Comparison Study of *Saron Ricik* Instruments' Sound Color (Timbre) on the Gamelans of *Nagawilaga* and *Gunturmadu* from *Karaton Ngayogyakarta*

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Abstract. **The aim of this research is to compare the timbre spectrums of *Saron Ricik* Instruments of Gamelan *Nagawilaga* and *Gunturmadu* of *Karaton Ngayogyakarta*. These gamelans, as a set of traditional Javanese ensemble, are a *pelog* scale, seven scales in one octave.**

Sound of *Saron Ricik* Instruments is recorded by sound software. This software can display waveform in the time domain and spectrum in the frequency domain. The fundamental frequency is shown directly by the software. Other peak frequencies can be traced by shifting the cursor on the top of it. The accuracy of frequency that can be produced is 1 Hz

Fundamental frequencies of *Saron Ricik* of Gamelan *Nagawilaga* are higher than of *Gunturmadu*. The locations of the harmonic frequencies are not always consecutive, but sometimes punctuated by another frequency. The number of harmonics or timbre of each instrument of *Nagawilaga* is different from the one of *Gunturmadu*..

Keywords: *Gamelan, Saron Ricik, Nagawilaga, Gunturmadu*

1. Introduction

The gamelan plays many roles in traditional Javanese society: from religion and ceremony to education and entertainment. In recent years, recordings of gamelan music have become available in the West [1, 2, 4, 13].

The gamelan ensemble can be characterized as music based on communal expression. The melody of a single instrument cannot be conceived as separable from the whole sound of the ensemble. Most of gamelan instruments are tuned to definite pitches corresponding to two kinds of tuning system (*laras*): five-tone *slendro* and seven-tone *pelog*.

Saron is a generic term for a keyed instrument with six or seven keys that covers one octave of either the *slendro* or *pelog* tuning system. The instruments of the saron family are *saron demung*, *saron ricik (barung)*, and *saron panerus*. They are metallophones with six or seven bronze keys placed on a wooden frame serving as resonators. The *demung*, which has thick keys, provides the medium octave of the *saron* group. The *saron ricik*, which has thick keys (narrower than the *ricik*'s keys), provides the high octave of the *saron* group. The *saron panerus* or peking, which has thick keys narrower than the *saron ricik*, provides the highest octave of the *saron* group. It provides the core melody (*balungan*) in the gamelan orchestra.

The *sarons* are struck with a mallet (*tabuh*). Typically, the striking mallet is angled to the right to produce a fuller sound. *Saron demung* and *saron ricik* generally use a wooden mallet, while the *peking* mallet is made of a water buffalo horn, which gives it a shriller sound. Another hand is used to dampen the previous note by grasping the key, in order to prevent a muddy sound. On repeated notes, the note is usually dampened half a beat before it is struck again [6].

Sekaten is a week-long religious Islamic festivity lasting in the month of *Mulud* of the Javanese calendar (the Javanese year is eleven days shorter than the Western one). Ceremonies in Surakarta, Yogyakarta, and Cirebon (on the north coast) celebrate the birth and death of the Prophet Mohammed. And in Central Java, the gamelan takes a very special sound – the powerful and mystical sound of the four *gamelan sekati* – two of each are in the courts of Surakarta and Yogyakarta [10,

12, 13, 14]. Both of them are gamelan named *Nagawilaga* and *Gunturmadu*.

Javanese sources attributed the origin of *Gamelan Sekaten* to the nine holy men (*Wali Sanga*), advisors of the first Sultan of Demak, the 16th century Islamic kingdom. However, Kunst [the renowned Dutch ethnomusicologist] suggests that the *sekaten* ensemble had already existed for Hindu ceremonial music before the arrival of Islam in Java [2].

The size of the instruments is about three times bigger than that of the regular gamelan. Mallets and hammers are consequently big and heavy, including buffalo horns weighted on the striking head with lead. The tuning of the *sekaten* ensemble is the seven-tone *pelog*.

