ECRONICON OPEN ACCESS

EC NURSING AND HEALTHCARE
Research Article

Pilot Study on Brain' Response to Nursery Rhymes: Comparison between a Musician, a Robot, or a Boombox Player

Mahsa Soufineyestani[1], Arshia Khan[1]*, Rana Emtiaz[2] and Yumna Anwar[3]

[1]*Department of Computer Science, University of Minnesota Duluth, MN, USA*

[2]*University of Pittsburgh, PA, USA*

[3]*University of IOWA, Iowa, IA, USA*

***Corresponding Author:** Arshia Khan, Department of Computer Science, University of Minnesota Duluth, MN, USA.

Received: January 11, 2021; **Published:** April 30, 2021

Abstract

Music has been known as a powerful tool that can change brain activities. This pilot study aims to investigate the impact of listening to nursery rhymes on brain Waves specifically Alpha and Beta wave activities when music played by a professional musician, a robot called Pepper, and a boombox. Applying Discrete Wavelet Transform (DWT) and statistical analysis of Electroencephalography (EEG) data revealed a strong correlation between brain wave activities of individuals who listened to music played by a robot or a musician. Also, despite the study hypothesis that listening to nursery rhymes may calm individuals, it made some participants restless.

Keywords: *Music; Electroencephalography (EEG); Alpha Waves; Beta Waves*

Introduction and Background

Music plays many important emotional and social roles in a person's life by arousing emotions and changing an individual's mood [1-5]. It can reduce anxiety, tension, stress, and blood pressure, alleviate depression, and pain [6-10]. Listening to music can help with memory recall, brain relaxation, and improvement in the learning process as well as memory performance [3-6]. Researchers found music to be an effective treatment for improving the mental balance of patients who suffer from disorders such as depression and dementia [11-14].

Investigation of EEG data shows more alpha waves during relaxation, listening to familiar or preferred music [15]. When individuals listen to their favorite music they want to be relaxed so they pay less attention to the content which produces more alpha waves [15]. Reversely, when they listen to an unpreferred music they pay more attention to the song because they are unfamiliar with, resulting in more beta waves [15]. In one study, rock and jazz music with three tempos (slowed, medium, and quickened) were played for individuals. The main aim was indicated whether listening to a favorite genre can increase alpha wave amplitudes. Changes the tempo showed no change in alpha waves while beta waves amplitude increased as the tempo increased [15]. In another study, the attention level of individuals while listening to music with different tempos (slow and fast) was measured [4]. The results revealed that listening to slow music significantly changes the alpha waves, while listening to fast music, such as Heavy Metal concerts, changes the power value of the beta waves [4]. Some studies reported that listening to classical music can make the brain relaxed and may change arousal and valence levels, which are indicative of their happiness level and excitants, respectively [5]. The outcome of a study indicated that the arousal score of emotion may have a negative relationship with the alpha wave [5]. Another study examined the impact of medication and music listening on brain waves [15]. It was noted that listening to meditation music had a calmer effect than listening to other types of music. In one study, background music was played for individuals with low and high levels of stress [16]. The outcome showed that listening to music increased the energy of alpha waves for participants with low levels of stress while the energy of alpha waves decreased for individuals with higher levels of stress. The results indicate that background music is relaxing only for people with lower levels of stress [16].

In this pilot study, we are exploring individuals' brain responses to listening to nursery rhymes. The main objective of this pilot study is to help patients with dementia to make them relax. Therefore, we asked several families of people with dementia and musicians about which kinds of music produced calming effects on their family members with dementia. Nursery rhymes were beneficial with recalling memories and helping patients to be relaxed. Additionally, caregivers were looking for alternate solutions to live musicians. Hence, the research team decided to focus on playing nursery rhymes by a musician, a robot, or a boombox.

Aim of the Study

The main aim of this study is to investigate the following items:

1. Compare individuals' brain activities.
2. Observe if the impact of music will last after the listening session.
3. Understand if participants' brain response to music played by a musician, a robot, or a boombox is similar.
4. Understand if listening to nursery rhymes can put the brain in a relaxed or disturbed state.

Methods

Participants

EEG data from 32 participants (15 participated with a musician player, 11 with a robot player, and 6 with a boombox player) were recorded. Participants consisting of healthy faculty, staff, and students of the University of Minnesota Duluth (aged 18 to 45) from the same cultural background and familiar with nursery rhymes. The Institutional Review Board (IRB) of the University of Minnesota Duluth approved all procedures, and written consent was obtained from each participant.

