Original Research Article

An investigation on brainwave signal analysis while listening to sounds of nature by using a portable EEG device: A pilot study

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Abstract

Electroencephalogram (EEG) is a method of measuring the neuro-signals of the brain. Portable EEG device was used to measure the level of attention and meditation before and during listening to the sounds of nature. Listening to the sounds of nature may induce relaxation to the body and mind. The objectives of this study were to identify the differences in the level of attention and meditation before and during listening to the sounds of nature and also to determine whether there is a difference between males and females with regards to the level of attention and meditation. Thirty pharmacy students (15 males; 15 females) were involved in this study. Attention and meditation levels of the students before and during listening to the sounds of nature were recorded, analyzed and evaluated. The results showed that the mean score of attention was higher during listening to the sounds of nature meanwhile the mean score of meditation was lower. There were no significant differences in the level of attention and meditation between males and females.

Keywords: electroencephalogram (EEG), attention, meditation and sounds of nature

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1.0 Introduction

Nature is believed to provide a calming effect and the ability to relax an individual's mind and body. According to Attention Restoration Theory (ART), natural environment invoke a different sort of attention from people such as a sense of 'fascination', 'being away', 'extent', and 'compatibility' that may lead to improve performance on tests that measure memory and attention (1). Nature has been known to deliver positive feelings, a sense of ease, rest, self-confidence and self-esteem. The time spent on nature improved people's mood and resulted in more positive thinking that give chances to people to reflect on and cope with their current situation (2).

ART is supported by previous studies that found that listening to the sounds of nature give a positive result on the level of attention and meditation. People become more relaxed due to activation of rest-digest nervous system (3,4). Listening to the sounds of nature has been proved to decrease pain in patients undergoing flexible bronchoscopy (5) and cancer patients (6). These studies show that listening to relaxing sounds of nature may help to comfort people.

Technological advancement has led human beings to be more apart from nature. Although internet technology including texting, emails, Instagram, Whatsapp, Twitter and others was designed to improve the human condition, the presence of all these technologies had made people to be less connected with nature. More and more students each year report having issues of anxiety or other problems (7). There is also a study that assessed stress among undergraduate pharmacy students in University of Malaya and pharmacy students were known to have higher stress levels (8). Perhaps, identifying strategies that brings people closer to nature or musical therapy such as sounds of nature could be helpful to reduce stress.

Listening to the sounds of nature may produce some calming effect and increased attention and meditation level as these factors are important for general wellbeing and to be able to perform better (9). People have used nature as their medium to let pure relaxation and calmness to take over them. Being surrounded by the sight of nature and listening to the peaceful sounds such as a the sound of a bird singing, the sound of the wind and a running stream can cause relaxation (10).

If listening to the peaceful sounds of nature can give a calming and relaxation effect, it will be valuable if such changes in terms of brainwave changes can be measured. EEG is a test to detect electrical activity in the brain using small, metal discs attached to our scalp.The electrical activity that happens in the brain comes from the small voltage fields generated by millions of neurons in a brain. There are portable EEG devices that have been commercially available in the market and have been used for various purposes. Portable EEG devices such as Brainwave Starter Kit along with its applications can be used to measure attention and meditation level via brainwave signal analysis (11).

Many studies have been done to study the effect of sounds of nature to the level of meditation and attention. However, most of these studies used different methods such as survey instruments to measure respondents' perception (2). Aside from these instruments, not many studies used objective measurement with regards to the measurement of attention and meditation level.

Thus, the aim of the study is to determine whether the Brainwave Starter Kit can be used as an alternative approach to measure the level of meditation and attention while listening to sounds of nature. We also wanted to identify the differences in the level of attention and meditation before and during

listening to the sounds of nature. Besides, we also wanted to determine whether there is a difference between males and females with regards to the level of attention and meditation.

This study might be able to show the potential use of a portable EEG device in measuring the level of attention and meditation.

2.0 IMaterials and methods

2.1 Study location

This project was conducted at Universiti Teknologi MARA (UiTM) Puncak Alam, Selangor. This research was conducted by using an experimental study design.

2.2 Participants

Thirty undergraduate pharmacy students over the age of 18 (15 males and 15 females) were recruited at the Faculty of Pharmacy through convenient sampling. Only participants who were free from any identified physical or mental disorders were selected for this experiment. Prior to the study, consent form, and information pertaining to the study were provided to each participant. Ethical approval was obtained from the Universiti Teknologi MARA Research Ethics Committee [600-FF(PT.5/1)].

