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Increasing Concentration with Neurofeedback

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***Abstract*— Bio-signals as electroencephalography (EEG) has been studied extensively in clinical and cognitive neurosciences. Recently, neurofeedback(NFB) is discussed as a type of biofeedback that measures brain waves(EEG) to produce a signal that can be used as feedback to teach self-regulation(self-control) of brain function. The neurofeedback has drawn much attention as a self-control training for children with developmental disorder who show several body disorders, attention deficit and attention deficit-hyperactivity disorder (ADHD). In this paper, first, the neurofeedback studies for the ADHD are surveyed. Neurofeedback is commonly provided using video or sound. Second, the neurofeedback is studied from the human-computer interaction. We experimented by using several animation videos to make relaxed states in the brain.**

Keywords—neurofeedback ; electroencephalography (EEG); attention deficit ; attention deficit-hyperactivity disorder (ADHD)

I. INTRODUCTION

Recently, studies using electroencephalography (EEG) to solve various problems of clinical and cognitive neurosciences have been carried out. With this trend, the neurofeedback (NFB) that is a biofeedback using brain activities has drawn much attention as a self-control training for children with developmental disorder who show several body disorders, attention deficit and attention deficit-hyperactivity disorder (ADHD).

Actually, studies of neurofeedback in a mentally handicapped person is applied by wide range such as Parkinson's disease, insomnia depression, personality obstacle and integration incontinentia as well as epilepsy and a drug dependence.

For example, the neurofeedback using the low resolution electromaganetic tomography (LORETA) that measures the strength of signal of the specific territory in the brain from multi channel brain waves is applied to an antisocial personality disorder person[1]. It's reported that there were improvements judged by the score of the psychology and the behavior index such as quantitative electroencephalography (QEEG).

Neurofeedback was applied by Ruiiz, Lee, et al.[2] using the strength of fMRI signal to schizophrenia patients. It is reported that this method activated prefrontal cortex and contributed to improve self-control, recognition of feeling such as hatred or happiness.In this neurofeedback study, it is aimed to improve the intellectual function and problem behaviors by controlling a cerebral function while a subject monitors his/her brain waves by own.

In this paper, first, the neurofeedback that targets ADHD study is surveyed and the future possibility of the relationship between tension and neurofeedback is described. These developed studies are based on the clinical field of experiments and their methods. Second, from the point of human-computer interaction, another effective possibility for the neurofeedback training will be suggested. We tried to make an effective animation video from the point of human-computer interaction. As the preliminary study, we performed experiments to show what kind of change of EEG can be observed under the animation video's conditions. We showed the subjects different animation videos, which are compared in the brain evoked potentials. Then, we measured the EEG characteristics before watching video and after watching it to make the relaxed states in the brain.

II. NEWROFEEDBACK AND DEVELOPMENTAL DISORDER

ADHD is studied for quite a long time. Neurofeedback was introduced [3] using EEG to the child of hyperactivity disorder. One of the back ground that neurofeedback turned

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out is it was found that to be able to change the pattern of the brain waves consciously .

Many ADHD children take the neurofeedback training lately. Some application examples of NFB to developmental disorder besides ADHD such as autism spectrum are also reported. Since putting it in ADHD, β training mainly using brain waves and sensory motor rhythm (SMR) training are applied to ADHD. The trials to reduce θ band ingredients and increase β band ingredient compared with a person without handicaps at the time of execution of a problem requiring attention and concentration[4].

When tension was eased moderately, cpm (cycles per minute) in SMR band was observed clearly. It becomes possible to control movement freely in such case. This method has been tried for the purpose of decreasing impulsivity[5].

Inspection of the effect of neurofeedback targeting ADHD children is also developed. For example, the experiment that assigned 102 of 8 to 12-year-old ADHD children to the NFB group (θ/β training, SCP training) or the control group (attention skill training: AST) at random[5]. It is reported that some improvement is shown in both groups in the behavior value of parents and teachers.

When the follow-up investigation was done 6 months later in the study[6], the behavior evaluation of parents with NFB group was higher than AST group and its effect was maintained. Then Wangler et al [6] considers the neurophysiology correlate that the increase of contingent negative variation (CNV) is related to the improvement of ADHD in slow brain wave training(SCP).

