Analysis of the Psychoacoustic of typical Indonesian Music as Candidate of Musical Therapy

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INTRODUCTION

Musical therapy is defined as the controlled use of music and its influence on human as a means of curing illness and pain, involving integrated individual’s physiological, psychological, and emotional aspects [Munro & Mount, 1978]. This therapy can also sustain individual’s health. Musical therapy is divided into passive and active therapy (Pacchetti et al., 2000). Musical therapy is active when the therapist and the patient are directly involved in playing musical instruments and producing musical sounds. On the other hand, musical therapy is passive when the therapist plays soft music while the patient is conditioned to be in resting position and is asked to visualize beautiful images which give relaxation effect. Musical therapy is often carried out by combining passive and active methods. The types of music used in the therapy are usually adjusted to the local culture of the therapist and/or the patient.

Response to musical sound is determined by the type of music. Classical music is the type of music that is generally related to human physiological and psychological conditions, therefore classical music is often used for therapy. The effects of classical music on human body have been much studied. Mozart Sonata which is played by two pianos in D major note (K448) can strengthen the spatial-temporal reasoning ability (Rauscher et al., 1995). Latest studies showed that when played in andante tempo, classical music can lower average blood pressure, heart beat, breathing speed, and tension before operation (Camara et al., 2008). However, in Javanese community, Javanese langgam has been proved to be more effective (p<0,05) in lessening pain and worry in women who are in labor (Safitri et al., 2012), compared to Mozart music. This indicates that the ethnical and cultural background of the subjects studied have an influence on the lessening of pain and worry, especially when related to psychological aspects.

The response to musical sound can be traced to bio molecular aspect by exploring the neural response of human hearing system to the psycho acoustic aspect of music. Psycho acoustic is a branch of science which studies the psychological response of the perception of the physical characteristics of basic sound. (Iakovides et al., 2004). The physical components of sound emerge from the change of pressure caused by the vibration of an
object. The change of pressure is captured by the area outside the ears and transmitted through the osikular system to the area of timpani membrane and oval window. The physical components of basic sound include the functions of frequency, amplitude, and phase. Based on these three components, complex sounds can be divided into basic sounds. The division of complex sounds into basic sounds is performed by employing the Fourier analysis. In this case, harmony is a frequency component of complex sound.

The relationship between the physical and psychological components is seen in the process of listening to music. Music is human effort to express emotion (Iakovides et al., 2004). Therefore music can influence mood and excite feeling. Music plays an important role in the process of communicating and delivering information in the form of semantic and emotional elements (Platel et al., 2001). Those elements indicate the involvement of central nervous system and peripheral auditory system in the process of integrating and interpreting sound signals. The psycho acoustic characteristics of music are not limited to pitch, intensity, and timbre, but also involve rhythm. Rhythm is time variable (Krumhansl, 2000). The combination of musical and psycho acoustic elements enables the emergence of the complex pattern of musical melody from the combination of the units of time variable, and frequency also plays an important role in the formation of the perception of sound signals in primary auditory cortex (Griffiths, 1999). The neuron in the nucleus area of auditory cortex responds to pure note stimulus, while peripheral area is more active in responding to complex sounds (Hudspeth & Konishi, 2000). In his study of acoustic basic elements, Chladni showed the existence of material specific response to exposition to sounds (Bauer, 2002). Study of the process of musical perception and the mechanism of its influence on human can be performed by (Iakovides et al., 2004) knowing the types of music, studying the emotional experience that occurs while playing or listening to music, studying the psychological and psychosomatic changes that occur while playing or listening to music, and studying the psycho acoustic characteristics of music. This study aims to analyze the psycho acoustic characteristics of several typical Indonesian musical sounds as candidates for therapeutic music.

