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Research Paper

Development of smartphone contents to improve concentration based on EEG

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Abstract

Background/Objectives: In recent years, the importance of concentration has been attracting attention in modern society, and interest in concentration-related diseases is increasing. As ADHD, one of the many diseases associated with concentration, has a great impact on academic and work efficiency and everyday life, so much research is underway on ADHD treatment.
Methods/Statistical analysis: In this research, we implemented smartphone - based concentration training system which is easy to use in everyday life.NeuroNicle E2 of Laxtha Company was used for EEG measurement and EEG was measured by attaching to FP1 and FP2 of the frontal part according to the international 10-12 electrode arrangement method.EEG data received from the measuring section were extracted as frequency - specific EEG data using FFT and the concentration index was calculated by applying the CI algorithm.
Findings: The system implemented in this study can control the aim point with the concentration of the user and perform the concentration training by feedback the changed EEG information to the user according to the movement of the aim point. Also, as the concentration of the user increases, the aim point moves to the center and the score of the game increases.Experiments were conducted using implemented EEG system and commercialization EEG system. EEGs were measured by EEG for 5 minutes each before, during, after training by wearing a wireless measuring instrument. The SMR wave, Mid_β wave, and θ wave which are highly correlated with the concentration are indicated before, during, and after experiment, and it can be confirmed that each waveform has a significant change according to the experiment state. Also, it was confirmed that the concentration was the highest when training using this system and the concentration level was maintained even after the training.
Improvements/Applications: The effectiveness of the system implemented in this research is verified and it can be expected that the user can utilize the portable device instead of the designated place such as the hospital or the professional institution to provide good training results through convenient and continuous concentration training.

Keywords: *EEG; Concentration; ADHD; Neurofeedback; Concentration training.*

1. Introduction

Recently, in the modern society, the importance of concentration has been highlighted, and a lot of researches have been done to solve the lack of concentration and attention deficit phenomenon [1-6]. Attention deficit hyperactivity disorder (ADHD), which is caused by lack of concentration and attention, is known to be a mental disorder that develops mainly in childhood, but it has recently appeared in adults [7]. Especially, as ADHD is raised as a cause of decrease in academic and work ability efficiency, researches on causes and treatments are actively carried out. ADHD is able to alleviate symptoms through continuous learning therapy, and it can be confirmed that continuous neuro-stimulation through neurofeedback training is involved in the pattern of EEG activity and particularly affects the attention part. To improve the symptoms of ADHD, neurofeedback techniques are used to improve the concentration of brain by training the brain. Existing training programs can utilize expensive special equipment or only in designated places and have disadvantages that burden and access are not easy to carry out ongoing training. In this research, we implemented an Android based concentration training content to enable users to easily access using a portable wireless EEG measuring device.

2. Concentration training

The concentration training program implemented in this research is a training program based neurofeedback. Neurofeedback is called 'neuro-feedback' or 'bio-feedback', which is one of behavioral cognitive therapy. This is one of the behavior-based therapies based on the theory that if you get information about the change, the behavior that you want to change is strengthened and the desired change is likely to occur [8].
The training program is merely a tool for verifying changes in the us-
er's brain waves. Successful training is important for continuous tr aining and User's willingness to participate.However, since the self-regulating ability learned through such training is learned by the body, it is known that once it is learned, it can remember and maintain the senses for a long time [9]. EEG information is divided into visual stimuli and auditory stimulus, and the EEG change due to visual stimulation is larger than auditory stimulus. Visual stimuli are divided into word and picture stimuli, affecting the SMR and β waves of EEG during concentration through two stimuli. Also, when using the stimulus of the picture rather than the

word stimulus, the concentration is high [10]. Types of EEG include δ waves measuring sleep state, θ waves measuring distraction, α waves measuring resting state, and β waves measuring concentration and activity state. Table 1 shows form characteristics of frequency.

Table 1: Form Characteristics of Frequency

Frequency type	Frequency range	Form characteristic
δ wave	0.5 ~ 4Hz	sleepstate
θ wave	4 ~ 8Hz	drowsiness and distractionstate
α wave	8 ~ 12Hz	reststate
β wave	12 ~ 18˜Hz	concentration, activity, tension, excitementstate

3. System configuration

In this research, we implemented smartphone - based concentration training system which is easy to use in everyday life. NeuroNicle E2 of Laxtha Company was used for EEG measurement and EEG was measured by attaching to FP1 and FP2 of the frontal part according to the international 10-12 electrode arrangement method. EEG data received from the measuring section were extracted as frequency - specific EEG data using FFT and the concentration index was calculated by applying the CI algorithm. Figure 1 shows international 10-12 electrode placement and EEG measurement equipment and Figure 2 shows system configuration.

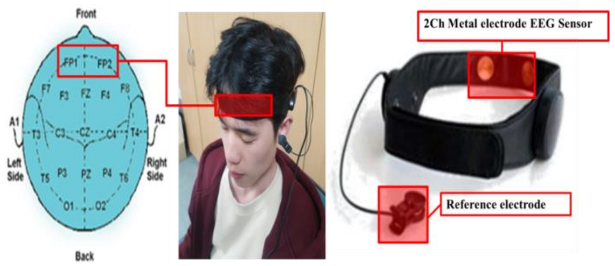

Fig. 1: International 10-12 Electrode Placement and EEG Measurement Equipment.

