_o (Kk)	ETS
						242	B3(246)
D	292.6	423.4	587.2	2:2.894:4.013			4(293.7)
E	331.7	503.4	647.7	2:3.035:3.905		320	E4(320.6)
					375		F4(349)
						369	F#4(369)
G	396.0	579.4	790.1	2:2.926:3.990	412		G4(392)
						421	G#4(415)
A	440.9	589.2	877.9	2:2.673:3.982			A4(440)
					472	478	A#4(466)
C	518.9	809.7	959.9	2:3.121:3.699			5(523.3)
						557	C#5(554)
					623		#5(622)

If a strong fundamental is not essential for perceiving the pitch of a musical tone, the question arises as to which overtones are most important (Sethares, 2005). When the parts of the complex tone are not harmonics, however, the determination of pitch is more subtle. Musical examples of the ability of the auditory system to formulate a pitch from near harmonics in a complex tone are the sounds of bells and chimes.

The manufacturer can bring out the fundamentals for a clearer pitch during the tuning process by raising a small boss at the center of the kenong. Hammering a small boss in a previously un-bossed kenong increases the pitch for the fundamental and most of the higher notes. Progressively enlarging, the boss continues to raise the pitch but more and more slowly. Finally, adding the boss will allow raising the pitch a maximum of a fifth or sixth, typically above that of the original flat disk (Rossing & Peterson, 1982).

The tuning of slendro-kenong of gamelan Swastigitha is 357Hz (F4), 412Hz (G#4), 472Hz (A#4), and 623Hz (D#5). While the tuning of slendro-kenong of gamelan Kyai KadukManis is 242Hz (B3), 320Hz (E4), 369Hz (F#4), 421Hz (G#4), 478Hz (A#4), and 557Hz (C#5) (Hamdan et al., 2019). In this work the spectrum of the respective slendro-kenong as shown in Table 1 are 293Hz (D4) with partial f, 1.44f, 2.0f; 332Hz (E4) with partial f, 1.52f, 1.95f; 396Hz (G4) with partial f, 1.46f, 1.99f; 441Hz (A4) with partial f, 1.33f, 1.99f; and 519Hz (C5) with partial f, 1.56f, 1.85f.

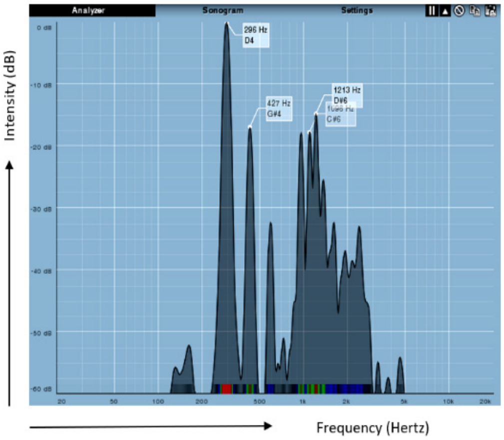
Table 1 shows that our slendro-kenong is very close to the frequency obtained from the ETS. The kenong from Swastigitha showed a deviation of 7.5% (375-349), 5% (412-392), 1.3% (472-466) and 0.1% (623-622), while kenong from Kyai KadukManis showed a deviation of 1.6% (246-242), 0% (320-320), 0% (369-369), 1.4% (421-415), 2.6% (478-466) and 0.5% (557-554).

Table 1 is reorganized so that the tuning is based on ETS and shows it to the nearest ETS; the reason for such tunings is because tuners were innovative in their client composition. The closeness of the tuning of the measured kenong to ETS was not meant to be intentional. It was given here purely as a reference and comparison. Mixed tuning was developed and created to enrich the color or sonority prior to their compositions. If all tuning is made the same, it will vanish other tunings. Each gamelan is tuned accordingly to a region from where it belongs because it is done purely by listening. If all tuning is the same value as the other tuning, culture will be extinct or write-off. So this must mean that standardizing the tuning is bad. Yes, it is bad because only western tuning will be used and nothing more. Pelog or slendro on gamelan no longer be important because instruments like marimba or xylophone can play it. The same thing applies to the makkam on gambus is no longer important to be played by the gambus because it can be played by guitar. That is a big problem, and all other ethnic instruments will be of no use, for example, samphonton/ santur/ sitar and many more.

