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Psychoacoustic analysis of preference reverberation time for Gamelan Bali Concert Hall

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ABSTRACT

Lately, there has been increasing interest to design acoustic concert hall for Indonesia traditional music, for example Gamelan Bali. In order to obtain a good and comprehensive design, some research on acoustical properties of Gamelan itself must be conducted. One of the main concerns was to find the optimum value of reverberation time for Gamelan music. Unlike the orchestra and classical music performance, preference value of reverberation time for Gamelan Bali is not known yet. Psychoacoustic research was conducted to obtain the preference of reverberation time for Gamelan Bali. A number of respondents were included in the experiment to give the subjective ratings. The subjects were divided into three groups based on their knowledge and experience of Gamelan Bali music. The results suggest that group which is accustomed to Gamelan music produced more significant results in their subjective ratings than the other groups. Based on that results, the preference value of Gamelan reverberation time was concluded.

Keywords:reverberation,Gamelan Bali,psychoacoustic I-INCE Classification of Subjects Number(s): 79.2

1. INTRODUCTION

Gamelan Bali is ensemble-like Indonesian traditional music instruments which consist of instruments such as, *kendang* (drums-like instrument), *suling* (wind-instrument), metalophones, and gong. The Gamelan music originally performed in open spaces (e.g. in temple's terrace) to accompany ritual ceremony. However, it becomes more popular nowadays and a lot of Gamelan music arrangements were made for dance and music performances. Outdoor performances usually take place in amphitheatre while indoor performances take place in auditorium, multipurpose hall, and theatre. Gamelan performances in outdoor and indoor spaces mostly using sound reinforcement system, despite that the original sound level actually is already high (between 80-90 dB).

It has been an interest of acoustic group research in Institut Teknologi Bandung, to enhance performances and musical quality of Gamelan music by developing a Concert Hall dedicated for this music. In the proposed concert hall design, Gamelan will perform acoustically without the use of sound reinforcement system. Ando's experiments mention four objective parameters that are important in concert hall (1). All the four objective parameters hold a unique value that is different for each kind of music. There are some researches have been conducted to find the optimum value for Gamelan Bali music (2, 3). From the IACC analysis by Merthayasa (3), it was found that Gamelan Bali music performance needs lower IACC value in order to have the same preference scale as classic orchestra music.

Reverberation time is one of the important objective parameter for music performances. Differences in reverberation time can greatly affect the subjective quality of the music (4). For classic orchestra music, there have been numerous references for the optimum value of reverberation time. Ando mentioned in his book (1), the reverberation of classical music will follow the equation below:

$$T_{\mathrm{sub}} = 23 * \tau_{\mathrm{e}} \tag{1}$$

Parameter τ_{e} represents information about the frequency content of a signal, and also described as personal reverberation time of a musical instrument or sound source. T_{sub} is the subsequent reverberation time after the delay of first reflection.

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Meanwhile, the optimum value of reverberation time for Gamelan Bali music is not known yet. With its musical characteristic such as, fast tempo and rhythm, high sound level, suitable reverberation is important to get the clarity of the music, and at the same time makes the music sounds live. Psychoacoustic research was conducted to find the optimum value of reverberation time for Gamelan. A number of respondents were involved in this experiments. Furthermore, it was also intended to evaluate the effect of respondents knowledge about Gamelan to the results of subjective test.

2. METHODS

2.1 Sound stimulus

In this experiment, a sound signal of Gamelan Bali Gong Kebyar was used. A music composition of *Oleg Tamulilingan* was chosen as the music sample. This piece is very popular among Gamelan Bali Gong Kebyar composition, there is also a dance composition using this music. Music composition of *Oleg Tamulilingan* contains a *Kebyar* fragment in the opening and the middle of the piece, the term *kebyar* itself means "to open". During this part of the music, all of the instruments were played stomping together at the same time producing very high sound level.

For the production of the sound signal, a set of Gamelan Bali was played by the musicians and then recorded. The recorded sound needs to contain minimum reverberation, therefore recording was done in open spaces with near field recording technique. The recorded sound then being used to create a sound stimuli.

Recorded sound were cut to take only the *Kebyar* fragment. Duration of this fragment and also the stimuli was 16 seconds. The fragment was chosen since it consists the sound of all instruments in one set of Gamelan. τ_e value of the fragment was 37 ms, it was low compared to τ_e value of orchestra music. Using Ando's theorem (equation 1), the preferred reverberation time of this stimuli was predicted around 0.8 second. However, Ando's theorem was developed for orchestra music, this might be not applied in the case of Gamelan Bali music.

