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Integrating Electroencephalogram Analysis for Improving Mental Condition in Physical Skill Learning

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Abstract: In this paper, we propose a supporting system for a learner to develop a motor-skill. This study focuses on an electroencephalograph during physical skill performance. There are close relations between brain wave and psychological condition. It is our beliefs that identifying the strong relation between brain waves and the physical motion leads new approach to support learning motor-skill. The purpose of this study is to make the ideal psychological condition by the mental support according to runner's psychological condition

Keywords: Motor skill, skill development, running support, mental support, brain wave.

1. Introduction

1.1 Background

We focus on running as a primary target of developing motor-skill by this study. A lot of people currently pay attention to running because it is an easy exercise that can be carried out alone [1]. The population of both regularly and temporal runners are increasing. It is because the advantage of running are eliminating lack of exercise and avoiding metabolic syndrome. Further, it is easy, low cost and having a lot of race-events. However, many runners sometimes tend to dropout. The expected reasons why to dropout are injury, seasonal estrangement and decreased motivation.

The people who are civil runners seldom take professional lectures on running. Therefore, educational support for such runners is important. In considering the approach, we take into account of the different approaches of supporting type. There are two major types; physical support and mental support. Both supports are important for runners [2]. Many previous studies are based on the physical support for sports at real time. However, real-time mental support is rarely seen. We believe the mental training in sports is important. Running

performance and mental state are closely related. In other words, running of high performance is created ideal mental state [3].

1.2 Purpose

The purpose of this study is to support runners who want to improve their running conditions efficiency and continuousness. One of the methods for detecting mental state is to monitor brain wave. Several tools to capture the brain wave are published. We adopt "*BrainAthlete*" to measure the brain state. With this device, the system is able to monitor the information of brain at real-time. The brain state of a runner is estimated for 15 seconds in every 5 minutes. With psychological design of a runner after the measurement, the system provides the feedback of the mental information. The feedback can cause with early-expression, maintain, re-expression of the runner's-high that is favorable psychological state.

2. Integrating Brain Wave

2.1 Brain wave

Brain wave shows potential change from electrode on the scalp. Those data are shown by line-chart. Horizontal-axis of the chart is time line. Vertical-axis indicates the potential change. Brain wave is detected potential change from cortex to extensive cortex. Brain wave takes the integral from cortex and distant point (e.g. Ear)
Brain wave is classified into Alpha wave, Beta wave, Theta wave, and so on (see Table 1). These waves can be divided and captured at the same time because of the different frequency. Cerebrum is always processing much information intricately. When the brain is working normally, potential of neuron is scattering. Thus, the brain shows beta wave. The potential of neuron is synchronized with other one in rough when the brain is non-active. Thus, the brain shows Alpha wave [4]. Activity of brain is understood by watching brain wave. Additionally, psychological state is estimated from activities of the brain.

Table1 The brain wave states

Brain wave	Frequency	Feature
Delta	0.5~4Hz	Deep sleep
Theta	4~8Hz	Shallow sleep
Alpha	8~13Hz	Memory, Learning, Stress reduction
Beta	13~40Hz	Focus, Concentration, Energy, Excitement, Attention
Gamma	30Hz	Angry State

2.2 The relationship between sports and psychology

To keep high state in mental condition is important for high performance of running. As mentioned before, the physical state and psychological one in sports are closely related [5][6]. The types of mental training for athlete are attention and meditation.
There are many kinds of mental training that is reported and regarded as an effective method for performance. However, most of the evaluation of effect of mental training is subjectivity. The problem is that evaluation always performed with less objectivity [4]. Therefore, it is important to integrate brain wave for the detection so as to evaluate the mental state objectively.

2.3 Runner's High

Repetitive motion like running will cause pleasant emotional states when a runner runs more than a certain time. A publicized effect of endorphin production is so-called "runner's high". This phenomenon is occurred by excreting a lot of endorphin in the brain. The endorphin cause analgesic effect and enhanced mood. Hence, a runner can train without emotional distress. If a runner can control the condition, it may lead to the better performance.