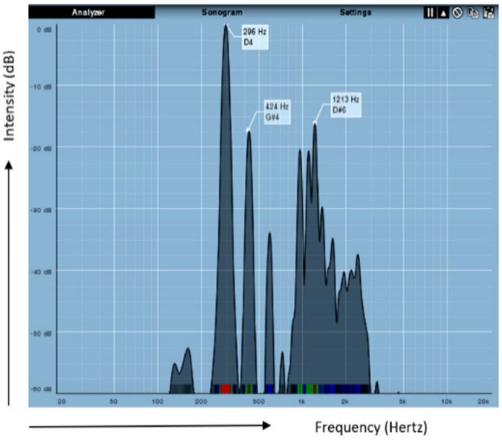
So the acoustician only referred to just the only Western tuning; they are the one who lacks comprehensive knowledge of musical instruments, which we cannot blame because they only have one tuning, and they are also not an ethnomusicologist. There is a variation where some are tuned lower or higher. As a tuner, should the maker consider our tuning reference or use the existing gamelan as a reference?

When the maker makes the gamelan, they will usually be based on the client's request, as our kenong was tuned similar to the ETS. It tells us that there is certain standardization. Each gamelan was developed and constructed accordingly to its tuning standards according to its district. In the past, each kenong was made according to certain standardization of each district. The authors believe that our kenong had been tuned purposely according to the ETS (purchase in 2013) compared to the Swagistitha and Kyai Kayu Manis. To the author's knowledge, the only tuning of the kenong was from Swagistitha and Kyai Kayu Manis (Hamdan et al., 2019).

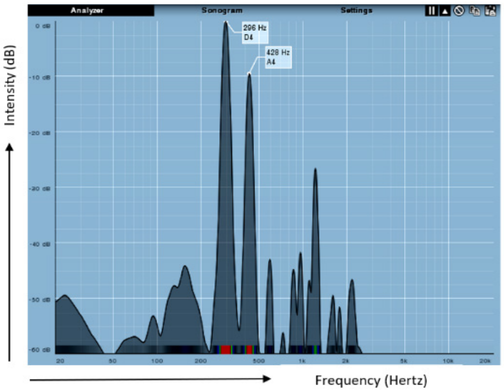
Figure 6 shows the typical sonogram recorded after excitation of kenong D captured using the Melda analyzer. Table 2 showed different peak frequencies for kenong D, E, G, A, and C obtained from the Melda analyzer recorded at t=0, 1, 2, 3, 4, and 5s. From Table 2, at t=0s, kenong D showed a high peak at 295Hz (exactly as D4 on ETS) and a second low peak at 425Hz (i.e., A4 on the ETS scale). This 295Hz (D4) peak gradually decays (replaced by ~425Hz (A4) peak) and eventually disappears at t=5s. It indicates that the overtone frequency later replaced the fundamental frequency at t=0s from the second peak at t=5s, which is the first overtone frequency, i.e., 423.36Hz (f_1) as detected by the PicoScope. The fundamental frequency E4 for kenong E disappears at t=4s and is replaced by B4. Kenong G sustain the fundamental frequency G4 until t=5s with the overtone G5 increasing from -25dB (at t=0s) to -9dB (at t=5s). Kenong A showed a gradually decreasing trend of A4 at -9, -12, -15, -22dB at t=2, 3, 4, and 5s, respectively, which is replaced by D#5 at t=2s. Kenong C showed that the fundamental C5 was sustained and maintained the amplitude for 5s. The overtone for kenong C was maintained for the whole 5s.