Variation of reverberation time were made using audio tools and signal processing software adobe audition. Reverberation time was the only changing parameter, while the other parameters such as level and IACC were keep constant. Three sound stimulus with three variations of reverberation time (1.3, 1.5, and 1.7 s) were made. The range of reverberation time variation were made carefully in order to passed its JND value (rel. 5%).

2.2 Respondents

Respondents that were involved in this experiment were divided into three groups based on their personal knowledge and experience about Gamelan Bali music. Respondents in each group were taken randomly from its own population. Groups of the respondents are listed below:

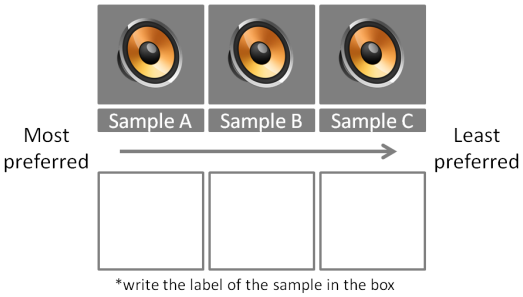
1. Group A, consist of 17 peoples which were familiar with Gamelan music. Belong to this group was Gamelan musicians (penabuh), dancers, and routine listeners (most of this listeners were students originally come from Bali and also amateur Gamelan musicians). In the next chapter, the background of this group is referred as positive background.
2. Group B, consist of 16 peoples who were never or rarely listen to Gamelan Bali music. In the next chapter, the background of this group is referred as negative background.
3. Group C, combination of Group A and Group B. In the next chapter, this group is referred as neutral background.

2.3 Psychoacoustics method

Psychoacoustics method of ranking procedures were used to conduct this experiment. Three sound stimulus with variation of reverberation time were made, this stimulus were called Sample A, B, and C. During the experiment, the reverberation of Sample A to Sample C did not in a decreasing nor increasing order.

In this method, respondent were asked to listen to all three sound stimulus. Afterwards, they were asked to choose their preferred sound between the sound stimulus and then put it in an order. Respondents were using headphones during the experiment. They can listen to the stimulus repeatedly until they made their judgement. Approximately it takes 2-5 minutes per respondent to finished the experiment. Scale value of 3 to 1 then given to each stimulus, starting from the most preferred to the least preferred sound. Illustration of the procedures shown in Figure 1.

The next step of the experiment was quantitative analysis. Tabulation of the scale value between three stimulus Figure (1b) were analysed using ANOVA F-test combined with SNK test. P-value of 0.05 was used in the calculation. Using this statistical method, significant difference between the samples were examined.



(a) Rank procedurs method

Respondents	Preferences		
Subject 1	Sample B	Sample A	Sample C
Subject 2	Sample A	Sample C	Sample B
Subject 3	Sample A	Sample B	Sample C
.....	...	...	...

Respondents	Scale Value		
	Sample A	Sample B	Sample C
Subject 1	2	3	1
Subject 2	3	1	2
Subject 3	3	2	1
.....			

(b) translation process from rank order to scale value

Figure 1 – Experiment procedures

3. RESULTS AND DISCUSSION

3.1 The effect of respondents background

ANOVA analysis was done separately for each group to find significant differences between three reverberation time samples. The average value of each samples from one group was normalized to find the maximum preference of reverberation time. From each group, the plotted results are presented in Figure 2. Based on that analysis, only Group A found the significant differences between three samples. On the other hand, Group B and Group C did not give significant differences.

Group A was the group of respondents with positive background. Seeing only from the background, it seemed that their knowledge and previous experiences in listening to Gamelan music related with their ability to distinguish between three samples. It is possible that they already had their own preference of good and poor sound of Gamelan music. Therefore, Group A resulted in significant differences. Meanwhile, Group B was the group with negative background. Respondents in this group rarely listen to Gamelan music, accordingly they found it more difficult to distinguish the differences between three samples. This difficulties were also shown during the experiments, where the total time of experiments for Group B were longer than Group A. The respondents needed longer time to repeat the samples and then made their choices. Group C were combination of the first two group, or neutral background. Results from this group showed similar preference with Group A, however the differences between three samples were not significant.