3. Tool

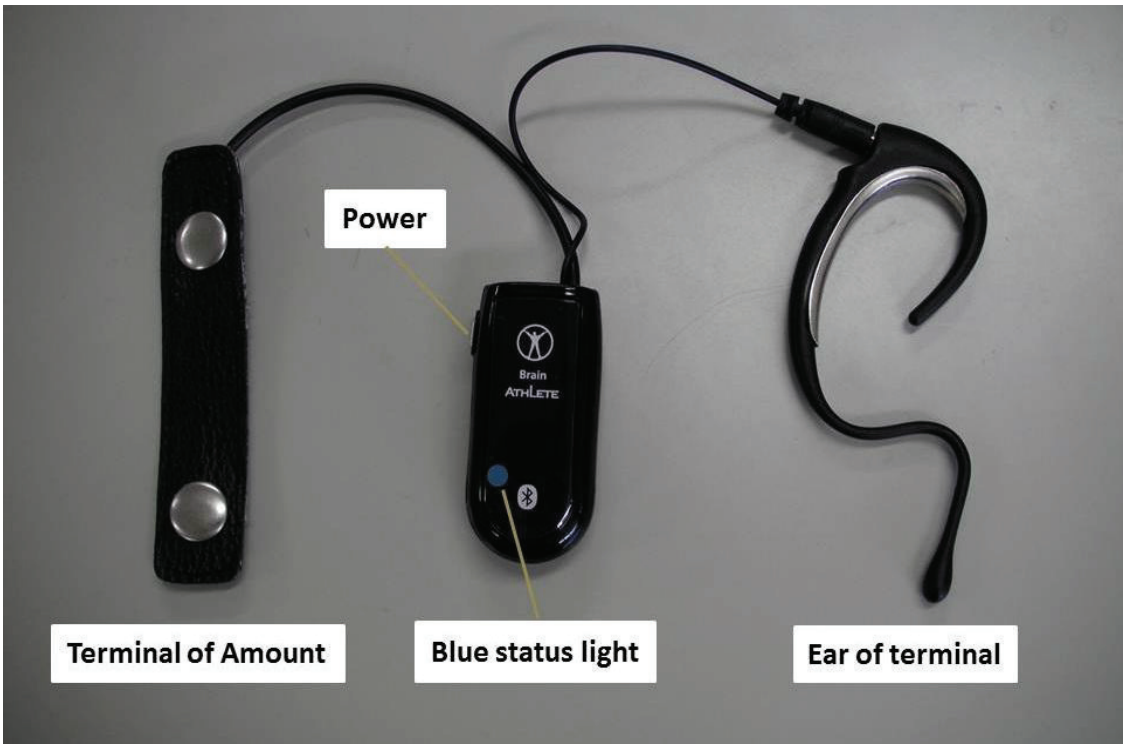

Figure 1 Sensing device in BrainAthlete

3.1 Module

3.1.1 BrainAthlete

BrainAthlete is the device that measures the brain wave (see Figure 1). This computes and determine attention and mediation from the brain wave based on the unique algorithm (this is called eSence). These values show the psychological state. It can be measured without obstruction of running. We can wear at a sun visor because this device is very small and lightweight.

3.1.2 Noise Filtering

Brain wave is very faint signal that is normally microvolt. Therefore, measurement result is sometimes affected by noise. Electroencephalogram is needed noise filtering to eliminate the interfere noise.

BrainAthlete eliminates the noise by using hardware and software filtering. The system removes bio-signal that is non-brain wave. The software on the device is able to output the wave in graphic representation at real-time during these process.
The device sends data on Bluetooth communication. If the distance between the sender and the receiver is less than guaranteed distance, Bluetooth can send data without being affected by angle. Therefore, it is easily measured in indoors and outdoors.

3.1.3 Conversion

BrainAthlete analyzes the brain wave by using unique algorithm called eSense. The brain wave is a complex data that is understood by only specialist. Therefore, eSense can convert from the raw data into two aspects as attention and mediation in order to be understood by non-specialist. These data is given from 0 to 100 of relative values. It shows relax and concentrating status that are important index values for sports. Besides, these values can be monitored without regarding the scene. Accordingly, this device is fitted one for our system. The device consists of smart shape because the process and analysis of the brain wave is mounted on only one module.