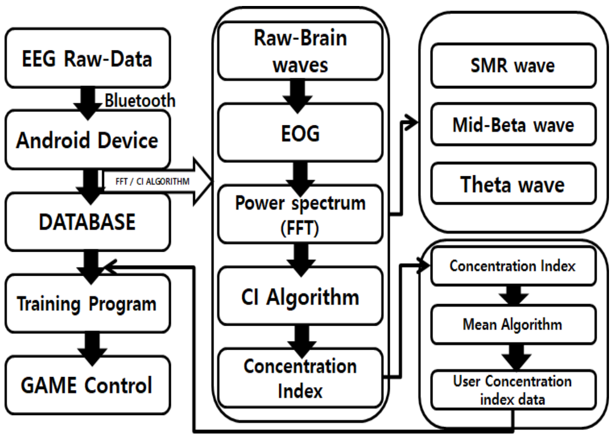

Fig. 2: System Configuration.

3.1. Calculation of concentration index

Equation 1 was applied to derive the concentration value from EEG data. Equation 1 is an equation for comparing changes in the low-frequency and high-frequency bands in the concentrated state. In the case of δ waves, the frequency of noise due to eye and body movements is high and the reliability of data is low. Therefore, in this research θ wave in the low frequency band and β wave in the high frequency band were used.In addition, the β waves were subdivided into SMR waves, Mid_β waves, High_β waves. Among them, SMR waves and Mid_β waves were used as an analysis factor in the concentration calculation.

$$\text{Concentration Index} = \frac{\text{SMR+Mid}\beta}{\theta} \quad (1)$$

There is a deviation of the individual EEG data and in order to apply it, it is possible to apply the value of concentration according to the user by using the database. In order to apply the individual EEG deviation, the equation used in this research is shown in Equation 2.

$$\overline{X} = \sum_{i=1}^{n} X_i / n \quad (2)$$

4. Experiments and results

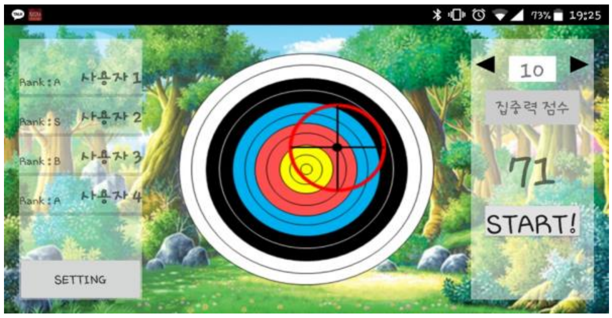

Fig. 3: Concentration Training Program.

As shown in figure 3, the system implemented in this study can control the aim point with the concentration of the user and perform the concentration training by feedback the changed EEG information to the user according to the movement of the aim point. Also, as the concentration of the user increases, the aim point moves to the center and the score of the game increases. Experiments were conducted using implemented EEG system and commercialization EEG system. EEGs were measured by EEG for 5 minutes each before, during, after training by wearing a wireless measuring instrument. Also, in this research, it can be seen that the concentration is changed intuitively through the CI algorithm used to calculate the concentration value. In order to derive the concentration value, mean value of SMR wave, Mid_β wave, and θ wave was calculated before, during, and after the experiment by applying $\frac{\text{SMR+Mid}\beta}{\theta} \times 100$to the existing CI algorithm.

Table 2: Comparison of Concentration by Experiment before, Doing, After Status

Object		SMR	Mid β	θ	CI
	Before	1.790	1.983	5.098	0.740
A	During	1.889	2.114	4.435	0.902
	After	1.850	2.073	4.722	0.822
	Before	1.801	1.987	5.004	0.756
B	During	1.973	2.181	4.812	0.863
	After	1.918	2.119	4.947	0.816
	Before	1.718	1.939	5.106	0.716
C	During	1.769	2.088	4.343	0.888
	After	1.732	1.971	4.751	0.779
	Before	1.734	1.937	4.933	0.744
D	During	1.853	2.054	4.415	0.884
	After	1.779	1.973	4.792	0.782
	Before	1.392	1.545	4.635	0.633
E	during	1.510	1.703	4.135	0.777
	After	1.457	1.661	4.372	0.713

Table 2 compares changes in concentration before, during and after the experiment. The SMR wave, Mid_β wave, and θ wave which are highly correlated with the concentration are indicated before, during, and after experiment, and it can be confirmed that each waveform has a significant change according to the experiment state. Also, it was confirmed that the concentration was the highest when training using this system and the concentration level was maintained even after the training.

5. Conclusion

In this research, we implemented smartphone - based concentration training system which is easy to use in everyday life. As a result of continuing training through improvement of concentration and content, I was able to confirm that concentration is improved from before training. In case of using this, it is thought that users can utilize mobile devices which are not specified places such as hospitals and professional organizations, and the user can achieve good training results through more convenient and continuous concentration training. In future studies, it is necessary to improve the algorithm to reduce the motion noise and individual EEG deviation in EEG measurement. Also, it is necessary to continuously study the CI algorithm used to derive the concentration value.

Acknowledgment

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