Materials

Electroencephalography (EEG) data was acquired by an Emotiv EPOC+ headset can record brain data at a sampling rate of 128 Hz. This headset has 16 channels, 14 electrodes for collecting EEG and two reference electrodes [17]. EPOC+ electrode arrangement follows the international 10 - 20 standard, namely: AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8 and AF4 positions. Captured EEG data can be transferred to the computer through EMOTIVPRO software using wireless connectivity and/or Bluetooth LE technology [17].

EEG signal acquisition

Figure 1 demonstrates the experimental procedure. EEG data was captured in three steps: before (baseline), during, and after (post) experiment. The participants were asked to sit on a chair in a comfortable and relaxed state while their baseline EEG data was gathered for one minute. Then, according to the selected modes, one of the mechanisms (musician, robot, or boombox) played seven nursery rhymes ("Baba Black Sheep," "Itsy Bitsy Spider," "Mulberry Bush," "Old MacDonald Had a Farm," "Ring Around the Rosie," "Twinkle Twinkle Little Star," and "You Are My Sunshine") for 10 minutes while participants' brain data was recorded.

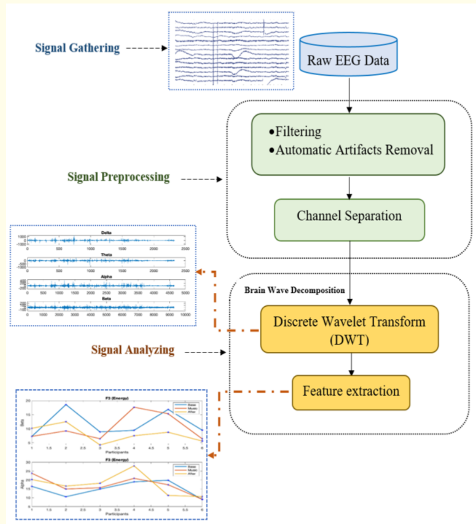


Figure 1: *EEG data processing steps.*

Participants listened to the nursery rhymes in two different modes, actively engaged or passive listening mode. If the mode was passive, then the participant was seated on a chair without any movement. If the mode was engaged, then participants were allowed to sing along or move their body parts. A musician was recruited from the Music Department; she played the piano while singing the rhymes. The robot chosen for this study was Pepper, a semi-humanoid robot manufactured by SoftBank Robotics that can communicate with humans by singing the rhymes and moving its body parts. The boombox was a transistorized portable music player. After the end of the experiment, EEG data of each participant was gathered every two minutes for about 14 minutes.

Procedure

Signal pre-processing

As figure 1 shows, the data pre-processing step consists of two tasks: 1) filtering and artifact removal and 2) channel separation.

Filtering and artifact removal

Raw EEG data always contains artifacts, which reduce the quality of the signal. These artifacts are categorized into two groups: physiological and non-physiological. Physiological artifacts occur due to individuals' eye blinks, eye movements, muscle activities, heartbeat, and head or body movements. Non-physiological artifacts include noises from the environment and malfunction of the EEG device. Performing data preprocessing is critical due to the need to eliminate any potential data corruption that can occur due to the presence of artifacts.

We performed artifact removal in two sessions. First, unwanted noise like line and lower frequency noises were deleted by applying a bandpass filter that allows frequencies in the range of 0.5 to 60 Hz using Matlab software version 9.5 [18]. Second, the enhanced-wavelet-ICA (EAWICA), which is a fully automated artifact removal toolbox that uses wavelet transform, ICA, entropy, and kurtosis concepts to identify and delete artifacts from all of EEG channels, was applied to the EEG data. This toolbox removes almost all of the artifacts related to eye blinks, muscle activities, electrical shifts, and linear trends [19].

Channel separation

Based on previous studies four EEG channels, F3, F7, F4 and F8, which are located in the frontal region of the left and right sides of the brain, provide information about positive and negative emotions [21,22]. Thus, we selected these channels for further investigation.