From this results it seemed that background of respondents can affect the results of the experiment, in this case the preferred value of reverberation time. It was found that it is important to have respondents with positive background in order to give significant result. Coming from that condition, no conclusion regarding the preferred reverberation time were made. Furthermore, additional experiments were made with respondents who had positive background.

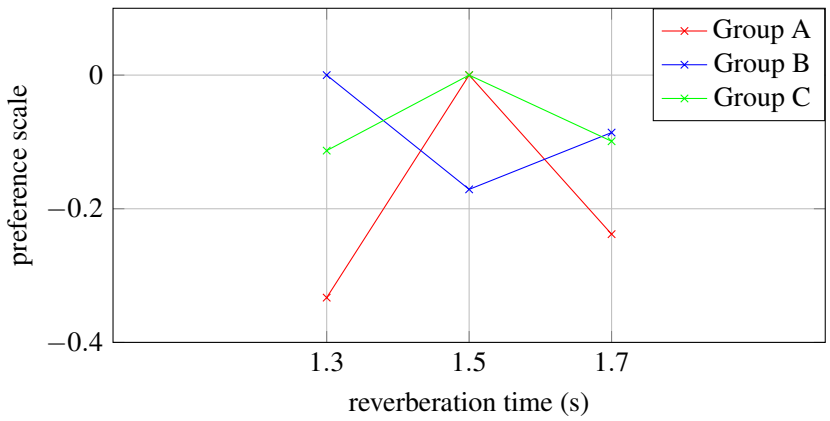


Figure 2 – Preference scale of reverberation time with relation to respondents background

3.2 Preference of Gamelan Bali reverberation time

Further experiments to find preference value of Gamelan Bali reverberation time were done. In this experiments, respondents were only peoples with positive background. A total of 33 respondents were involved, including the respondents from Group A, and some additional respondents. Two sound stimulus were added in both extreme condition, 0.8 s and 2.2 s. Using exactly the same psychoacoustic method and quantitative analysis, the results are presented in Figure 3.

The ANOVA analysis with P-value 0.05 shows significant differences between five samples. Furthermore using SNK-test, it was found that the samples statistically divided into three groups: 0.8 s, 1.3-1.7 s, and 2.2 s. The graph shown in Figure 3 shows similar curve behaviour with Ando's preferences curve (1). From this experiments, it was concluded that the optimum reverberation time for Gamelan Bali music is 1.7 seconds. Meanwhile, reverberation time within the range 1.3-1.7 seconds, was found still acceptable. However, reverberation longer than 1.7 and shorter than 1.3 seconds might decreased the preference significantly, due to too much or lack of reverberation.

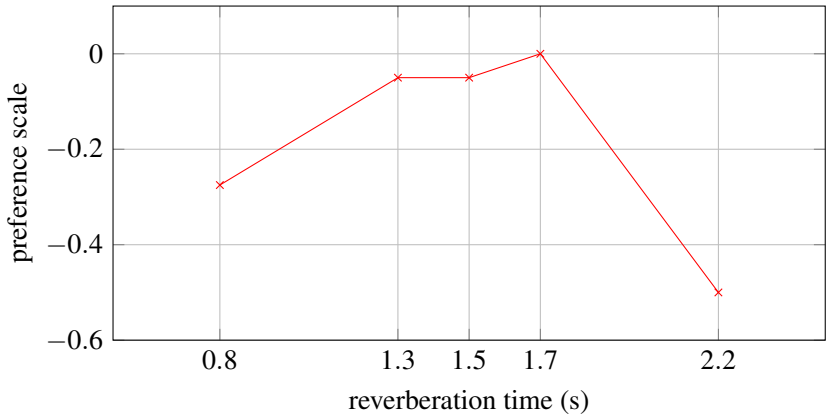


Figure 3 – Preference scale of Gamelan Bali reverberation time

4. CONCLUSION

From this study it can be concluded that background of the respondent will affect its preference and perception of music. In this experiment, respondent with background and knowledge about Gamelan Bali had more ability to distinguish the differences of reverberation time between samples. On the other hand, respondent with minimum or no background about Gamelan Bali found it hard to differentiate the sound sample and then guess randomly of their preference. Furthermore, significant difference between sound sample was found for the results from group A. Based on that results, 1.7 seconds was considered as the preference value of Gamelan Bali reverberation time.

For comprehensive results in this particular topic, subjective test using sound simulator to evaluate listening condition in the design of Gamelan Bali Concert Hall, will be performed in the near future.

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