2.3 Instruments

The figures below were the instruments used in this experiment in measuring the level of attention and meditation while listening to the sounds of nature by using a portable EEG device. The instruments and materials involved were MP3 player sound of nature (Figure 1), Brainwave Starter Kit (Figure 2), EEG reader4 NeuroSky Mindwave (Figure 3 & Figure 4) and Classic Puzzles: Word Search book (Figure 5).

Figure 1: MP3 player sounds of nature

Brainwave Starter Kit is a device used to measure the brainwave of a person. It is a non-invasive and mobile portable brainwave sensor that can actually measure the attention and meditation level through an EEG reader. This device uses automatic bluetooth wireless pairing to send attention and meditation levels of the measured EEG at the left prefrontal (Frontal pole 1) point to smart devices. This device includes a left-ear clip and metallic tip that rests against the user's forehead, just above the left eye. This device will function by inserting a single AAA Battery which has approximately 8-hours of battery run time. Android or iOS users are compatible with this headset.

Figure 2: Brainwave Starter Kit

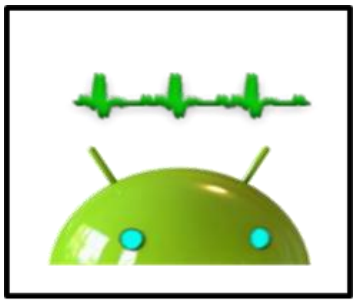

Figure 3: EEG reader 4 NeuroSkyMindwave application

Figure 4: EEG reader 4 NeuroSky Mindwave application

Before the study was conducted, many applications were tried to test the device. Applications that can connect to the headset can be downloaded for free. EEG reader 4 NeuroSky Mindwave application were chosen because this was the most suitable and user friendly compared to other applications. EEG reader 4 NeuroSky Mindwave is a free software application which is available in English and can be installed on Android phones. The headset can be connected to this application via bluetooth pairing and it gives the data about the level of attention and meditation. The data were recorded for every minute allowing the users to control the use of this application. The data recorded in this application then can be exported to android external storage to give numerical data in the form of a table which is more systematic and easier to read.

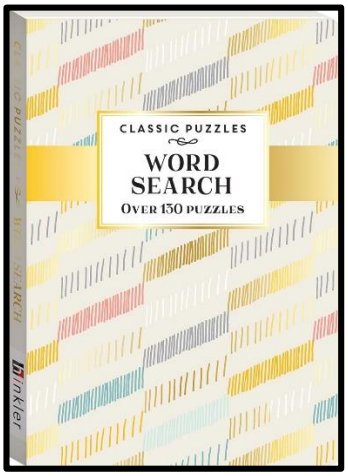

Figure 5: Classic Puzzles: Word Search 3

Find the word in the puzzle is one of the brain training activities that improve concentration. Crossword puzzle can improve fluency in the speech and language center of the brain. By practicing crossword puzzles, the brain is trained to find words quickly.

2.4 Case-control design

The experimental design was conducted in two stages (Figure 6). Each participant wore the wireless headset, which was the Brainwave Starter Kit (Figure 2). The Bluetooth headset was activated and it was then connected to the mobile phone containing EEG reader 4 NeuroSky Mindwave application (Figure 3 & Figure 4). Data was taken two minutes prior to listening to the sounds of nature and another two minutes during the listening process. The recorded data was used to determine the level of meditation. Similar method was used to measure attention level by getting the participant to do a puzzle crossword search and data was recorded two minutes before and during listening to the sounds of nature.