Signal analysis

Discrete wavelet transform (DWT)

DWT has been widely applied in EEG data processing because EEG data is non-stationary with low frequencies and DWT performs better than other frequency domain techniques like FFT. We chose the Daubechies wavelet (db4) as our mother wavelet function to deconstruct the EEG signal into its subbands, which are alpha, beta, theta, and gamma. Each brain subband belongs to a related frequency. It was presumed that listening to nursery rhymes might relax individuals, meaning that lower beta activity and higher alpha activity could be observed. Therefore, we chose the decomposition levels that show only beta and alpha activities, i.e., D3 (beta waves) and D4 (alpha waves), for further investigation.

Feature extraction

In this step, features like energy, entropy, average, and standard deviation were calculated from wavelet for each level of wavelet coefficient and selected channels.

Results

Analysis of selected features

To monitor how participants' alpha and beta wave activities were altered when listening to the nursery rhymes, extracted features from the EEG data for baseline, during and post-experiment for each scenario were compared.

It was observed that during the time that the boombox played the rhymes:

- For energy, entropy, and standard deviation features, whenever the alpha waves were more dominant, the beta waves were weak, and vice versa.
- For mean features, there were no considerable differences between alpha and beta wave activities.

For the musician and robot player scenarios, the results showed that:

- For energy features, a clear pattern was seen between baseline data and the data during the experiment and after the experiment. For some participants, more alpha activity occurred and for others more beta activity occurred.
- For entropy and standard deviation, the same trend between alpha and beta waves was observed for both baseline and during the experiment, and during and post-experiment.
- For mean features, we detected no considerable differences between alpha and beta activity.

Additionally, to compare participants' brain responses to listening to nursery rhymes in each scenario, a Pearson correlation coefficient between each pair of participants was calculated and compared. The results are summarized in table 1-3.

	MP1	MP2	MP3	MP4	MP5	MP6	MP7	MP8	MP9	MP10	MP11	MP12	MP13	MP14	MP15
MP1	1.0	0.0	0.2	0.5	-0.1	-0.1	0.0	-0.4	0.4	0.1	0.9	0.4	0.9	0.5	-0.7
MP2	0.0	1.0	0.8	0.4	0.5	0.5	0.0	0.6	0.0	0.4	-0.1	-0.6	0.3	0.0	-0.2
MP3	0.2	0.8	1.0	0.3	0.6	0.4	0.1	0.2	-0.2	0.0	0.2	-0.2	0.5	0.0	-0.6
MP4	0.5	0.4	0.3	1.0	-0.1	-0.4	0.4	0.3	0.0	0.3	0.0	-0.6	0.2	0.1	0.0
MP5	-0.1	0.5	0.6	-0.1	1.0	0.6	0.5	0.4	0.6	0.7	-0.2	0.1	0.2	-0.6	-0.4
MP6	-0.1	0.5	0.4	-0.4	0.6	1.0	-0.1	-0.1	0.2	-0.1	0.1	0.0	0.2	0.6	-0.2
MP7	0.0	0.0	0.1	0.4	0.5	-0.1	1.0	0.7	0.9	0.6	-0.9	-0.2	-0.2	-0.8	0.0
MP8	-0.4	0.6	0.2	0.3	0.4	-0.1	0.7	1.0	-0.2	0.7	-0.7	-0.6	-0.3	-0.7	0.4
MP9	0.4	0.0	-0.2	0.0	0.6	0.2	0.9	-0.2	1.0	0.6	0.5	0.4	0.6	0.7	-0.2
MP10	0.1	0.4	0.0	0.3	0.7	-0.1	0.6	0.7	0.6	1.0	-0.1	-0.1	0.2	-0.1	0.1
MP11	0.9	-0.1	0.2	0.0	-0.2	0.1	-0.9	-0.7	0.5	-0.1	1.0	1.0	1.0	0.6	0.9
MP12	0.4	-0.6	-0.2	-0.6	0.1	0.0	-0.2	-0.6	0.4	-0.1	1.0	1.0	1.0	0.2	0.9
MP13	0.9	0.3	0.5	0.2	0.2	0.2	-0.2	-0.3	0.6	0.2	1.0	1.0	1.0	0.9	-0.9
MP14	0.5	0.0	0.0	0.1	-0.6	0.6	-0.8	-0.7	0.7	-0.1	0.6	0.2	1.0	1.0	0.9
MP15	-0.7	-0.2	-0.6	0.0	-0.4	-0.2	0.0	0.4	-0.2	0.1	1.0	1.0	-0.9	1.0	1.0

Table 1: *Correlation coefficient between participants for musician player.*

MP: Indicated that participants listened to the rhymes played by a musician.