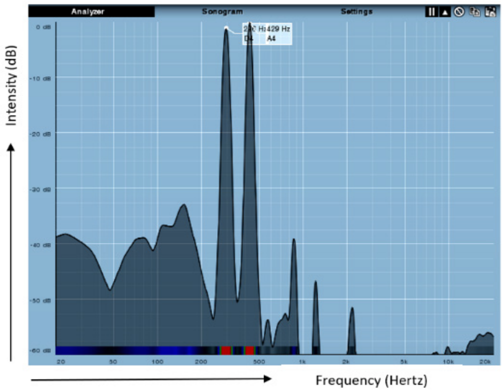
6a. t = 0 seconds



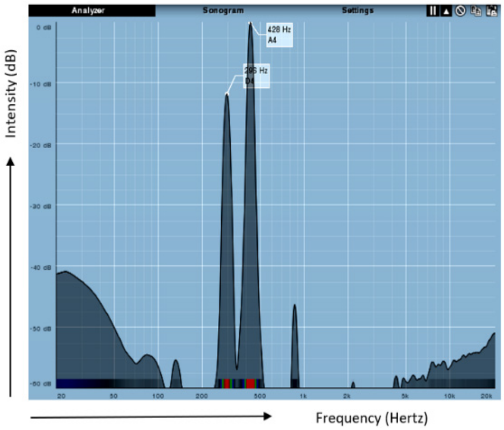
6b. t = 0.5 seconds



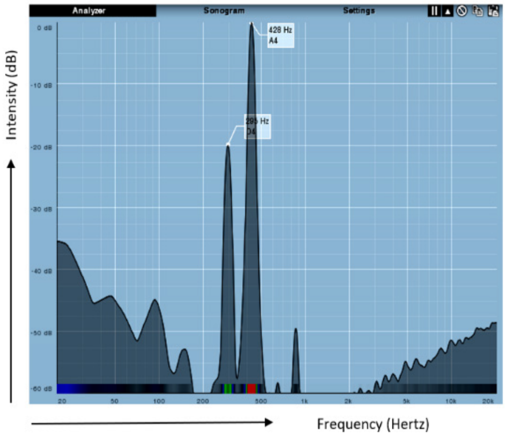
6c. t = 1 seconds



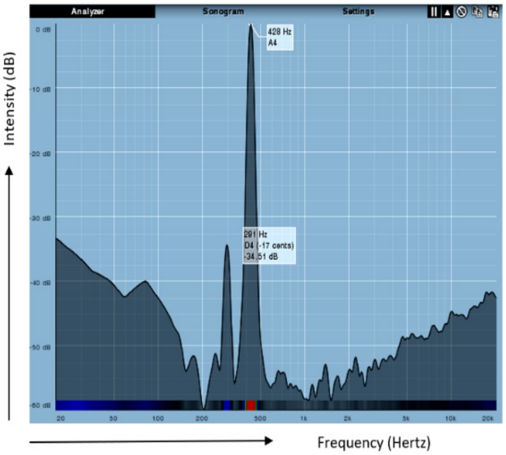
6d. t = 2 seconds



6e. t = 3 seconds



6f. t = 4 seconds



6g. t = 5 seconds

Figure 6. Kenong D at t=0, 0.5, 1, 2, 3, 4, 5 seconds

The FFT time interval is given in Table 2, where different peak frequencies for kenong D, E, G, A, and C were obtained from Melda Analyser recorded at t=0, 1, 2, 3, 4, and 5s. From Figure 6, the short time intervals at t=0, 0.5, 1, 2, 3, 4, and 5s clearly showed distinct and significant fundamental and overtone peaks at their particular time. Most important, Figures 6d, 6e, 6f, and 6g showed the changes in the amplitude of the fundamental being overridden by the amplitude of the overtone with time. As such, it can be concluded that at t=0s, several frequencies appear together with the fundamental, but with time the overtone peak becomes more dominant than the fundamental frequencies.

The precisions of the result of each investigation describe that if all tunings are made the same, other tunings will be lost. Each gamelan is tuned to the region it belongs to because it is solely done by hearing. If all tunings have the same value as the others, culture will become extinct or be forgotten. Therefore, it must imply that standardizing tuning is a poor decision. It is poor because only western tuning will be used, so pelog or slendro on gamelan will no longer be important. It can be played with any instrument, such as a marimba or xylophone. The same is true for the makkam on gambus, which no longer needs to be played by the gambus because it can be played by guitar. That is a major issue; all other ethnic instruments, such as the samphonton/santur/sitar and many more, will be rendered obsolete.

Table 2

Different peak frequencies for kenong D, E G A C obtained from Melda Analyser recorded at t=0, 1, 2, 3, 4, and 5s

Kenong	Time Sec	First Peak	dB	Second Peak	dB	f_o
D	0	f(296D4)	0	1.4f(427G#4)	-19	293
	0.5	f(296D4)	0	1.5f(424G#4)	-19	
	1	f(296D4)	0	1.5f(428A4)	-10	
	2	f(296D4)	0	1.5f(429A4)	0	
	3	f(296D4)	-12	1.5f(428A4)	0	
	4	f(296D4)	-24	1.5f(428A4)	0	
	5	-	-	1.5f(428A4)	-	
E	0	f(332E4)	0	1.5f(502B4)	-28	332
	0.5	f(332E4)	0	1.5f(502B4)	-18	
	1	f(332E4)	0	1.5f(502B4)	-4	
	2	f(332E4)	-18	1.5f(502B4)	0	
	3	f(332E4)	-32	1.5f(502B4)	0	
	4			1.5f(499B4)	0	
	5			1.5f(501B4)	0	
G	0	f(396G4)	0	1.5f(596D5)	-25	396
	0.5	f(396G4)	0	1.5f(596D5)	-25	
	1	f(396G4)	0	1.5f(596D5)	-22	
	2	f(396G4)	0	1.5f(596D5)	-19	
	3	f(396G4)	0	1.5f(596D5)	-17	
	4	f(396G4)	0	1.5f(596D5)	-11	
	5	f(396G4)	0	1.5f(596D5)	-9	
A	0	f(441A4)	0	1.4f(613D#5)	-12	441
	0.5	f(441A4)	0	1.4f(613D#5)	-9	
	1	f(441A4)	0	1.4f(613D#5)	-8	
	2	f(441A4)	-9	1.4f(613D#5)	0	
	3	f(441A4)	-12	1.4f(613D#5)	0	
	4	f(441A4)	-15	1.4f(613D#5)	0	
	5	f(441A4)	-22	1.4f(613D#5)	0	
C	0	f(519C5)	0	1.5 f(805G5)	-34	519
	0.5	f(519C5)	0	1.5 f(805G5)	-34	
	1	f(519C5)	0	1.5 f(805G5)	-32	
	2	f(519C5)	0	1.5 f(805G5)	-32	
	3	f(518C5)	0	1.5 f(805G5)	-32	
	4	f(518C5)	0	1.5 f(805G5)	-32	
	5	f(522C5)	0	1.5 f(805G5)	-32	