3.1.4 Appearance

The body of the sensing device is set on a sun visor and the relative-grand position is located at ear. The measurement of the brain wave and the sending of the data are realized by only these devices. Therefore, the runner does not mind deeply about wearing it. It is a basic advantage of this device.

3.2 Output Attention and Meditation

The device outputs the attention and meditation from measurement data. These data are output from 0 to 100 in real-time. Figure 1, 2 show the experimental result of output pattern. Red line shows attention, green line shows mediation. The horizontal line shows time. The vertical line shows the score of each data.

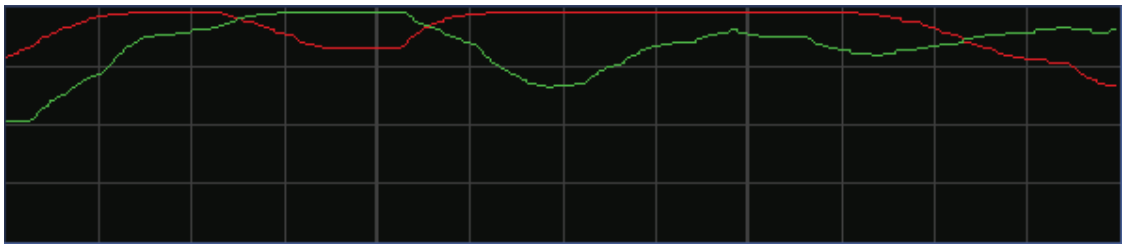

Figure 2 Sample of concentration

When the examinee is concentrating, the attention always shows high values such as from 70 to 90. The mediation also shows high value. Judging from the data, it can be confirmed that the examinee is concentrating (See Figure 2).

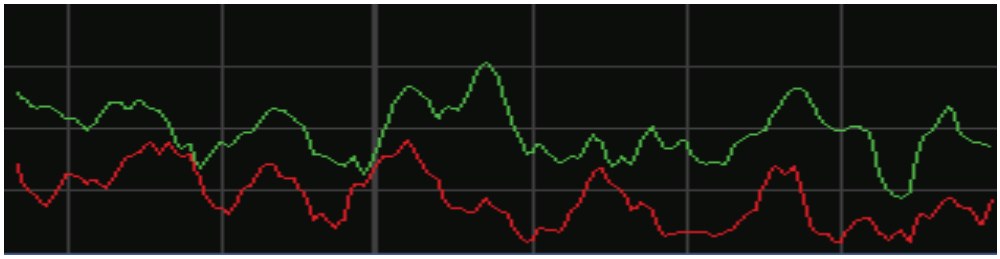

Figure 3 Sample in reading a book

When the examinee is reading (See Figure 3), the attention and the mediation oscillate in a chaotic pattern for instance. The average of the mediation is about 50. It is monitored that the attention is lowered at the same time as flipping the page. It is assumed that the examinee have a lapse of concentration when one flip the page.

3.3 Usefulness

Electroencephalogram measurement experiment uses flash mental arithmetic. Because, we want to demonstrate the usefulness as an index of BrainAthlete. From this experiment, measured characteristic data were similar between subjects in flash mental arithmetic. Thus, we demonstrated the usefulness as an index of BrainAthlete.

3.3.1 Flow

The number of subjects is four at this time. Subjects solve flash mental arithmetic on PC during measuring the brain waves. Subjects wait 5 seconds until the next issue after the answer. The flash mental arithmetic is going up difficulty according to solving the question. Subjects will end the measurement, when they mistake.

