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A Study of Smartphone Game Users through EEG Signal Feature Analysis

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Abstract

Recently, studies on different applications using measured brain waves have been increasingly progressing. It started out with studying brain waves of a monkey to control an arm with a motor. Then it is applied for raising children's attention or understanding a patient situation. This paper deals with measuring the attention and meditation of EEG signal when a smartphone game user is playing. A survey will be conducted that measures the EEG signals for the smartphone game users while playing the game for analysis. The results will be depending on the memory and expressions of game users when solving hard problems during the game.

Keywords: *Game Play Test, Game User Feedback, EEG*

1. Introduction

The Brain Computer Interface (BCI) has been widely emerging for use in medical related fields. It is mainly used for prophylactic and therapeutic programs intended for patient's suffering dementia or attention deficit hyperactivity disorder patients [1]. The cost of BCI has been recently decreasing so the range of demand for usage has gradually increased. The BCI has been widely used for monitoring the state of patients in the medical related field [2]. Its usage was also in demand for training programs to control the brain waves. This is known as neuro feedback [3]. In addition, its use to measure brain waves and its application for control is now widely increasing [4].

In this paper, the EEG signal is applied, compared and analyzed the features on the attention and meditation of measured EEG signals while the smartphone game user is playing. Obtaining an objective data through the measurement of EEG signals while playing a game could be difficult so a survey is made that depends on the memory and expressions of game users. The measure EEG signals while playing the game will be compared and analyzed based on the quantitative attention and meditation results. The state of the attention while playing the game shows the boredom and tiresome state while the meditation was checked as a pleasant state while playing a game.

The rest of this paper is organized as follows: Section 2 explains the EEG signal analysis and introduces the existing related studies for measuring EEG signals when playing a game; Section 3 outlines the EEG measurement composition for a game user while playing and discusses the results of the EEG measurement; and the concluding remarks in Section 4.

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2. Related Works

This section presents a discussion of the existing studies for EEG cognizance and EEG signal analysis.

The Electroencephalography (EEG) refers to the recording and measure of electrical activity of the brain for a short period of time that ranges from 20-40 minutes by placing multiple electrodes on the scalp [10]. The spectral content of the EEG is generally the focus of diagnostic applications. It is commonly used for diagnosing epilepsy that causes abnormalities and EEG signal recordings [11]. Other applications include diagnosing sleep disorders, coma, encephalopathies, brain death, and monitoring the brain during brain surgery.

In the past, the EEG test is used to be a first-line method of diagnosis for tumors, stroke and other focal brain disorders [12, 13], however, with the emergence of high-resolution anatomical imaging techniques such as MRI and CT, its use has been decreased. In addition, EEG continuous to be a valuable tool for research and diagnosis, especially when millisecond-range temporal resolution is required.

2.1. EEG Cognizance

The EEG refers to the electronic flow when deliver the signals between nervous system and a cranial nerve. A very complex form of structure of signals appears when measuring an EEG as shown in Figure 1. This refers to a raw data and is unseparated brain waves by each frequency [5]. Since these raw data contains more static signal than extraction signal part, it needs filtering at preconditioning process. The preconditioning process uses power spectrum method at the most, conversion of raw data to power spectrum form as shown in Figure 2.

