

ATTENTION MONITORING AND ENHANCEMENT  
BY NEUROFEEDBACK TRAINING

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Universiti Teknikal Malaysia Melaka

ATTENTION MONITORING AND ENHANCEMENT  
BY NEUROFEEDBACK TRAINING

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This Report Is Submitted In Partial Fulfillment of Requirements for the  
Bachelor Degree of Electronic Engineering (Wireless Communication)

Faculty of Electronic and Computer Engineering  
Universiti Teknikal Malaysia Melaka

JUNE 2016



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**  
**FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER**

**BORANG PENGESAHAN STATUS LAPORAN**  
**PROJEK SARJANA MUDA II**

**Tajuk Projek** : ATTENTION MONITORING AND ENHANCEMENT  
 BY NEUROFEEDBACK TRAINING

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To my family for nursing me with love and their dedicated partnership for success in my life.

## ACKNOWLEDGEMENTS

For the past four years in Universiti Teknikal Malaysia Melaka (UTeM), I was being away from family and friends. Nevertheless, it became interesting and memorable. Along the way, I am glad that receive generous help and support from numerous people. I would like to take this opportunity to express my gratitude to them.

First of all, I convey my gratefulness to my supervisor, Dr Low Yin Fen for giving me the precious chance to have my final year project under her supervision. Besides that, I do not forget her guidance, motivation and invaluable discussion throughout the project. Despite she is being extraordinarily busy with her jobs and duties, she is still managed to guide me along, apart from suggesting me the best solutions to almost every challenges.

To the panels, Dr. Yosza bin Dasril and Pn. Khairun Nisa binti Khamil, I also place on record, my most sincere thanks to them in sharing their expertise and recommendation during the seminar session to gives me the right direction towards completion of my project.

My deepest gratitude goes to my academic supervisor, Ass. Prof. Tan Kim See, with his support and continuous advices along these four years, I can pursue my degree. He had cultivating my passion of being an engineer in this field. Without his encouragement, I would not finish my study and passed with flying colour.

I am also grateful to my course mates who have been helping or teaching me all the way in these four years especially during my final year. Their participation in stimulating discussion and investing time for discussion to solve the difficulties that we faced would be my precious tools in dealing with my real working life in the

future. It is my pleasure to learn from them. In particular, full co-operation given by my team mates that we were working together before deadlines for the sleepless night is of my utmost pleasure.

Most important, I wish to dedicate my special appreciation to my family for the unceasing support and attention in my entire study. Their spiritually support has extended to me throughout these four years and my life in general.

In short, all helps and contributions given from different parties have helped me finish this final year project successfully. Lastly, my sense of gratitude express to one and all who directly or indirectly have lent their hand in this venture. As I have gained a lot of valuable knowledge from this project, I hope to apply them in the future as an engineer.



## ABSTRACT

Neurofeedback or EEG biofeedback is a new therapy in applied psychophysiology field. It has been investigated for use with a multitude of brain disorders such as epilepsy, hyperactivity, attention deficit disorder, tinnitus or attention related problems. As the attention is the basic cognitive ability of a person to perform any task or to develop a skill, the timely monitoring of this ability is important when his/her performance enhancement is concerned. Therefore, the primary purpose of project is to develop the so-called attention monitoring system based on Auditory Late Responses (ALRs). The attention level is objectively quantified by using the Wavelet Phase Stability (WPS) measure. To visualize the quantified attention level, different amount of flowers is used to represent this attention level and feedback to the subject by displaying it on the computer screen. The project was implemented using the MATLAB software. In total, ten subjects who are free from hearing problem were participated in the study. Results have shown that the shortest time taken for a subject to accomplish the desired sequence in the training protocol was six minutes with twelve training sessions. The developed neurofeedback system is not only able to quantify the attention level but can also serve as a training to regulate subject's attention in a series of training protocol. It is concluded that the developed neurofeedback system has a great potential to be used to improve the brain's performance in selective attention.