NFB is applied to various body and mental disorders and developmental disorders, and its effect has become clear. The more highly precise of effects is being considered by large-scale and randomized studies aimed to ADHD children as the subjects. On the other hand, almost no subjective side of the effects is referred. If this method is actually applied clinically, a measure to understand the changing of self-control feeling gained on the process of the training and support the motivated situations would be needed.

In this study, the subjective change of emotional tensions from introspection reports is considered along with viewing the training effects of neurofeedback from psychological, behavior and neurophysiology indicators. It is confirmed that NFB is effective to normal developing people as well as ADHD patients[7]. Therefore, neurofeedback and SMR training is carried on to adults who can make This study So I look into my own thought by this research, the adult it'll be possible to introspection reports, then the clues of subjective change was considered.

A. Electroencephalography; EEG

Electroencephalography is one index of the information processing process of a human. When a nerve cell in the brain is fired or a synapse does a neurotransmission, an electronic signal forms. For this biomedical signal is shown as an electric potential change in the brain, it's possible to record using poles put on the scalp. This is called electroencephalography (EEG). EEG is classified into 6 kinds from the size of the frequency, and the roles are different.

Table 1. Brain potential waves of EEG

Type	Measurable data	Mental state
δwave	1～4Hz	Sleep state
θwave	4～8Hz	Drowsiness and contemplate
αwave	8～12Hz	Relax and eye-opening
SMRwave	12～16Hz	Ideal concentration
βwave	13～30Hz	Concentration and stressed
γwave	30～Hz	Anxiety tension and Complicated information processing

These frequencies can be found each power spectrum by doing Fourier analysis the obtained original EEG data.

But there are big individual differences in EEG and a relation between EEG and the thought situation changes by time even with the same person. It is not the simple definition that the subject relaxes when α wave can be observed as generally speaking.

Therefore it is necessary to pile measurement and compare EEG in the various situations of every individual many times. The important thing to understand EEG is the role of each part of the cerebral cortex is totally different. For example, the right brain and the left brain have totally different roles even they are in the same prefrontal area. The left brain controls logical thought and the right brain creative and social thoughts negative thought or illogical, delusion and negative thoughts.

In other words, when understanding the active state of the cerebral cortex from EEG, it is important to know that it is differ from on which parts the data is measured. For example, when a lot of β wave comes from the left brain, it is considered that the thinking activity is active. When β wave come too much, it is assumed that the subject thinks unnecessary things.

B. θ wave

Some resent researches show that θ wave is effective to improve creative thoughts and memory. And it is expected to use θ wave to learning and working situations.

θ wave is different from α wave and β wave and it rises when hippocampus functions is active. Hippocampus is the part in the cerebral center. When doing the mental work for which short-term memory is used aggressively, a lot of θ wave from hippocampus is produced, and that shows as brain waves.

It is necessary that θ wav is suppressed before works to make it increased because the width of the fluctuation is important. It seems possible to put the brain in the deep meditation state that occurs when suppressed θ wave is released at once. In the next section, the following mechanism to suppress the θ wave is referenced [8] .

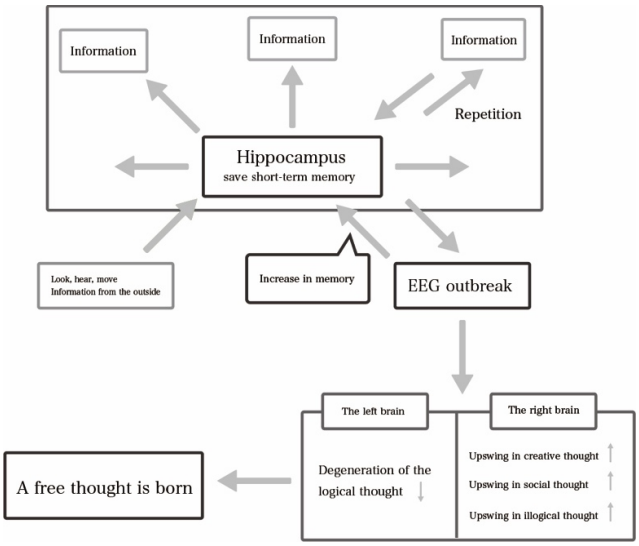

Fig. 1. About θ wave

III. EXTREME TENSION TO SUPPRESS Θ WAVE

Tension is adopted as the way to suppress θ wave in this study. The tension state is observed from various viewpoints, and the mechanism of occurring tension and the physical change are also considered.