MATERIALS AND METHODS

This study was performed by playing back several selected types of music on sound analyzing program to find out the temporal and spectral characteristics, and the temporal spectrum. The programs we used were Sony Sound Forge 7.0 and Yoshimasa Sound Analyzer which were run on a personal computer. The Indonesian music selected was Balinese gamelan (Paksi Neglayang Orchestra), Javanese langgam (Gending Tejanata), Techno dangdut (Dugem-Pacar yang hilang-House mix 2011). The characteristics of these music types were compared to the characteristics of classical music (The Magic Flute – Mozart) which had been known as therapeutic music. For non musical comparison we chose Single tone which was recorded from an electric sound producing tool. All the types of music studied were recorded in mpg files.

From the analysis result of the programs we could know the psycho acoustic variable of each type of music, where for physical variable we only observed the characteristics of the sound intensity and frequency, while the psychological variable was analyzed through the form of spectral envelope.

Results:

The analysis results of Sony Sound Forge 7.0 program are shown in Figure 1, Figure 2, and Figure 3. This program showed temporal and spectral graphics and spectral envelope of the analyzed music while it was played back. The analysis result of Yoshimasa Sound Analyzer program was shown in Figure 4 and 5. This program showed the graphic of the combination of temporal and spectral, where sound intensity was shown in color gradation. Yoshimasa Sound Analyzer could also present the Tau-e graphic which was a time different parameter which was passed by the sound from its source to the hearer, between direct transmission and bounced transmission.

From Figure 1 and Figure 2 we could measure the sound intensity (dB) at several points of the graphic, as samples. The prominent frequency was read at the highest sound intensity. The data quantification of the sound intensity was done by using the J Image reader program. Then we made statistical analysis of the sound intensity data to find out normality, and tested the different characteristics of the 5 treatments being compared. Statistical test was performed by using the SPSS ver. 13.0. program. From the statistical analysis result we found that the data sample of sound intensity taken from the quantification of spectral graphic of each type of music behaved normally and differed significantly (p ≤ 0.05) in points. The data graphic was shown in Figure 6.

Discussion:

The temporal characteristics showed a change of sound intensity (vertical axis) in the time range of music playback (horizontal axis). The sound intensity (dB) also indicated the loudness or weakness of the music sound. When observed from their highest intensities, the 4 types of music had almost similar loudness. In this case, single tone had the lowest intensity. However, the change of sound intensity of each type of music was very varied where high temporal intensity variation was shown by Piano performance of Mozart music and...
Balinese gamelan, followed by Javanese langgam. Techno dangdut hardly showed varied sound intensity, and during the whole of its playback time was always in high intensity condition. In this case Techno dangdut was similar to Single tone which did not show variation of points, either. The frequency characteristics showed almost similar frequency range for the 4 types of music although the frequency of each highest intensity was different. Both these temporal characteristics represented the physical components of the sound that was processed by human hearing system, straight to the primary auditory area without passing the limbic system.

Spectral graphic showed sound intensity variation in the range of frequency which appeared during playback time. All exposed music, except Single tone, showed similar sound intensity in low frequency (until about 120 Hz), and began to show variation at high tone. Single tone showed similar intensity in all frequency range.

The characteristics of right and left audio spectral for Balinese gamelan, Techno dangdut, and Single tone showed similar pattern, both in low and high frequency range. Javanese langgam and Piano performance of Mozart music showed different pattern of sound intensity variation between right audio and left audio, in high frequency range. This difference of variation was not seen in the figure of pure temporal analysis. The difference in sound intensity variation for right audio and left audio caused different stimulus for the hearing nervous system of right ear and left ear. This would create cross reference in the primary auditory area. Thus, additional response would emerge which was a combination of right and left stimulus effect, individually or combinedly. The difference in the stimulus for right ear and left ear would complicate the activation flow of the auditory nervous system, which would cause more diverse and complex responses.

When reviewed from the spectral envelope, Piano performance of Mozart music and Balinese gamelan showed a more dynamic character than Javanese langgam and Techno dangdut. Javanese langgam and Techno dangdut were more like the flat envelope of Single tone. The characteristics of spectral envelope showed a sound type which represented the psychological component of sound. As had been known, this psychological component was transferred to the primary auditory area through the limbic system which was responsible for human emotional condition.