## ABSTRAK

Neurofeedback atau EEG biofeedback ialah terapi baru dalam bidang Psychophysiology. Terapi ini telah diselidik untuk penggunaan dalam pelbagai gangguan otak seperti epilepsi, hiperaktif, ADD, tinnitus dan selain-lainnya. Hal ini demikian disebabkan oleh tumpuan ialah keupayaan kognitif asas untuk melaksanakan tugas atau membina kemahiran. Selanjutnya, pemantauan keupayaan ini amat penting untuk peningkatan prestasi seseorang. Oleh yang demikian, objektif utama projek ini adalah untuk membina sistem pemantauan tumpuan yang berkaitan auditory late response (ALR). Tahap tumpuan diukur secara objektif dengan cara Wavelet Fasa Kestabilan (WPS). Untuk menggambarkan tahap tumpuan, kuantiti, bunga yang berbeza digunakan untuk mewakili tahap tumpuan dan maklum balas kepada subjek dengan memaparkannya pada skrin komputer. Projek ini telah dilaksanakan dengan menggunakan perisian MATLAB. Secara keseluruhan, sepuluh subjek yang bebas daripada masalah pendengaran telah mengambil bahagian dalam kajian ini. Keputusan telah menunjukkan bahawa masa yang paling singkat diambil oleh subjek untuk mencapai urutan yang dikehendaki dalam protokol latihan adalah enam minit dengan dua belas sesi latihan. Sistem Neurofeedback dibangunkan bukan sahaja untuk mengukur tahap perhatian tetapi juga boleh berfungsi sebagai latihan untuk mengawal perhatian subjek dalam siri protokol latihan. Secara kesimpulan, sistem Neurofeedback yang dibangunkan mempunyai potensi yang besar dalam penggunaan untuk meningkatkan prestasi otak dalam tumpuan selektif.

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## LIST OF ABBREVIATIONS

AAPB	-	Association for Applied Psychophysiology and Biofeedback
ADHD	-	Attention Deficit Hyperactivity Disorder
ALR	-	Auditory Late Respond
ASSR	-	Auditory Steady State Responses
BFE	-	Biofeedback Federation of Europe
BCI	-	Brain Computer Interfaces
CWT	-	Continuous Wavelet Transform
EEG	-	Electroencephalogram
ERPs	-	Event-Related Potentials
FIR	-	Finite Impulse Response
FFT	-	Fast Fourier Transform
fMRI	-	Functional Magnetic Resonance Imaging
GUI	-	Graphic User Interfaces
ICA	-	Independent Component Analysis
ISI	-	Interstimulus Interval
ISNR	-	International Society for Neurofeedback and Research
MEG	-	Magnetoencephalography
NF	-	Neurofeedback
NF-FR	-	Neurofeedback - Frequency Bands
NF-SCP	-	Neurofeedback - Slow Cortical Potentials
NFT	-	Neurofeedback Training
N1	-	N100
PCA	-	Principal Component Analysis
PET	-	Positron Emission Tomography
PSS	-	Phase Synchronization Stability
P2	-	P200

QEEG	-	Quantitative Electroencephalography
SOM	-	Self-Organizing Map
SNR	-	Signal-to-noise ratio
SSAEP	-	Steady State Auditory Evoked Potential
SSVEP	-	Steady State Visual Evoked Potential
TMSI	-	Temporary Mobile Station Identify
WPS	-	Wavelet Phase Stability

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## **CHAPTER ONE**

### **INTRODUCTION**

This chapter provides an overview of the research entitled “Attention Monitoring and Enhancement by neurofeedback training”. It will embrace the background study, objective, problem statement and scope of the project. The objective of this project will identify the gap of the problem statement that is revealed in this chapter.

#### **1.1 BACKGROUND STUDY**

Attention is a necessary cognitive skill to perform our daily tasks. With the attention skills, you can focus on the task, learn information and process the data such as language acquisition, literacy and mathematics. Shifting attention can occur consciously when we are focusing intentionally or unconsciously when we are distracted by environmental noise instantly. Other than that, we can perform multitask due to the attention is divided into several task such as talking with the passenger during driving but it needs more brain capacities.