A. Mechanism of tension

First, it is considered what kinds of physical changes occur when someone feels tension. When someone feels tension, an amygdala senses danger and sends an order to the brain. Then muscle of the whole body is activated and the heart rate rises. And at the same time, the blood vessels shrink and the surface temperature of the body falls to make oxygen spread over the whole body. When a person gets a stress from tension, cortisol included in the blood and saliva rises and stress hormone is secreted. Cortisol is one of the steroid hormones that is produced in the adrenal cortex and it reacts to a stress and hypoglycemia to be secreted. If secretion of cortisol is not temporally and it becomes high and low chronically, there is danger that affects a human body.

For the blood vessels shrink when the heart rate rises, it is necessary to send oxygen to the cell in the area with less blood vessels especially. Therefore the body temperature falls. That is the reason why the body temperature falls when a person feels fear. This is defined as the mechanism of tension.

IV. METHOD FOR MEASUREMENT OF EEG

The purpose of this study is to investigate the way to increase the concentration using neurofeedback to overcome such phobia.

A. Neurofeedback system using BrainPro

Brain-Pro FM-929 and Pullux Pro made by FUTEK Inc. [9] were used to measure α wave in this research. These equipments can measure frequency in 3.0Hz-30Hz, and it's possible to record data every 0.5 second. The semaphore measured by Brain-Pro FM-929 and Pullux Pro is forwarded to a PC. Then fluctuations are picked out by the multiple resolutions with scatter wavelet transformation in real time. Fluctuations of the cycle were picked out to remove noise of the measurement instruments and influence of heartbeats and breathing.

Fig. 2. Measurement photograph in the experiment

B. Measurment of data

In this study, 30 patterns of animations including ones as shown in Figure 3 were presented to aim to increase α wave that indicates relaxing earlier than the usual. Then 9 patterns of the animations show that the change of EEG was larger , and the experiment was carried out to consider how EEG changes. In addition, the 9 animations are based on the RGB colors including black and white. The circle or the square patterns in the animation as in Figure 4 rotates clockwise in the center. Further, the square is expand with its rotation. Thus the fundamental dynamic patterns in each animation are made during 5 seconds. The 5 seconds pattern is iterated for 300 seconds in the one experiment. It is considered which condition increases α wave earliest. The subjects are 20-year-old healthy ones (8 males and 5 females), who watch the animation video on the monitor as shown in Figure 3. When

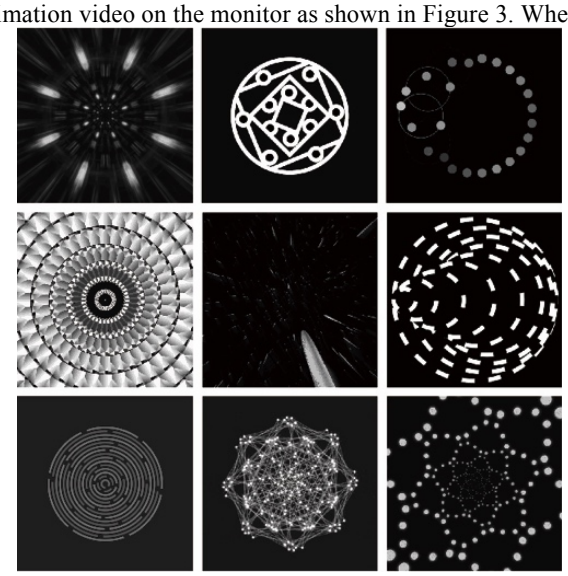

Fig. 3. Types of animations

detecting more than 10 μV of EGG potentials, it is determined as the relaxed state in this study. We considered how much the time to reach to the relaxed state is shortened comparing before and after watching the animation movies and which movie or which color influence to the EEG potentials the most. Brain - Pro (FM-929) and Pullux F are used as measuring instruments[9].