Kunst is the first major studying about the instruments, repertoire, and history of the gamelan ("the result of twenty-eight years' listening, collecting, and reflecting") and is the landmark of *Music in Java*. There are many reasons why gamelan music challenges Western listeners. The timbre of the instruments is unusually bright and harsh. The scales and tunings are unfamiliar.

In many traditional Western forms, the themes are stated, developed, and restated. In contrast, the gamelan performance presents many different ways of disguising the same underlying theme.

There are as many different gamelan tunings as there are gamelans because instruments in the Indonesian musical tradition are not all tuned to a single standard reference scale. Rather, each instrument is tuned and timbrally adjusted to work in its own orchestral context; each instrument is created for and remains with a single ensemble. Each gamelan is tuned to its own variant of *pelog* or *slendro*. Every kettle of each *bonang*, every key of each *saron*, is hand-shaped with hammer and file. The result is that a piece played on one gamelan inevitably differs in intonation, tone, and feel from the same piece played on another gamelan. Recalling that Western diatonic scales is intimately connected to sounds with harmonic spectra. Perhaps, a similar relationship exists between the *pelog* and *slendro* scales and the inharmonic sounds of the *saron*, *bonang*, gender, or gong. Furthermore, perhaps, the differences among the tunings of various gamelans can be explained in the terms of the differences among the spectra of the various instruments.

The study of the Javanese gamelan has been conducted by experts from both Western and culture of the East. Scientific investigations with the measurement of Javanese gamelan tones had been pioneered by a British physiologist, AJ Ellis, in 1884 on the hose and the voice on the barrel *pelog*. It was then followed in 1933 by a renowned Dutch musicologist, Jaap Kunst [3], who had conducted investigations on the gamelan tone system intensively by measuring the frequency of its instrument's vibration. The main tool used at that time was the thoroughness monochord relying on the ability of hearing (ears) of a person. Then, in 1969, Wasisto Surjodiningrat et al. also investigated the frequency of gamelan instruments' vibration on various best gamelans' devices, representatives of *Kraton* (Kesultanan, Pakualaman, Kasunanan, and Mangkunegaran), government agencies (RRI), and individuals. The instrument used was more modern than the previous, Cathode Ray Oscilicop [3].

The investigations of the gamelan conducted by both Jaap Kunst and S. Wasisto et al. are limited only in measuring the fundamental frequencies, i.e. frequencies that have the highest amplitude, but can not display color frequencies that make up the accompanying sound which are often called the timbre in the study of music theory. Timbre is a trait of the human voice or instrument because of different intensity and number of harmonics and sub harmonics (overtones) that can distinguish one instrument with another instrument. Timbre analysis utilizes Fourier transformation, a transformation that changes the waveform in the time domain to the form of spectrum in the frequency domain. Fourier spectra do an excellent job of identifying the frequency content of individual notes, it is as easy as here to assign fundamentals and overtones.

This article examines the color of sound of each instrument for *Saron Ricik* on Gamelan *Nagawilaga* and *Gunturmadu*. The results can be used as a prior study in order to make standardization on the gamelan tone.

2. Research Methods

Data are collected in *Karaton Kasultanan* Ngayogyakarta (Yogyakarta Sultanate Palace), Indonesia. The musician blends are palace courtiers assigned as the gamelans. The appointment was recommended by *Panghageng Kawedanan Hageng Punakawan Kridhamardawa* in *Karaton Ngayogyakarta, GBPH Yudhaningrat.*

Microphones to capture sound are placed near each instrument. These microphones are connected to a portable computer that already contains sound processing software. The resulting sound is recorded and stored. Preliminary analysis is carried out after each recording to determine the consistency of the resulting spectrum. Further analysis is conducted in the laboratory.

Audio processing software displays the waveform of the signal intensity in the form of graphic as a function of time. To obtain a frequency spectrum of intensity as a performed function, the spectrum analyzer menu is turned on. This menu works based on Fast Fourier transform (FFT). The frequency range is displayed in the audio, which is 20 -20 000 Hz. By

turning on the statistics menu, the signal being analyzed can be displayed directly from the fundamental frequency. The next peak frequencies can be determined by shifting the cursor on the top of it. The accuracy that can be generated frequency is 1 Hz.