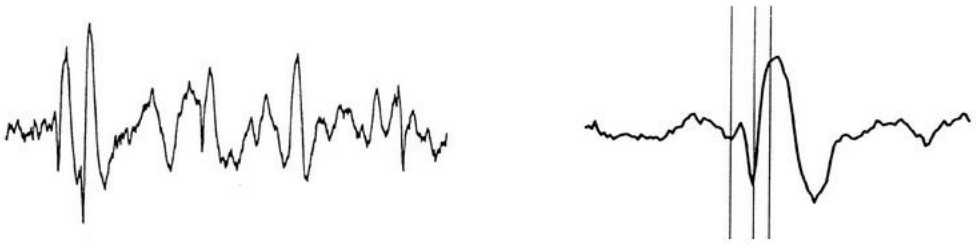


Figure 1. Raw Data of EEG

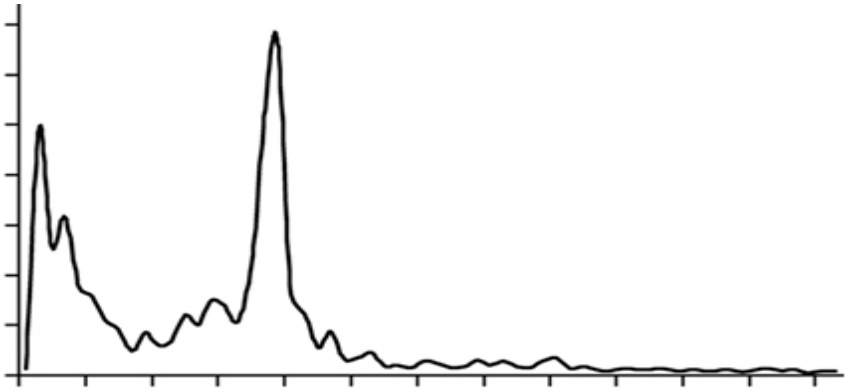


Figure 2. Change Raw Data to Poser Spectrum

2.2 EEG Signal analysis

The power spectrum of brain waves is categorized by frequency bands with different amplitude for each frequency. The features of each frequency band are classified as shown in Table 1.

The analysis of EEG signals involves the description of the two terms: (1) rhythmic activity; and (2) transients. The rhythmic activity is divided into bands of (*i.e.*, any rhythmic activity between 8–12 Hz can be described as "Alpha", between 12–30 Hz can be described as "Beta"). In addition, it is observed that mostly, EEG signals falls in the range of 1-20 Hz.

Table 1. Types and Feature of Brain Wave

Type	Frequency (Hz)	Normally
Delta	0.5 – 4 Hz	hypnoidal
Theta	4 – 7 Hz	slow wave sleep
Alpha	8 – 12 Hz	stable wave
Beta	12 – 30 Hz	action wave
Gamma	Over 30 Hz	arousal and excitement

Furthermore, some features of the EEG signals are transient rather than rhythmic. For example, a seizure activity in individuals with epilepsy is represented by the spikes and sharp waves in the brain waves. The vertex waves and sleep spindles are normal transient features that are seen in normal sleep [13].

- Delta refers to the frequency that ranges from 0.5 to 4 Hz. It has waves of the highest in amplitude but is the slowest. It is seen normally in babies and adults in slow wave sleep.
- Theta refers to the frequency that ranges from 4 Hz to 7 Hz. Theta is seen normally in young children.
- Alpha refers to the frequency that ranges from 7 Hz to 14 Hz.
- Beta refers to the frequency that ranges from 15 Hz to about 30 Hz. It is seen usually on both sides in symmetrical distribution and is most evident frontally.
- Gamma refers to the frequency that ranges approximately 30–100 Hz. Gamma rhythms are thought to represent binding of different populations of neurons together into a network for the purpose of carrying out a certain cognitive or motor function [14].

There are types of activities known as normal variants (*e.g.*, mu rhythm) that can be statistically uncommon, however, are not associated with dysfunction or disease. The normal EEG varies by age, wherein adult EEG quite differs from neonatal EEGs. That is, EEG for a child has a generally slower frequency oscillations compared to that of an adult.

3. EEG Measurement of Game User when a Game Plays

This section presents a discussion of EEG measurement process and explains the measurement target and hardware spec. The measurement results are also outlined in this section.

3.1. Measurement target and Hardware spec

The EEG measurement tests for this paper were done for 6 persons, 3 males and 3 females. The three males include one in his twenties, and the other two on their thirties while the female participants include one on her twenties and the other two on their thirties. The EEG of the chosen participants will be tested with the chosen game "POKO PANG" as shown in Figure 3. This game is an application service from NHN Entertainment. It is a smartphone game with a casual puzzle game genre. The game rule is to connect the puzzle pieces to a line and explode to get a high score in 1 minute limited time.

Figure 3. Smartphone Game Contents, POKOPANG

The EEG measurement testing is done through Brain Wave Interface hardware developed by NeroSky from United States of America. The attention and meditation is distributable by this low price device. It utilizes a dry active sensor which is suitable for

unprofessional or professional usage. The mindset analyzes and checks the brain waves in real time by using a Neuro feedback system which contains a technology that helps to change according to the brain wave needs [9].

Figure 4. Mindset

3.2. EEG Measurement Process

The following section describes the EEG measurement process for the 6 participants. During the game play the process for EEG measurement testing, the game user interacts with the game world as indicated in Figure 5. The EEG is measured in real time by the mindset device and transmits the measured data as the game progresses.

Figure 5. EEG Measurement Process

3.3. EEG Signal Measurement Test and Result During Game Play

The obtained EEG measurement data is transformed into a game play EEG as indicated in Figure 6. The EEG raw data is transformed using a Fast Fourier Transform (FFT) algorithm. The acquired brain waves contains numerical values for each frequencies is processed

through the FFT algorithm and transformed into attention and meditation numerical values to obtain the game play EEG.