C. Experimental results

In this experiment, the animation movie indicated in Figure 5 showed the best high potential value. The charts indicated in Figure 6 shows EEG measured before watching movie. Figure 6 is considered to be the controlled state in the experiment, without any stimulus of movie or sound which we call here normal time in Figure 6. In Figure 6, the horizontal axis indicates time in seconds, while the vertical axis shows the EEG potentials in μV. The 10μV line is indicated in the upper part in Figure 6, which shows the reference potentials to estimate relaxed state. The EEG does not exceed 10 μV in the time interval, 300 seconds and it show relatively lower value as indicated in Figure 6. But when subjects watch the movies colored in red, blue or green as Figure 7, the EEG exceeds 10 μV in the time interval, 300 seconds and it is higher on average (Table 3). The 10μV line is also indicated in the upper part in Figure 7 and Figure 8. The EEG also exceeds 10 μV in the time interval, 300 seconds by the monochrome movie as shown in Figure 8 and it is quite higher value on average in Table 3.

Comparing before and after watching the movie, α wave occurs most frequently and it was detected much after watching movie than before watching it. When the movies colored in red, blue and green in Figure 7 and the monochrome one in Figure 8 are compared, a lot of α waves were more often detected in the monochrome movie in Figure 8. Then, subjects could relax earlier than without watching the movie. From these experimental results, α wave will be produced more often when a person watches the movie and it is possible to affect subconsciousness by controlling EEG.

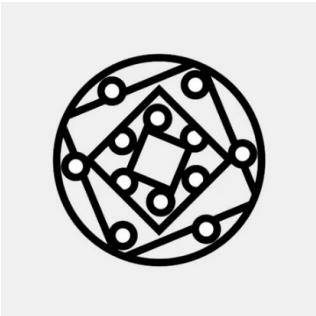

Fig. 4. The animation which makes the most relaxed state

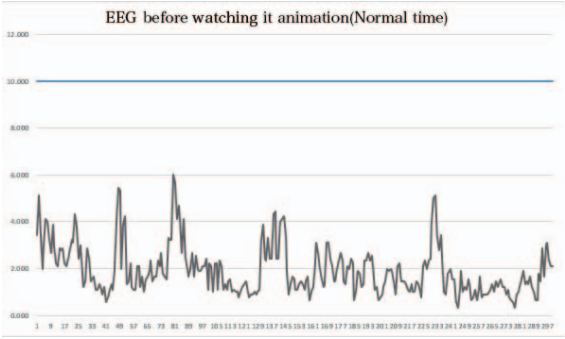

Fig. 5. EEG before watching animation (normal time)

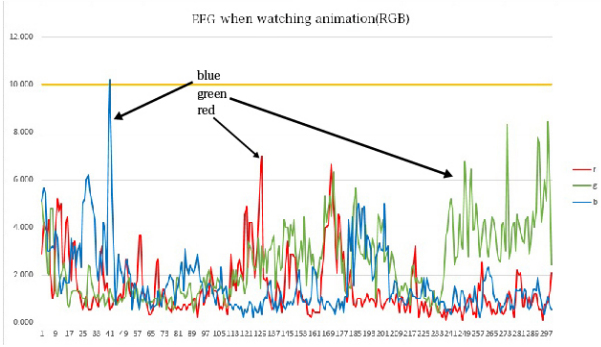

Fig. 6. EEG while watching animation (RGB)

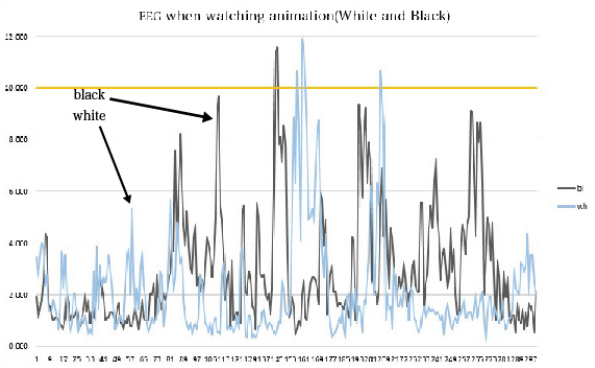

Fig. 7. EEG while watching animation (White and Black)