	RP1	RP2	RP3	RP4	RP5	RP6	RP7	RP8	RP9	RP10	RP11
RP1	1.0	-0.2	-0.5	-0.6	-0.1	0.8	-0.3	-0.6	0.3	-0.7	0.5
RP2	-0.2	1.0	0.3	0.5	-0.8	0.1	0.9	-0.2	0.4	0.2	0.7
RP3	-0.5	0.3	1.0	0.8	0.2	-0.5	0.2	-0.3	-0.4	0.3	-0.2
RP4	-0.6	0.5	0.8	1.0	-0.1	-0.4	0.6	0.0	-0.5	0.6	-0.2
RP5	-0.1	-0.8	0.2	-0.1	1.0	-0.3	-0.8	0.0	-0.7	0.2	-0.7
RP6	0.8	0.1	-0.5	-0.4	-0.3	1.0	0.1	-0.4	0.2	-0.2	0.8
RP7	-0.3	0.9	0.2	0.6	-0.8	0.1	1.0	0.2	0.2	0.4	0.6
RP8	-0.6	-0.2	-0.3	0.0	0.0	-0.4	0.2	1.0	-0.1	0.5	-0.3
RP9	0.3	0.4	-0.4	-0.5	-0.7	0.2	0.2	-0.1	1.0	-0.5	0.6
RP10	-0.7	0.2	0.3	0.6	0.2	-0.2	0.4	0.5	-0.5	1.0	-0.1
RP11	0.5	0.7	-0.2	-0.2	-0.7	0.8	0.6	-0.3	0.6	-0.1	1.0

Table 2: *Correlation coefficient between participants for robot player.*

RP: Indicated that participants listened to the rhymes played by a robot.

	BP1	BP2	BP3	BP4	BP5	BP6
BP1	1.00	-0.19	0.81	0.68	0.64	0.88
BP2	-0.19	1.00	-0.34	-0.10	0.18	-0.23
BP3	0.81	-0.34	1.00	0.85	0.83	0.64
BP4	0.68	-0.10	0.85	1.00	0.85	0.51
BP5	0.64	0.18	0.83	0.85	1.00	0.53
BP6	0.88	-0.23	0.64	0.51	0.53	1.00

Table 3: *Correlation coefficient between participants for boombox player.*
MP: Indicated that participants listened to the rhymes played by a boombox.

Based on table 1, for the musician player scenario, there was a strong negative correlation between EEG data of participant 1 with 11 and 13 (r = 0.9, p < .001), participant 2 with 3 (r = 0.8, p < .001), participant 5 with 10 (r = 0.7, p < .001), participant 7 with 9 (r = 0.9, p < .001), participant 11 with 15 (r = 0.9, p < .001), participant 12 with 15 (r = 0.91, p < .001), participant 13 with 14 (r = 0.9, p < .001), and participant 14 with 15 (r = 0.9, p < .001). Also, there was a positive strong correlation between EEG data of participant 7 with 8 (r = 0.7, p > .05).

Based on table 2, for the robot player scenario, there was a considerable relationship between EEG data of participants 1 with 6 (r = 0.8, p < .001), and participant 2 with 7 and 11 (r = 0.9, p < .001; r = 0.7, p < .05), participant 3 with 4 (r = 0.8, p < .001), and participant 6 with 11 (r = 0.8, p < .05).

Based on table 3, for the boombox player scenario, a negative strong correlation was detected for participant 1 with 6 (r = 0.88, p < .001), participant 3 with 5 (r = 0.83, p < .001), and participant 4 with 5 (r = 0.85, p < .001). Also, there was a positive strong correlation between EEG data of participant 1 with 3 (r = .81, p > .05).

In conclusion, it is not possible to generalize the changes in brain activity for all participants in each unique scenario because no same brain wave activities were detected. While for some participants, music made them calm or relaxed, it had a negative effect on other participants.

Comparison between different scenarios

Comparison between different scenarios (a musician, robot, or boombox player) was made by calculating the Pearson correlation coefficient and one-tailed t-test techniques between different scenarios and participants in each scenario. The results are summarized in figure 2 and 3 and table 4.