3. Results and Discussion

Fig.1. displays waveforms for Gamelan *Saron Nagawilaga*. **Fig. 2** shows the color spectrum of sound of Gamelan *Saron Gunturmadu*. The initial spectrum of *Nagawilaga* (Figure 1 (a)) shows a sharper decrease in the intensity compared with that obtained from *Saron Gunturmadu* (Figure 2 (b)), which displays a more gentle change in the intensity. If both spectra are magnified by considering the shorter one, it will be seen the spectrum as shown in Figure 1 (b) for the instrument of *Saron Ricik* on Gamelan *Nagawilaga* and Figure 2 (b) for the instrument of *Saron Ricik* on Gamelan *Gunturmadu*. The spectrum owned by Instrument Number 1 of Gamelan *Saron Ricik Nagawilaga* has similarities although the *Nagawilaga* starting with the the top of the hill with three peaks followed by the following hill reduced. In *Gunturmadu*, the spectrum begins with two peaks hilly and steep one in turn.

Spectrum shown in Figure 1 (c) and 2 (c) is the result of Fourier transformation, which converts a function of time into a function of frequency.

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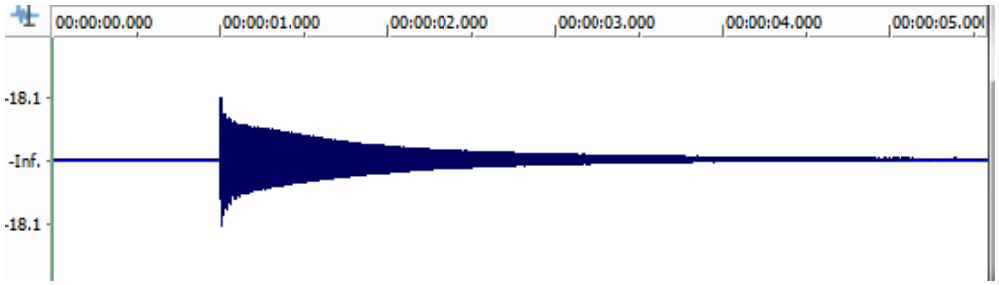
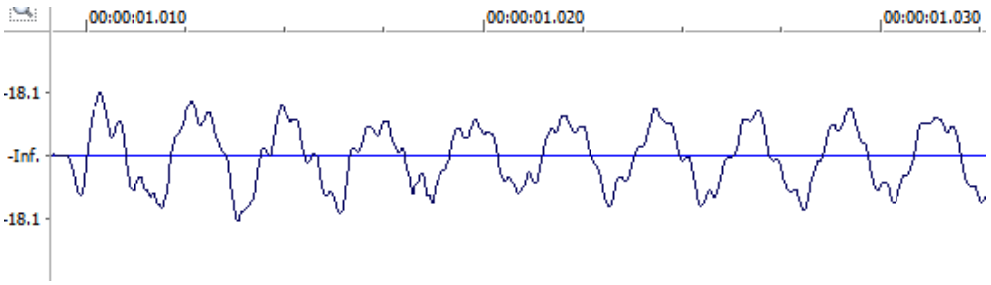
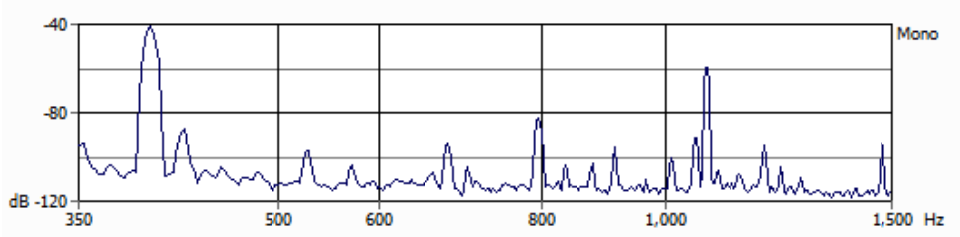