Table 2. Comparison of average potential values (Best)

Color	Average	Color	Average
Normal	1.9429	Green	2.5022
Red	1.4756	White	2.1393
Blue	1.7104	Black	2.9382

Fig. 8. The animation which makes the second relaxed state

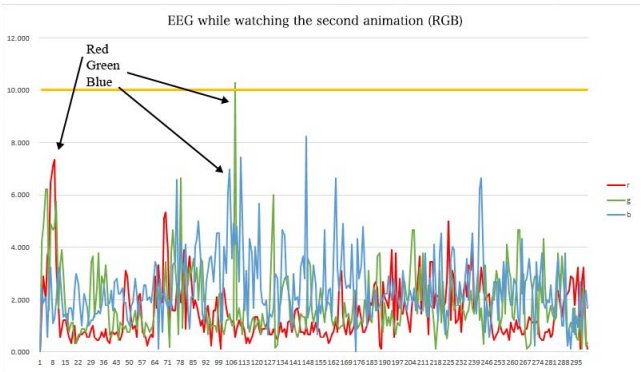

Fig. 9. EEG while watching animation (RGB)

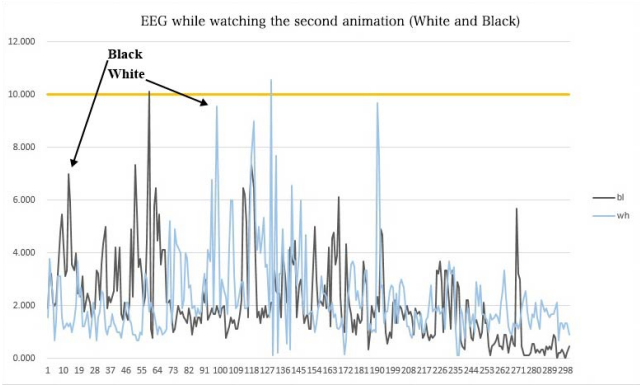

Fig. 10. EEG while watching animation (White and Black)

Table 3. Comparison of average potential values(2nd better)

Color	Average	Color	Average
Red	1.5179	White	2.2674
Blue	2.4438	Black	2.1556
Green	1.8957		

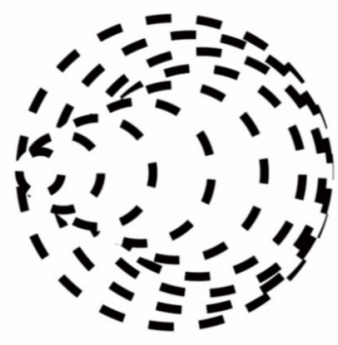

Fig. 11. The animation which makes the worst relaxed state

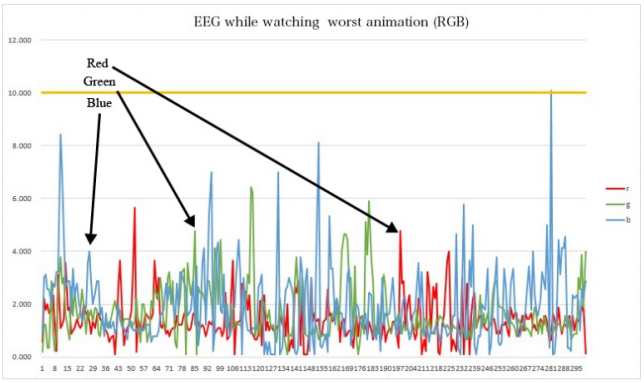

Fig. 12. EEG while watching animation (RGB)