The dynamic change of the form of spectral envelope indicated the change of emotion that would be triggered. In this case, Piano performance of Mozart music and Balinese gamelan more likely triggered diverse emotions than Javanese langgam, Techno dangdut, and Single tone. This indicated that the emotional areas triggered were also more diverse, especially when we referred to the different stimulus variation of right audio and left audio for these two types of music.

If the analysis of music frequency (spectrum) was shown as temporal, together with sound intensity measurement during playback time, we found that the sound intensity pattern (the lighter color in the spectrogram graphic) of Javanese langgam was closer to Piano performance of Mozart music. The signal of Javanese langgam had background noise (BN) at all frequencies. The background noise was flat up to 16,000 Hz frequency. This signal appeared during all playback time which might be caused by ‘inappropriate’ recording. This meant that the background noise in the room when the music was played back was dominantly present in the recording. This condition was not shown in the graphic of temporal analysis and pure spectral.

The background noise did not appear in the other three types of music, but it appeared in Single tone. This combined analysis also showed the fact that Single tone was comprised of 4 dominant frequencies, namely 600, 1,200, 1,800, and 3,000 Hz. The highest sound intensity appeared at 600 Hz frequency. Although the intensity pattern was flat, the frequency variation would give a different effect from the effect which appeared from single frequency exposition. Thus, Single note could not be stated as ‘single note’ exposition since the note parameter was based on frequency.

Referring to the analysis result of temporal, spectral, and the combination of temporal spectrum, with reference to Piano performance of Mozart music as a positive control, Javanese langgam and Balinese gamelan had similar characteristics to Piano performance of Mozart music, while Techno dangdut and Single note had quite different characteristics. This categorization became a little different when we referred to the graphic of Tau-e points which showed different travel time from the source of sound to human ear, between direct delivery and bounced delivery. In this case, Javanese langgam had the highest dominant Tau-e when compared to the other three types of music. The dominant points of the other three types of music were almost similar. This seemed to be caused by the monotonous background noise during all playback time. If the background noise factor was excluded and the dominant Tau-e point was ignored, the graphic patterns of the Tau-e of Javanese langgam and Piano performance of Mozart were similar, while The Balinese gamelan was closer to Techno dangdut.

It has been known that the Mozart Sonata played on two pianos at D major note (K448) can strengthen the spatial-temporal reasoning ability (Rauscher et al., 1995), although this finding disagreed with the result of several other studies on the same subject (Carstens et al., 1995; Hughes et al., 1998; Steele et al., 1999). In physiological aspects, the study of Gerra et al., (1998) showed that classical music did not influence heart beat, systolic pressure, and the level of stress hormones. However, latest studies showed that when played in andante tempo (walking), classical music can lower average blood pressure, heart beat, breathing speed, and tension.
before operation (Camara et al., 2008). Thus, classical music, especially Mozart music was found to have a positive effect on human physiological and psychological aspects, and therefore could be used as therapeutic music. Referring to these findings, Piano performance of Mozart music used in this study was assumed to have a positive effect on human hormonal system.

From Indonesia, when compared to Mozart music, Javanese langgam was proved to be more effective (p<0.05) in lessening pain and worry in women in labor (Safitri et al., 2012). We assumed that this condition was caused by ethnic and cultural background of the subjects studied, especially when related to psychological aspects. Thus, there was an involvement of limbic brain in the process, since this area was actively involved in the formation of emotion. Several other Indonesian typical music sounds, such as keroncong and campursari, was assumed to have positive effects on psychological aspects. The result analysis of this study supported previous findings, which proved that the characteristics of Javanese langgam were similar to the characteristics of Piano performance of Mozart music.