(a)



(b)



(c)

Fig. 1. Instrument #1, Gamelan *Saron Ricik Nagawilaga*; (a) waveform as a function of time obtained, (b) magnification of (a), and (c) as a function of the frequency spectrum (Fourier transform of the spectrum (a))

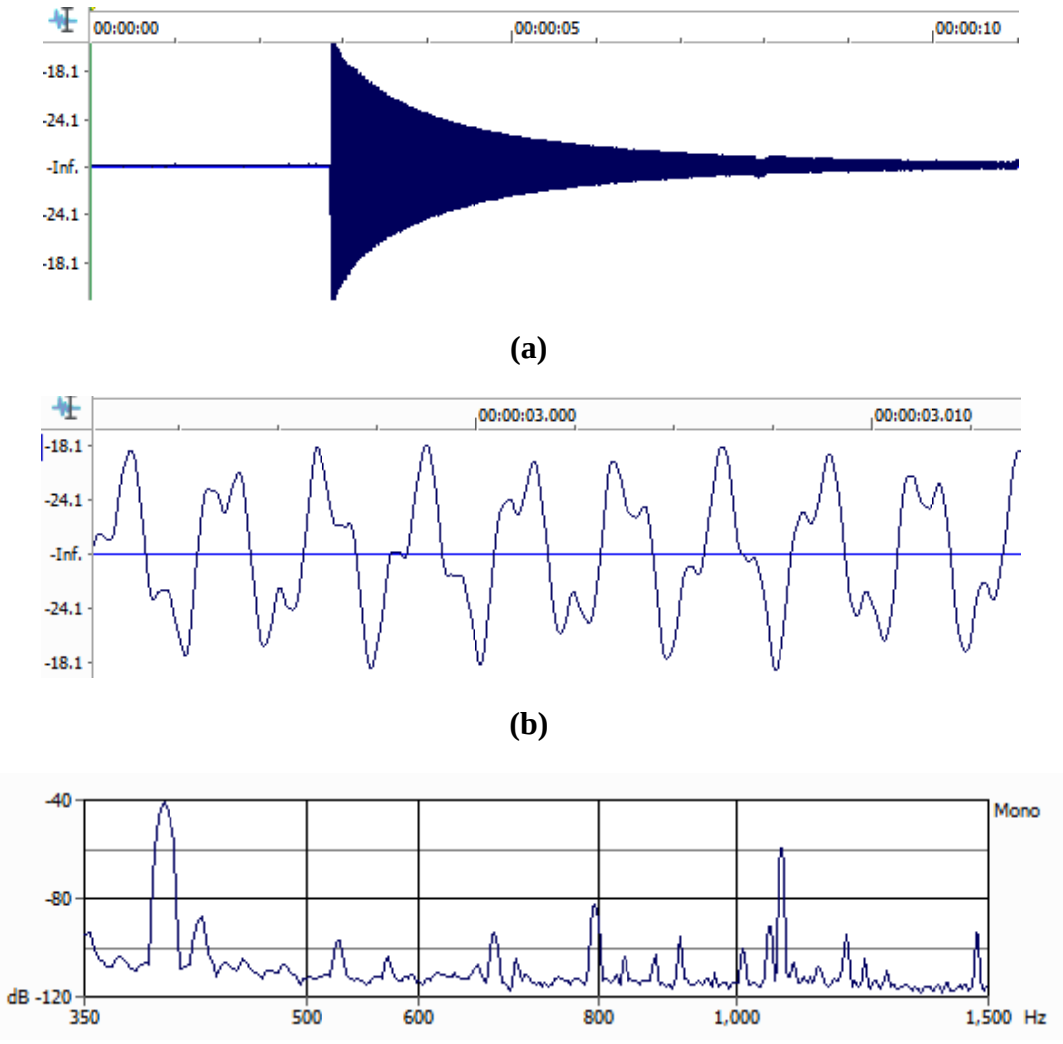


Fig. 2. Instrument #1 Gamelan *Saron Ricik Gunturmadu* (a) waveform as a function of time obtained instrument 1, (b) magnification of (a), and (c) as a function of the frequency spectrum (Fourier transform of the spectrum (a))