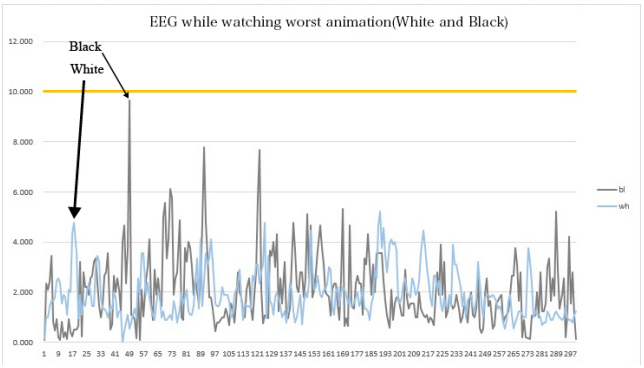

Fig. 13. EEG while watching animation (White and Black)

Table 4. Comparison of average potential values(worst)

Color	Average	Color	Average
Red	1.3862	White	1.8750
Blue	1.9685	Black	2.0628
Green	1.6739		

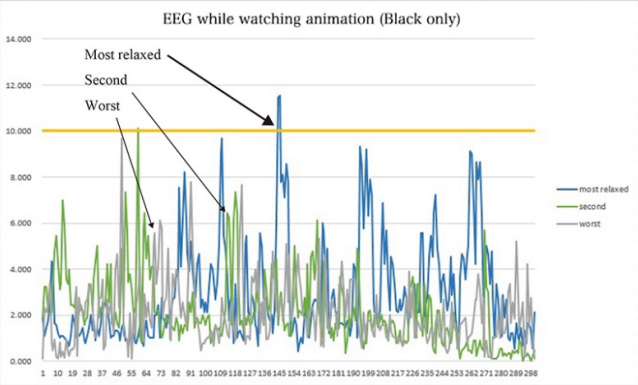

Fig. 14. EEG while watching animation (Black Only)

In Figure 9 and Figure 10, the EEGs are shown which are evoked by the animation in Figure 8. The average potential values are shown in Table 3. From these results, the stimulus of the animation will cause the EEG to be relaxed state secondary in the porder of thye stimulus by comparing with the animation stimulus in Fig.4. So, we call here the second better to the stimulus animation in Figure 8. As case of the respose of the evoked EEG shows relatively lower value, the animation stimulus in Figure 11, was experimented. In Figure 12 and Figure 13, the evoked EEGs are shown which are lower values. So, we call here the worst in the stimulus. These evoked EEG values among the stimulus in Figures 4 , 8 and 11 are compare in the black stimulus case. Then, the evoked potentials of EEG are shown in the order Figure 4, Figure 8 and Figure 11. Figure 14 shows black animation video causes the higher evoked potentials. From these experiments, the symmetric figures in the animation will produce the higher values of the evoke EEG with the relaxed α waves.

D. Consideration

The result of this research can be applied to the patients of depression or ADHD. There are only 9 animations now, so it is necessary to carry out more experiments to make more effective animations.

V. Future issues of Newrofeedback

Neurofeedback using an animation is studied as an effective method in the neurofeedback research. It is necessary to pile up the evidences of its therapeutic effects to let neurofeedback using an animation be admitted widely as one of the treatment methods. But many problems are left to consider the therapeutic effect of neurofeedback. It is necessary to collect more data by gathering more subjects that cooperate in experiments to indicate the result that can be trusted. There are many variations exist in new feedback, and to unify the way isn't unified. There is a lot of existing neurofeedback, because various researchers dealt with neurofeedback study and developed it from each different interest and have developed it for each purpose. The point is that it is difficult to collect evidence of the therapeutic effect.

When making a plan of neurofeedback study, it is necessary to decide what to make the target first. Another approach will be important to make clear the neurofeedback of the brain. It will be useful to study what kind of the animation will be effective from the human-computer interaction.

VI. Conclusion

Neurofeedback study was surveyed as a possibility of the new treatment to ADHD. The disease for which neurofeedback would have the therapeutic effect is few now, but it is confirmed it has effect not only ADHD that is one of the behavior disorder, but also the mental disorder such as depression or the body symptom such as pain. A common point of these diseases is to concern cerebral dysfunction. Therefore it is considered that neurofeedback can be used to the disorders concerned with cerebral dysfunction even if the therapeutic effect is not confirmed. In this paper, we tried to study the neurofeedback from the point of the human-computer interaction as an another approach. We conducted a experiment to make clear the relationship between tension and neurofeedback, in which several animations with or without colors are shown for making relaxed states of the brain.

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