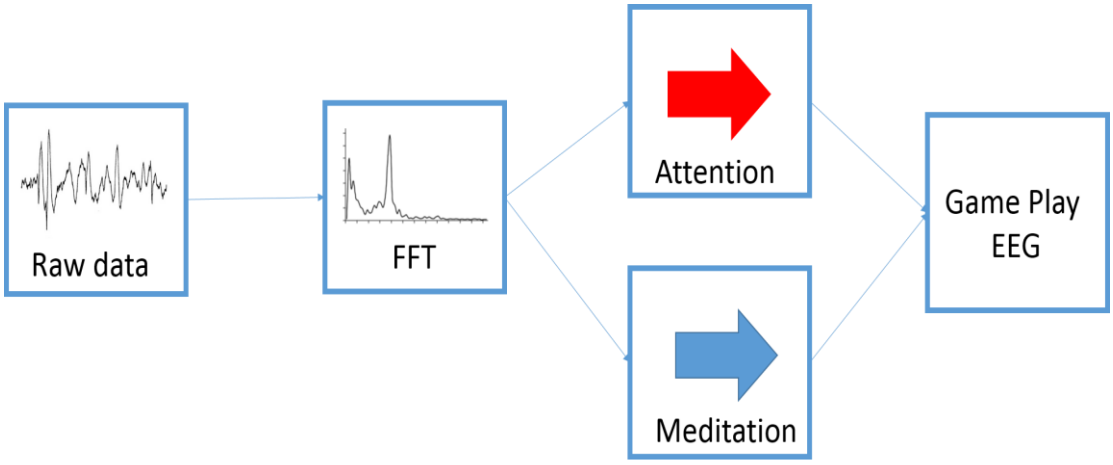
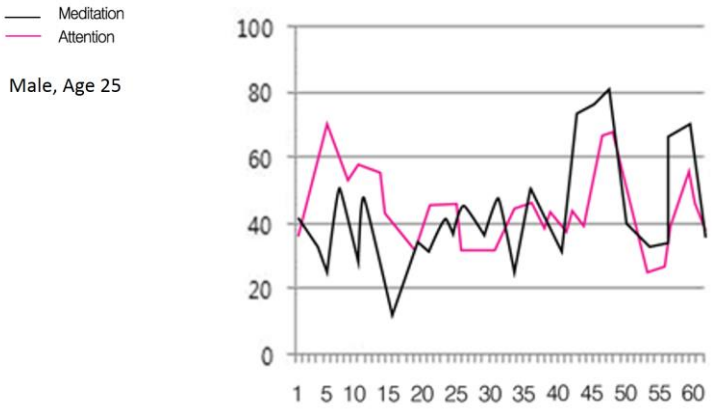
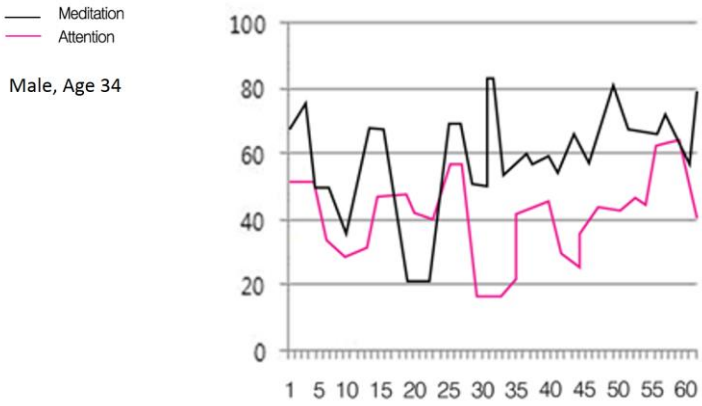
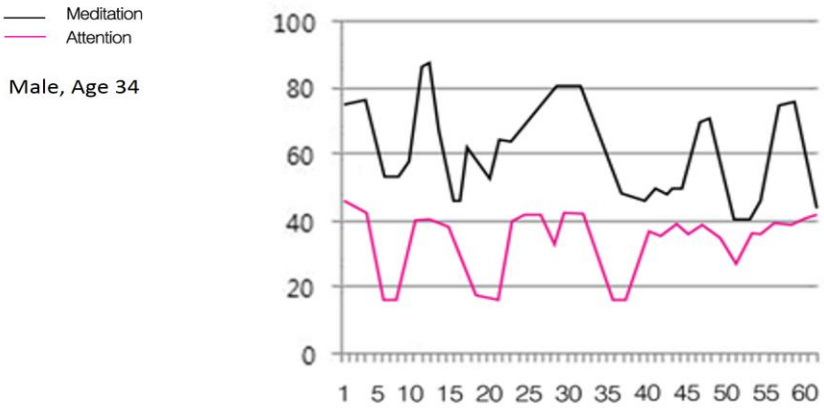
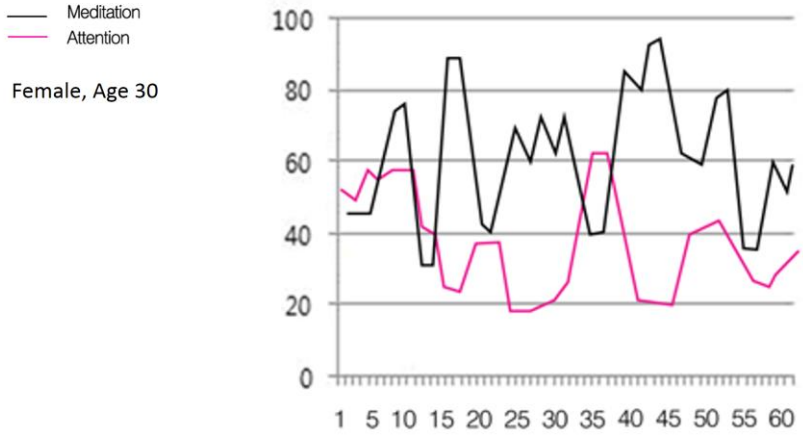