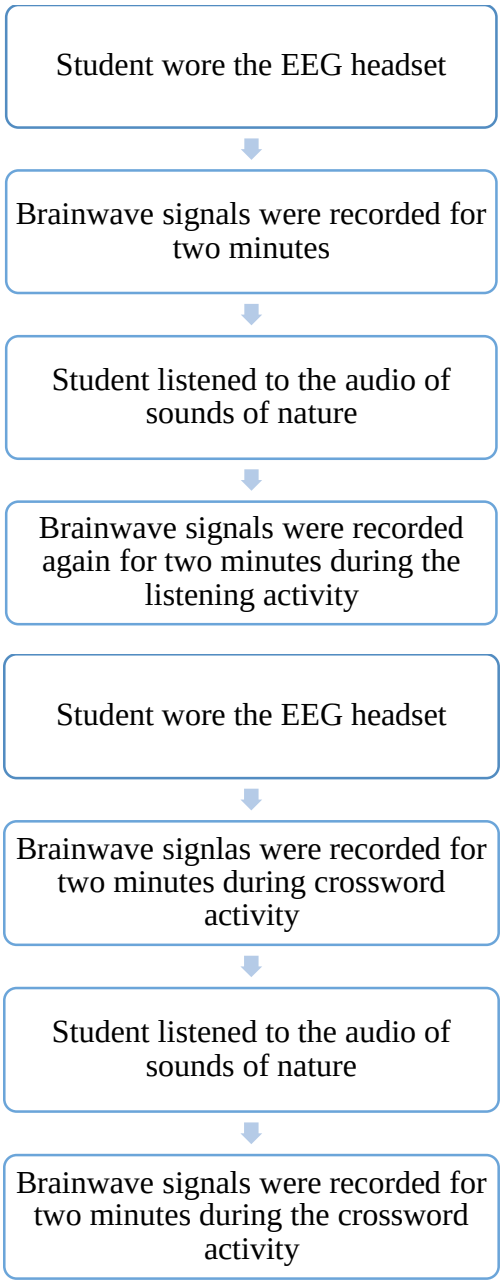

Figure 6: Case-control design

2.5 Measurements

EEG results were recorded using a Neuro Sky Mind Wave headset. The headset records brainwaves from the frontal lobe position above the eye and is divided into four parts which are a headband, an ear clip, a sensor arm containing the EEG electrode and a Bluetooth device. The sensor tip identifies electrical signal of the brain from the forehead. The ear clip allows the 'think gear chip' to filter out the electrical noise (12). The device has small microchips that pre-process data and transfer electrical signals directly to the mobile via bluetooth. The headset can detect brainwave signals in the form of attention and meditation scores. According to e-Sense meter, attention and meditation data are scaled from 0-100 (Table 1). The EEG reader 4 Neuro Sky Mind wave was the application used to record the data of attention and meditation during the two minutes measurement. Figure 4 showed the data obtained. The data were recorded in the application and exported to Microsoft Excel.

Table 1: e-Sense meter

Scale	Levels
0 – 20	Very low
21 – 40	Slightly low
41 – 60	Natural state
61 – 80	Slightly high
81 - 100	Very high

2.6 Data analysis

Paired t-tests and chi-square test were used to compare mean values of two variables and to identify the differences between categorical variable respectively. The data was analyzed using Statistical Package for the Social Science (SPSS) version 24.0.

3.0 Results and Discussion

The subjects' attention mean score was slightly higher during listening to sounds of nature than before listening to the sounds of nature (attention score: before listening activity: 51.0 ± 2.2 and during listening activity: 52.3 ± 1.9; $p < 0.01$, Figure 7). Meanwhile, the subject's meditation mean score was significantly lower during listening to the sounds of nature compared to before listening to the sounds of nature (meditation score: before listening activity: 58.8 ± 2.6 and during listening activity: 57.1 ± 2.3; $p < 0.01$, Figure 7).

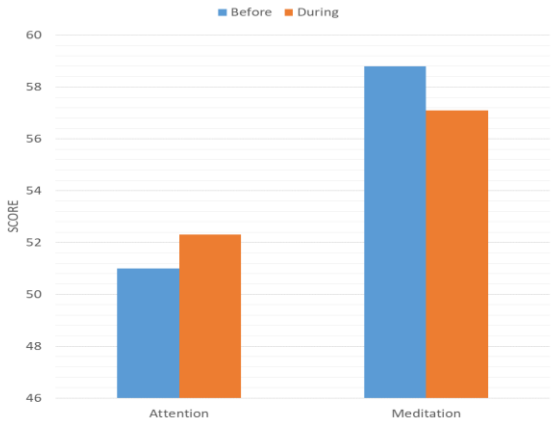

Figure 7: Participants' attention and meditation scores before and during listening to sounds of nature.

Figure 8 shows both males and females have the same level of attention before and during the listening activity. The p-value of test statistic was $p = 0.152$ (before listening) and $p=0.183$(during listening) and both were not significant. Thus, there is no association found between gender and the level of attention before and during the listening activity. Therefore, the null hypothesis of there is an association between gender and level of attention during listening to the sounds of nature is rejected.