Waves	Stage of Experiment	Boombox-Robot	Boombox-Musician	Robot-Musician
Beta	Baseline	t(15) = 0.72, p = .23	t(19) = -1.58, p = .06	t(24) = -1.31, p = .09
	Experiment	t(15) = 0.31, p = .37	t(19) = -1.28, p = .11	t(24) = -1.32, p = .09
	Post-Experiment	t(15) = 1.85, p = .04	t(19) = 1.56, p = .06	t(24) = -1.18, p = .12
Alpha	Baseline	t(15) = 1.35, p = .10	t(19) = 1.80, p = .04	t(24) = -1.18, p = .12
	Experiment	t(15) = 1.49, p = .07	t(19) = 1.58, p = .06	t(24) = -0.89, p = .18
	Post-Experiment	t(15) = -1.71, p = .05	t(19) = -2.46, p = .01	t(24) = -1.53, p = .06
Average of Alpha and beta	Baseline	t(15) = 1.17, p = .13	t(19) = 1.68, p = .05	t(24) = -1.08, p = .15
	Experiment	t(15) = 1.34, p = .10	t(19) = 1.24, p = .11	t(24) = -1.21, p = .12
	Post-Experiment	t(15) = -1.25, p = .11	t(19) = -2.30, p = .02	t(24) = -1.65, p = .06

Table 4: *T-test results (one-tailed, alpha value = 0.05).*

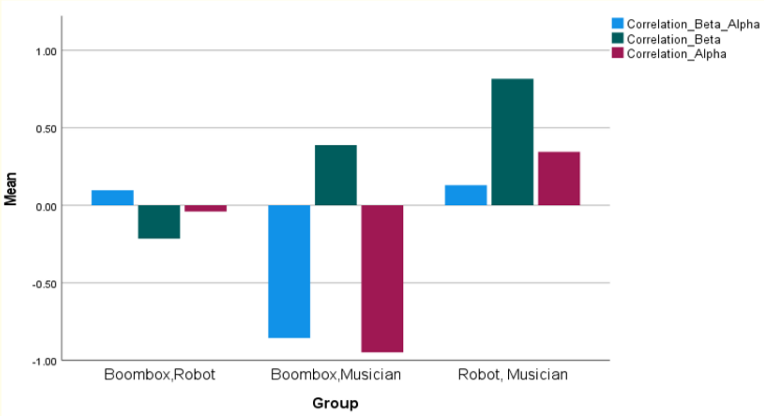
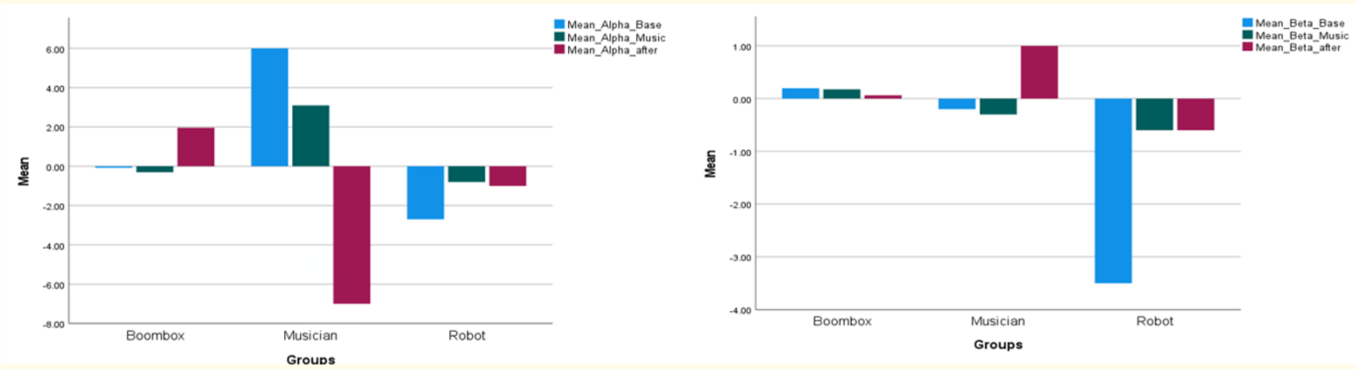


Figure 2: *Average Pearson correlation coefficient of brain activity for each pair of scenarios.*



a) *Average of alpha waves* ***b)*** *Average of beta waves*

Figure 3: *Comparison between average alpha and beta activity for all participants during various scenarios.*

Figure 2 shows the plot of Pearson correlation coefficients between each pair of scenarios. It was noticed that there is no correlation between listening to rhymes using a boombox or a robot player during and post-experiment. Also, there is no correlation between listening to rhymes when played by a boombox or a musician before and post-experiment. The correlation coefficient between musician and robot player shows a significant relationship between these scenarios. Therefore, listening to live nursery rhymes, played by a robot or a musician, may not have the same impact on the brain as being exposed to a boombox player.