The frequency with highest intensity in each spectrum is the fundamental frequency. The fundamental frequency for a *Saron Ricik* instrument of the *Nagawilaga* is at 428 Hz. This frequency is followed by peaks located at 461,513, 558, 682, 811, 903, 1069, 1289, 1660, 1721, 2149, and 2319 Hz. Fundamental frequency for *Saron Ricik* of Gamelan *Gunturmadu* is at 398 Hz, followed by 422, 798, 1081,and 1201 Hz

Table 1 presents the fundamental frequency for each instrument Saron *Ricik* for both gamelans. The nominal fundamental frequencies of the two are not exactly the same, but with the difference between 30 and 60 Hz for each instrument. We compare the results measured by Wasisto [3] using CRO. The methods can only show the fundamental frequency and higher filtered frequencies. The result shows the similarities among each instrument, with a slightly difference on both for *Nagawilaga* and *Gunturmadu*. The slightly difference may be assumed due to the characteristic change of instruments caused by different times of measurement (more than 40 years).

In general, the fundamental frequency of the Gamelan *Nagawilaga* is higher than *Gunturmadu*. This is indicated by Fig. 3. The trends increasing in the gamelan are also almost similar. It is interested to normalize these fundamental frequencies to Instruments Number 1, fundamental frequency as shown in Fig. 4.

Table. 1
Fundamental frequency (in hertz) for each *Saron Ricik* instrument of Gamelan *Nagawilaga* and *Gunturmadu.* The Comparison of the results of this study and ones of Wasisto [3].

Instruments number	Gamelans			
	Nagawilaga		*Gunturmadu*	
	This study	Wasisto [3]	This study	Wasisto [3]
1	428	432	398	399
2	455	458	423	423
3	498	500	452	456
4	590	596	536	541
5	625	624	584	586
6	665	670	616	622
7	730	735	660	664

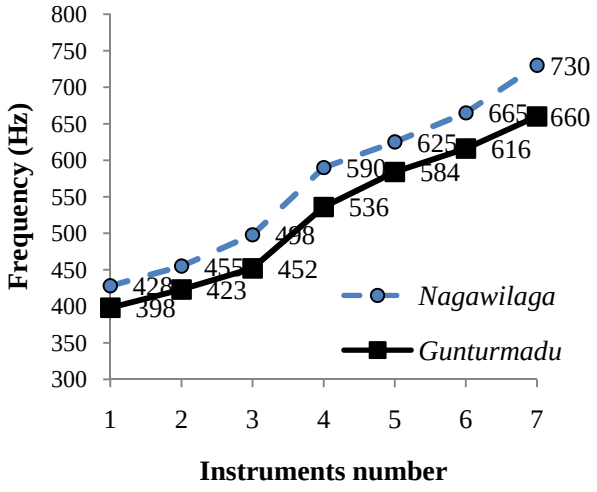


Fig. 3. Graph comparison of the fundamental frequency of gamelan *Saron Ricik Nagawilaga* and *Gunturmadu*.

Both lines are coinciding. The results indicate that without regarding the different fundamental frequencies, their tendencies are equal. This result can be used as reference to standardize the tone of gamelan as western music A shown in Fig. 1 and Fig 2 for instruments number 1, the spectrum shows a different timbre and also their fundamental frequencies.

The timbre or sound color of each instruments can be obtained by measured the frequency of each peak of their spectrum Every frequency on every instrument is normalized by referring to the fundamental frequency on the instrument. The results of the normalizations are outlined in Table 2. Figures in bold are the number (and almost, in a reading error) round, meaning that in these frequencies, they are the harmonics frequencies. The locations of the harmonic frequencies are not always consecutive, but sometimes punctuated by another frequency. This situation is different from the assumption has been stated that in the percussion instruments, there is no harmonic function. This situation is true when comparing it to the fundamental frequency among instruments. The normalization is done from a higher instrument to instrument #1.