CONCLUSION

The spectra recorded by PicoScope oscilloscopes and Melda analyzer were investigated through the vibration overtones. The two-tone quality of the kenong set, namely the kenong of gamelan Swastigitha and Kyai Kaduk Manis, are compared with kenong D, E, G, A, and C from this study with the tuning set to D4, E4, G4, A4, and C5. The kenong of gamelan Swastigitha used their tuning set to F4, G#4, A#4, and D#5. At the same time, the kenong of gamelan Kyai Kaduk Manis are tuned to B3, E4, F#4, G#4, A#4, and C#5. Our study confirms that our *kenong* are well-tuned to the ETS's D4, E4, G4, A4, and C5. Furthermore, this study confirms that one gamelan inevitably differs in intonation, tone, and feelings from another. It is due to the intuitive feeling (listening experience inherited from generation) of the gamelan tuner during the tuning of kenong gamelan Swastigitha and Kyai Kaduk Manis using primitive tools. During a field visit by the authors to Jogjakarta, the tuner only used a pianica and tuned it purely based on his listening. The authors suggest that our instrument results are similar to ETS because it was intended by the purchaser to be tuned according to the ETS, although the tuning tools were primitive.

Hence it proved that these primitive tools could translate the tuning onto the gamelan set. From a field visit to Jogjakarta, the authors were told that the gamelan tuner tuned the gamelan purely based on hearing inherited from generation. The instrument is struck and heard by the tuner based on what he hears from a standard pianica. In our work, this primitive tuning was replaced by reading with PicoScope and Melda analyzer, and it proved that the transmission of the tuner onto the tuning of the gamelan set can be shown on the aspect of intonation, tone, and feels. From the PicoScope data, kenong D, E, G, A, and C showed complex tones with their fundamental equivalent to ETS.

However, kenong's frequency is different when comparing its frequency precision with ETS. Although its frequency accuracy is nearly similar, it differs in the aspect of intonation and tone characteristics. One aspect that needs to be considered in this study is the sound characteristic sense. The sense derived from the maker allowed him to craft a specific 'signature 'through the sound characteristic of a particular gamelan set. When kenong is sat in an ensemble of gamelan, the sound stands out as other parts make the sound faculty of the gamelan ensemble unique. It is the peculiarity of gamelan; it is exclusively handmade, produced, and constructed through primitive tools and processing such as hammer, hand file, and ground metal foundry, creating an offset tuning and timbre. The gamelan is the entire instrument. It has a tuning bound to the aesthetics of a group of musicians (of a community in the past, today of some professionally engaged musicians serving the entire sound of the instrument). Destroying this through an imposed "rightful tuning" kills the instrument, especially when people refer to constructed ideas of equidistance tuning. From the Melda analyzer data, at t=0s, kenong D showed a high peak at 295Hz (exactly as D4 from the ETS) and a second low peak at 425Hz (i.e., A4 from the ETS). This fundamental peak gradually decayed and was replaced by the first overtone peak and eventually disappeared. It indicates that the overtone frequency later replaced the fundamental frequency. The fundamental frequency for kenong E disappears at t=4s and is replaced by B4. Kenong G sustain the fundamental frequency (G4) with the overtone (G5) increasing from -25dB (at t=0s) to -9dB (at t=5s). Kenong A showed a gradually decreasing trend of A4 peak at -9, -12, -15, -22dB at t=2, 3, 4, and 5s, respectively, which is replaced by D#5 at t=2s. Kenong C showed that the fundamental C5 peak was sustained and maintained the amplitude for 5s. The overtone for kenong C was maintained for the whole 5s.

ACKNOWLEDGEMENT

GERAN PUTRA: GP/2017/9561700 funded this research.

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