Figure 3 presents a comparison between the average value of alpha and beta waves for all participants in each scenario. This figure shows that:

1. For the average value of alpha waves, the data indicates that for the musician player scenario, the baseline data was higher than both the boombox and the robot players data. Also, for the musician scenario, a significant drop in the average value of alpha waves was seen during and after the exposure to the rhymes. The average value of alpha waves showed a small fluctuation for participants in the boombox player scenario during the experiment, while it increased after the experiment. There was a reverse trend for the average value of alpha waves for the robot player scenario; it increased during the experiment and decreased after the experiment.
2. For the average value of beta waves, the data did not show any significant differences between the different scenarios at baseline.

A declining trend during and after the exposure to the nursery rhymes played by the boombox was seen. The average value of beta waves also dropped for participants in the musician player scenario during the experiment, while it increased after the experiment. For the robot player scenario, an increase in the average value of beta waves was noticed during the experiment whereas there were no changes after the experiment.

The results of hypothesis testing using the one-tailed t-test technique indicate the value of $p < .05$ for both alpha and beta waves for data after the experiment between the boombox and the robot players, which means that there is a significant difference between these modes. Additionally, the value of $p < .05$ for both alpha and the average value of alpha and beta waves was observed for baseline and after experiment data between a boombox and musician players, which means that there is a difference between these modes. The hypothesis testing shows no significant differences between the musician and the robot player. Based on table 5, the average value of beta and alpha waves for all participants in the different scenarios showed a negative correlation between alpha and beta activities. Whenever alpha increases beta decreases and vice versa. Additionally, after the experiment, participants in both the robot and musician player scenarios were more relaxed than participants in the boombox scenario.

Scenario	Results
Boombox player	Baseline alpha < baseline beta During experiment alpha < During experiment beta After experiment alpha > After experiment beta Post-experiment observation: Increase in alpha and decrease in beta
Musician player	Baseline alpha > Baseline beta During experiment alpha > During experiment beta After experiment alpha < After experiment beta Post-experiment observation: Decrease in alpha and increase in Beta
Robot player	Baseline alpha > Baseline beta During experiment alpha > During experiment beta After experiment alpha > After experiment beta Post-experiment observation: Increase in alpha and decrease in beta

Table 5: *Comparison between average value of alpha and beta of participants in each scenario.*

(<: lower than, >: higher than).

Discussion and Limitations

This pilot study shows that while for some participants, nursery rhymes were relaxing, for others, it was disturbing. Also, for most of the participants, the impact of nursery rhymes on brain waves did not last after the experiment. The results suggest that individuals' brain response to a musician or a robot player is similar. However, the musician's presence might not allow participants to express their emotions. Also, the robot might distract the participants so instead of focusing on the songs the robot might catch participants' attention.

One of the limitations was the accuracy of the data collected. It is important to ensure that the EEG device is collecting legible data with few artifacts. In the current study, a significant amount of data was lost during the data collection because of malfunction of the headset or software. Another limitation was that participants may have been biased because they knew they were being observed as part of the study; thus, we may not have noticed the expected trend in the data. Using an EEG device for gathering the brain data during passive or engaged listening may not be helpful. When participants are engaged, they move their body parts and even small movements can easily be considered as an artifact and have a negative impact on the quality of recorded EEG. Therefore, during the EEG data acquisition it is very important to ask subjects to be in a relaxed and non-moving state. Further, it is necessary to make sure that individuals are attentive or their unfocused attention may have a negative impact on EEG signals. Another main limitation is to consider individuals' preference, past memories, and culture. Having a chance to pick the music genre may have a different impact on the brain state. If the music genre is not the favorite or familiar one, it may not change brain wave activities. Listening to the preferred music can balance brain waves or even relax the mind in comparison to disliked music. Associated memory with the selected music can put the brain in a relaxed state (increase in alpha waves and decrease in beta waves) or disturb (increase in beta waves and decrease in alpha waves) state.