3.3.2 Experimental result

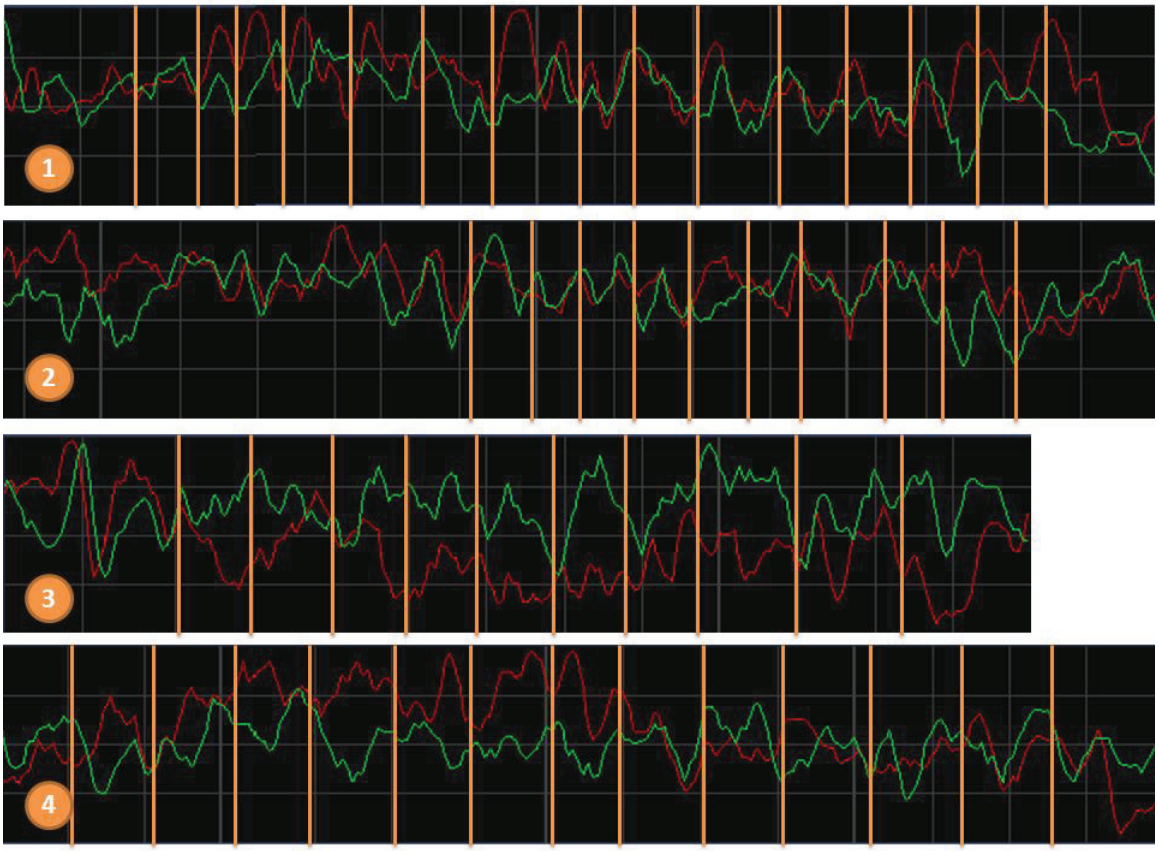

Figure 4 An experimental graph

The red line indicates *Attention*. The green line is for *Meditation*. Both lines are represented in a same graph (Figure 4). The vertical bar is the time that started to solve the question. When subjects start to solve the question, Attention raises sharply, then descent after the

answer. This pattern appeared frequently. At first, Attention had to rise from begin the question. However, when the difficulty in question goes up, just before beginning the question, the rise of Attention appears notably.

4. Implementation

4.1 Flow

In this study, our purpose is to support to the runner by using electroencephalogram and feedback on time. At first, the runner runs 30 minutes by using treadmill. The runner using BrainAthelete for electroencephalogram. Next, the runner slows down speed of running equally walking speed when after the 5 minutes. The runner kept shaking head as much as possible. The measurer measure the electroencephalogram while 15 seconds. If the measurer finishes measurement, the runner begins running. The measurer feed back to the runner by using electroencephalogram. These repeat every 5 minutes that are running, slowdown, measurement, acceleration, feedback.