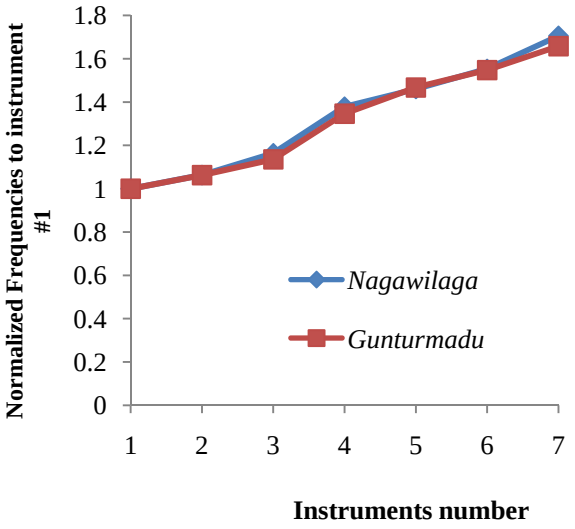


Fig. 4. Comparison of normalized frequencies and the fundamental frequency of instruments number 1 of *Saron Ricik*, Gamelan *Nagawilaga* and *Gunturmadu*

Table 2.
The timbre of each instrument of *Saron Ricik* on gamelan *Nagawilaga* and. *Gunturmadu*. Frequency peaks are normalized to the fundamental frequency of each instruments.

Peak order	*Nagawilaga*							*Gunturmadu*						
	Instruments number							Instruments number						
	1	**2**	**3**	**4**	**5**	**6**	**7**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	1.08	1.13	1.47	1.06	1.08	1.10	**2.00**	1.06	1.07	1.13	1.09	1.06	1.08	1.03
3	1.20	1.22	**2.00**	1.83	1.10	1.29	2.57	**2.01**	1.22	1.23	1.23	**2.00**	**2.01**	1.29
4	1.30	1.51	2.37	**2.00**	1.17	1.48	2.88	2.72	1.31	1.51	1.27	2.35	2.70	1.36
5	1.59	1.78	2.74	**3.00**	1.30	1.54	**3.01**	**3.02**	1.62	1.88	1.51	2.75	**3.03**	1.55
6	1.89	1.89	**3.00**	3.27	1.37	1.61	3.36		1.91	**2.00**	1.59	**3.00**		1.61
7	2.11	2.02	3.61	**4.01**	1.58	1.68	**4.02**		**2.00**	2.27	1.68			**2.01**
8	2.50	2.25	**5.00**	4.94	1.65	1.81			2.12	2.37	1.83			**3.00**
9	**3.01**	2.26	5.19	**5.01**	1.71	**2.01**			2.32	2.36	1.91			3.07
10	3.88	**3.01**			**2.00**	2.87			2.42	2.46	**1.99**			
11	**4.02**	3.89			**3.00**	**3.01**			2.52	2.74	2.66			
12	**5.02**	**4.03**			3.38				2.67	**3.01**	**2.98**			
13	5.42	4.76							**3.00**		3.27			
Number of harmonics	5	4	5	5	3	3	4	3	3	3	3	3	3	3

The number of harmonics on the *Nagawilaga* is more and varied, in contrast to *Gunturmadu*, in which all instruments only have three harmonic frequencies. The number peaks those indicate their characteristic timbre different for each instruments.

The first instrument of *Nagawilaga* has five harmonics frequencies but there is no second harmonics. The condition is different of *Gunturmadu* with three harmonics only. These conditions also occurred for other instruments. This result challenge to compare with more other gamelan in order make standardization due to their different timbre, although the tendencies of fundamental frequencies are similar.

4. Conclusion

Fundamental frequencies of Saron Ricik of Gamelan *Nagawilaga* are higher than of *Gunturmadu*. The locations of the harmonic frequencies are not always consecutive, but sometimes punctuated by another frequency. The number of harmonics of each instruments of *Nagawilaga* is different from one of *Gunturmadu*, those equal.

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