Conclusion

For future study, it is suggested to play music based on individual music preferences. Additionally, it is crucial to put participants' brains in a relaxed situation before any data collection. This study also suggests that to draw a broader conclusion it would be necessary to consider the long-term impact of music on the brain and on a larger scale.

Bibliography

1. Mohd Nasir SA and Wan Mahmud WMH. "Brain Signal Analysis Using Different Types of Music". *International Journal of Integrated Engineering* 7.3 (2015).

2. Iwaki T., *et al*. "Changes in alpha band EEG activity in the frontal area after stimulation with music of different affective content". *Perceptual and Motor Skills* 84.2 (1997): 515-526.

3. Tanaka Y., *et al*. "Music therapy with ethnic music for dementia patients". *International Journal of Gerontology* 6.4 (2012): 247-257.

4. Xu Y., *et al*. "EEG Research Based on the Influence of Different Music Effects". *In Journal of Physics: Conference Series* 163.1 (2020): 012147.

5. SK Tai and YJ Kuo. "Alterations in brainwaves caused by different Music Genres". 2019 IEEE 10th International Conference on Awareness Science and Technology (iCAST), Morioka, Japan (2019): 1-4.

6. Phipps MA., *et al*. "Music as a therapeutic intervention on an inpatient neuroscience unit". *Complementary Therapies in Clinical Practice* 16.3 (2010): 138-142.

7. Stanczyk MM. "Music therapy in supportive cancer care". *Reports of Practical Oncology and Radiotherapy: Journal of Greatpoland Cancer Center in Poznan and Polish Society of Radiation Oncology* 16.5 (2011): 170-172.

8. R Maddick. "Naming the unnameable and communicate the unknowable : Reflections on a combined music therapy/social work program". *The Arts in Psychotherapy* 33 (2011): 130-137.

9. Shin HS and Kim JH. "Music Therapy on Anxiety, Stress and Maternal-fetal Attachment in Pregnant Women During Transvaginal Ultrasound". *Asian Nursing Research* 5.1 (2011): 19-27.

10. BB Scheiby. "Beyond talk therapy: Using movement and expressive techniques in clinical practice". *in Music as Symbolic Expression: Analytical Music Therapy* (1999): 263-285.

11. Hassan Hasminda., *et al*. "A preliminary study on the effects of music on human brainwaves". 2012 *International Conference on Control, Automation and Information Sciences ICCAIS* (2012): 176-180.

12. Ogata S. "Human Eeg Responses to Classical Music and Simulated White Noise: Effects of a Musical Loudness Component on Consciousness". *Perceptual and Motor Skills* 80.3 (1995): 779-790.

13. Götell E., *et al*. "The influence of caregiver singing and background music on vocally expressed emotions and moods in dementia care: a qualitative analysis". *International Journal of Nursing Studies* 46.4 (2009): 422-430.

14. McCaffrey T., *et al*. "Is there a role for music therapy in the recovery approach in mental health". *Arts in Psychotherapy* 38 (2011): 185-189.

15. Gentry H., *et al*. "Music genre preference and tempo alter alpha and beta waves in human non-musicians (2013).

16. Helman A., *et al*. "Neuroimaging Electroencephahlography (eeg) Application on Human Electrical Brain Activities during Meditation and Music Listening". *Journal of Advanced Manufacturing Technology (JAMT) 13*.2 (2019).

17. Nawaz R., *et al*. "Can background music help to relieve stress? An EEG analysis". *2019 IEEE International Conference on Signal and Image Processing Applications (ICSIPA)* (2019): 68-72.

18. Matlab. "Version 9.5 (R2018b)". Natick, Massachusetts: The MathWorks Inc (2018).

19. Mammone N and Morabito F. "Enhanced Automatic Wavelet Independent Component Analysis for Electroencephalographic Artifact Removal". *Entropy* 16.12 (2014): 6553-6572.

20. Mohammadi Z., *et al*. "Wavelet-based emotion recognition system using EEG signal". *Neural Computing and Applications* 28 (2017): 1985-1990.

21. Priyanka A Abhang., *et al*. "Introduction to EEG- and Speech-Based Emotion Recognition (1st. ed.)". Academic Press, Inc., USA (2016).

22. Satheesh Kumar J., *et al*. "Analysis of Electroencephalography (EEG) Signals and Its Categorization". *A Study Procedia Engineering* 38 (2012): 2525-2536.

Volume 3 Issue 5 May 2021