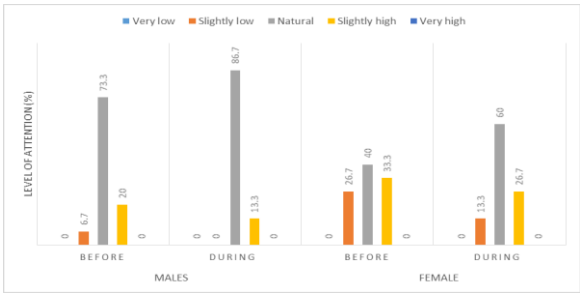

Figure 8: Differences between genders with regards to the level of attention.

As shown in Figure 9, there were no differences observed between males and females with regards to the level of meditation before and during the listening activity. The p-value of the test statistic for both before and during listening to the sounds of nature are larger than the significance level ($\alpha = 0.05$) which are 0.096 and 0.706 respectively. Therefore, there is no association between gender and the level of meditation before and during the listening activity. However, higher scores were observed for both males and females with regards to the level of meditation before listening to the sounds of nature. Ironically, decreased level of meditation scores were observed in both males and females while they were listening to the sounds of nature.

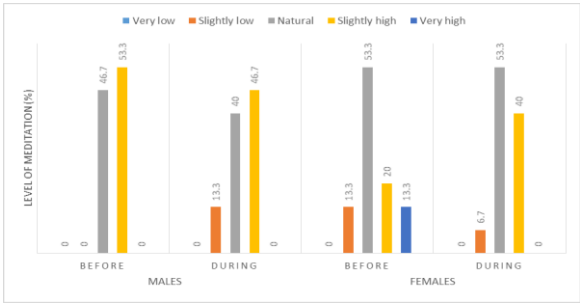

Figure 9: Differences between genders with regards to the level of meditation.

In this study, we investigated the usability of a portable EEG to measure the level of attention and meditation while listening to the sounds of nature. Our results indicated that the subjects' level of attention increased

slightly during listening to the sounds of nature. Thus, the sounds of nature may have enhanced the ability to focus. However, the level of meditation during listening to the sounds of nature was slightly lower. Our results were not similar to those in previous studies measuring the effects of nature to the level of meditation (3,4). This could be due to the differences of study design. Previous studies obtained a positive result on the level of attention and meditation for each respondent. It was reported that the participants became more relaxed and it was associated with the stimulation of rest-digest nervous system. Activation of rest-digest system causes a decrease in heart rate and lowers blood pressure (3,4). According to e-Sense Meter, both results showed that the participants mean values were categorised under natural states which means the level of attention and meditation were in normal range. There were many differences in our study compared to the previous studies. For example, the subjects were different (5). Our study included healthy students and their participations were voluntary, but previous studies, mostly included patients who suffered from cancer, patients who have autism spectrum disorder or undergoing specific clinical procedures. The findings about the level of attention before and during listening to the sounds of nature is similar to another study that reported that the subjects' attention mean score were significantly higher when walking in the bamboo forest. It was also reported that the mean scores of meditations were also significantly higher when walking in the bamboo forest but this was not the case in our study. Forest environment has the capability to induce mental relaxation (13), but just listening alone wasn't sufficient to increases meditation level in this study. This could be due to the differences in environmental conditions, due to artificial setting compared to actual presence of nature which include the sight of plants, river, trees and sounds of the birds singing. The short duration of time given for listening to the audio sounds of nature could have also impacted the level of attention and meditation. With regards to gender, there were no significant differences observed and it was similar to previous study about gender differences on attention although the methods used to document or measure the level of attention and meditation were different (14).

This study was limited to small number of participants and a short period of measurement. Future studies may need a larger sample size, people from different age group and various measurement intervals. Additionally, studies on real environment of nature are preferred. The actual site of nature may spark other senses, such as sight, hearing, touch and smell. Nevertheless, the strength of the study lies on the new method of measuring levels of meditation and attention via portable EEG device and the EEG reader.

4.0 Conclusion

This small study indicated that listening to the sounds of nature increases the level of attention and decreases the level of meditation. There was no significant difference among males and females with regards to the level of attention and meditation. This study managed to show the usability of a portable EEG device to measure the level of attention and meditation in an objective manner.

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Conflicts of interests

The authors declared that there were no conflicts of interest.

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