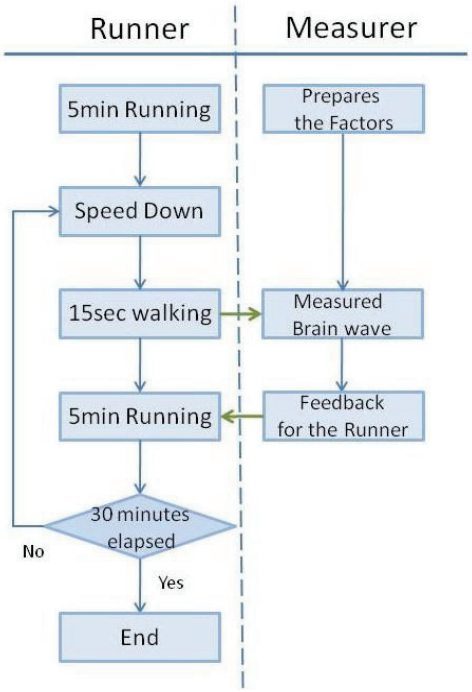

Figure 5 The process of supporting skill-development

To measure brain waves may then runner is stop. But, it is difficult, the runner stops to take brain wave like the running. Because, runner was calm heartbeat and respiration. If the measurer measure the electroencephalogram, the runner walk while keep shaking head as much as possible. There by, measurer can get low-noise electroencephalogram and similar to the electroencephalogram during running.

The measurer provides feedback for the runner by using electroencephalogram that was measured. The runner can get continue and re-emergence of runner's high. Thereby, the runner was sported of mental.

4.2 3×3 Thresholding

The measured brain waves are output as attention and meditation. These are represented by the value from 0 to 100. In this study, we define the 3 scope of attention and meditation.

Thereby, psychology is estimated of runner. Attention and meditation done in this area divided. Then, psychological state of the runner is divided into 9 states. The measurer provides feedback for the runner by using them.

4.3 Feedback

The measurer provides feedback for the runner by using the measured brain wave. Thereby, the runner was inspired to appear, continue and re-emergence of runner's high. The feedback approach is to encourage 5 sensory. There, the measurer prepares the factors to encourage for 5 sensory in advance (Table 2). These are factors that runner can relax or exit. Therefore, the runner is changed to ideal psychology by using them.

Table 2 Sensory organ and approach

Sensory organ	Approach
Vision	Projector, Monitor, etc...
Hearing	BGM, Natural sound, etc...
Smell	Perfume, Aroma, Incense, etc...
Taste	Candy, Drinking water, Cigarette, etc...
Touch	Temperature adjustment, Air Conditioning, etc...

5. Summary

This paper provided problems in running and the importance of mental support. we proposed solution of them.
Section 2 explained the relationship between brain wave and mental status. It explained the suitability of the brain wave in mental support.
Section 3 explained BrainATHLETE that is electroencephalogram measurement.
Section 4 explained this support system's flow, threshold value and feedback.

Acknowledgements

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References

[1] Gotoda, N., Matsuura, K., Hirano, T., Tanaka, T. & Yano, Y. (2010) : Supporting real-time awareness for the community of runners, International Journal of Knowledge and Web Intelligence, Vol.1, No.3/4, 289-303.

[2] Tokunaga, M. (1998) "A Study on Mental Conditioning for Athletes :Development of Diagnostic Inventory of Psychological State Before Competition", Institute of Health Science,Kyushu University, Journal of health science 20, 21-30

[3] Tokunaga, M. & Hashimoto, K. (1986) "A Study on the Training of Phychological-Competitive Ability for Athletes (2) -On Relaxation Training by Skin Temperature Biofeedbac-", Journal of health science 8 , 65-77

[4] Medical Systems Research, What is brain wave
http://www.kenn.co.jp/text/eeg_text.pdf

[5] Yamanishi, T. & Matsumoto, H. (2005) "The Relationship between Mood Change and Exercise Intensity following Running in POMS : about Athlete and non-Athlete", Department of Health and Physical Education, Faculty Education, Gunma University (Accepted September 14)

[6] Fujita, T. & Sugihara, T. (2007) "Prediction of exercise participation of university students based on intrinsic motivation in physical education while at high school", Japan J. Phys. Educ. Hlth. Sport Sci. 52: 19-28, January