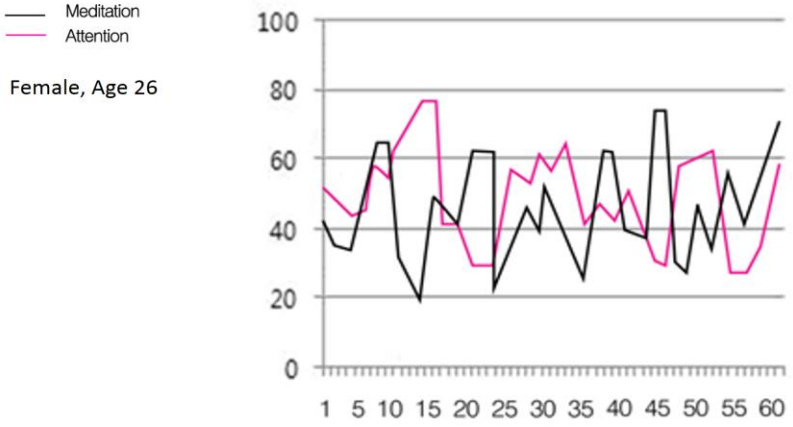
Figure 6. Transformation Process











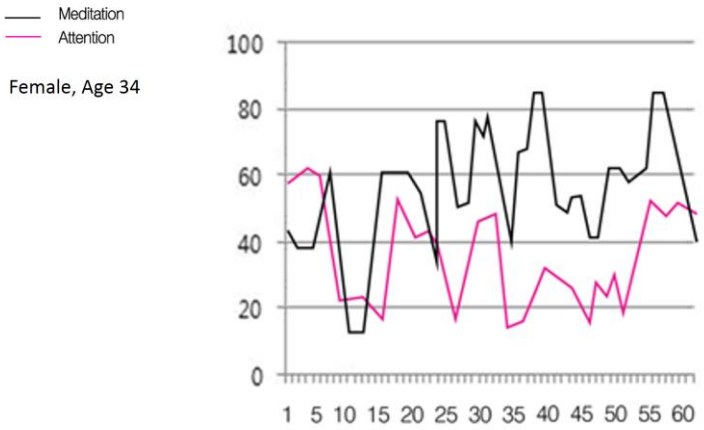


Figure 7. EEG Measurement Transformation Result Game Play

The results for the game play EEG of the six participants are shown in Figure 7. The graphs are shown for each of the game users as indicated in Figure 7. The measurement result of meditation value for both male and female game users are checked with a high value after 40 seconds. It is observed that the meditation average value for female game users is higher compared to that of the male game users. However, the attention value for male game users is higher compared to that of the female game users. This simply shows that female game user's shows more interest during the game play.

4. Conclusions

In this paper, the change of the state for EEG signals of s smartphone game user while playing was measured. The measured EEG data is compared and analyzed for male and female game users to be able to confirm the quantitative results of attention and meditation of the game users while playing a smartphone game. During the game play, the attention state indicates the boredom and tiresome of game users while the meditation state that the game players feel comfortable and enjoys through checking the EEG data. For the future studies, problems for the measuring method while on a game play will be further studied and a test of additional physiological signal will be added to solve the problem widely.

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