Analysis of physical characteristics (sound intensity and frequency) and psychological characteristics (spectral envelope) of Techno dangdut showed monotony during all exposition time. The characteristics were high frequency and intensity with flat envelope pattern. These physical characteristics were similar to the characteristics of noise, so they have negative effects on human physiological condition. The flatness of spectral envelope pattern supported this assumption because here we did not find indication of diverse stimulus on psychological emotion. This finding also supported the results of previous studies which proved that Techno dangdut music had a negative effect in the form of significant raise of heart beat, systolic pressure, and the level of stress hormones. Based on the sound loudness and the disturbance it caused, Techno dangdut music was categorized as noise, although Fucci et al., (1997, 1999) disagreed with this proposition and regarded the finding as subjective.

Non musical tone caused different influences on human physiological and psychological conditions. It is known that mechanic sound hinders the parasympathetic nervous system together with the emergence of feeling of discomfort and high vigilance (Darner, 1966). Distorted sound at 400 Hz frequency and 109 dB intensity could raise systolic and diastolic blood pressure temporally in subjects exposed to the sound for 0.5 second (Yanagihasi et al., 1997). Thus, Single note exposition was assumed to have an effect similar to the study of Yanagihasi et al., since Single note had a dominant sound intensity at 128 dB at 600 Hz frequency. The effects of Single tone were certainly more diverse since its dominant frequency was not really 'single', with sound intensity variation that also contained background noise.
Figure 2: The analysis result of the view of spectral of SSF 7.0, program. The horizontal axis showed the range of frequency. The vertical axis showed amplitude in dB unit. The upper part of the graphic was the left audio spectral component. The lower part of the graphic showed the right audio spectral component.

Figure 3: The analysis result of the view of spectral envelope of SSF 7.0, program. The profile of graphic ends showed the combination of the lines of left and right audio spectral components.
Figure 4. The analysis result of YSA spectrogram. The colored graphic showed the variation of sound intensity during playback. The horizontal axis indicated playback time. The height of colored lines indicated frequency characteristics. Black background indicated that the sound captured was chiefly musical sound with a little noise (darker color).

Figure 5. The result of Tau-e analysis. The dominant point lied in range 10-15 ms. Several point leaps indicated the change of music characteristics (the dynamics of music) which related to rhythm. The single tone was unmeasurable.

Figure 6. Data graphic of average intensity of the music exposed. The boundary at the block of data indicated the range of standard data error. It was shown that the average intensity of the sound of Balinese gamelan and Javanese langgam was inside each range, thus we could assume that the music of Balinese gamelan and Javanese langgam had almost similar intensity. The prominent frequency of the Balinese gamelan and Techno dangdut was inside each range, thus we could assume that both types of music had almost similar prominent frequency. Piano performance of Mozart music and Javanese langgam were also similar.
Conclusion:

The result of this study showed that there was a significant difference in the intensity and prominent frequency of the music exposed, although the prominent frequencies were almost the same. These two parameters represented the physical parameters of music. At low frequency (until 120 Hz), the spectral pattern and sound intensity of all the exposed music showed similarity. At high frequency (more than 120 Hz) we found diverse patterns. The right and left audio spectral pattern in all frequency ranges showed similarity, except for Piano performance of Mozart music and Javanese langgam. Therefore these two types of music were assumed to produce more diverse stimulating effects on psychological emotion.

Javanese langgam had a dominant noise during all its playback time, although the combined analysis of its temporal spectral still showed similarity to Piano performance of Mozart music. The positive influence of psycho acoustic characteristics of Piano performance of Mozart music and Javanese langgam on physiological and psychological conditions showed consistency with previous studies. This consistency was also shown by Techno dangdut and Single tone in the negative response of the physiological and psychological conditions. The psycho acoustic characteristics of Balinese gamelan showed a transitional pattern between Piano performance of Mozart music–Javanese langgam and Techno dangdut–Single tone. Thus, Javanese langgam could be assumed as an excellent candidate for therapeutic music.

REFERENCES