Attention is the brain process compulsory for learning. When we need to memorize the new knowledge, we need to pay attention so that we can master it. Aging will impair the speed of processing information ability meanwhile reduce the ability of selective attention. For instance, a 20 year old can study easily when the

environmental noise exists, a 60-year old hardly achieve. Have you ever faced the difficulties during focusing the presentation or solving the problems if there are too many the inputs for you?

Since the brain as an information processing system, it has the capabilities to learn or reorganize itself from the experience. The brain can be challenged same as our body in doing the physical exercise, then our brain can learn to function better. A better functioning brain help us in fully focus on a task even it is bored. Thus, we can train the brain to help improve its ability to fully focus instead of distracted easily by the noise.

Recently, the brain training centres provide the brain rehabilitation program to help the patients with traumatic brain injury. Besides that, the brain training program such as neurofeedback is provided. This process is the same as the recovery process in the body to repair the wounds by itself. The neurofeedback has 50 years of history in changing how the brain operates. It is different with the medications because it has virtually no side effects and without the consumptions for pill.

Neurofeedback is a therapy that can improve brain function by allowing the brain to communicate with itself. The process of self-regulation for brain is effective and drug free in helping people control their brain safely. During the training, the brain waves is monitored computer-based and gradually correct to optimize the brain's ability to focus, learn, improve impulse control and lower anxiety in children and adults.

The brain imaging techniques allows us to view the activity within the human brain. There are two types of neuroimaging methods which are invasive and non-invasive. The non-invasive method is acceptable compared to invasive method because no pain or surgery involved in the process. Event-related potential (ERP) signal is used to develop the neurofeedback training in the attention monitoring system for this project. It is acquired by placing the electrodes on the scalp to record the electroencephalogram (EEG) of the brain in a millisecond-level and has higher temporal resolution in time domain. This event is time locked to a stimulus event. The stimuli can be in auditory or visual form as well as cross modality. The auditory

stimuli are chosen for the selective attention monitoring system because the brain response faster to the auditory stimuli compared to the visual stimuli (Shelton & Kumar, 2010).

## 1.2 PROBLEM STATEMENTS

Cognitive skills such as auditory, visual processing and memory are required for good learning performance which involves the attention during the process. Schmidt (2001) point outs attention is essential for process of the learning and controlling the action. The attention is important in the learning skills and cognitive process such as remembering, processing information and calculation. When the people are weak in focus, he/she will become a slow learner. It can affect the organizational skills, time management and working productivity. Although weak in attention will not affect the daily life, it can lower down the quality of the life.

Therefore, it is essential to regulate the performance of the brain for the person who is weak in focus. A lot of researches have been proven that the attention can be improved by using the neurofeedback training and lead to better learning performance as well as the quality of life. However, the neurofeedback training needs to carry out in the brain training centre with the help of therapist.

Another important drawback, there is no objective quantification of attention level. During the neurofeedback training, the brain activities are reflected on the EEG signal and display on the screen through the continuous waveform. The subjective interpretation of the EEG signal is not accurate and user friendly. Thus, the attention monitoring system is proposed and enhanced by neurofeedback training with quantification analysis by using wavelet phase stability (WPS) method. The indicator use to represent the attention level show by WPS so that the outcome of neurofeedback training can interpret by non-expert comprehensively.

### 1.3 OBJECTIVES

The primary objective of this project is to design and develop a neurofeedback training with auditory stimuli.

The two sub-objectives are listed below:

- a. To acquire the brain signals by using TMSI EEG amplifier
- b. To quantify the attention level that reflected in event-related potentials (ERPs) by using wavelet-phase synchronization measure (WPS)

### 1.4 SCOPES OF PROJECT

The modality of this attention monitoring system is based on auditory selective attention. Since the stimuli of the BCI paradigm will be in auditory form, the participants must free from the problem of hearing. The pure tones will be in ISI random sequence.

The hardware used in this project is EEG amplifier (TMSi). The brain-related electrical potentials are recorded from scalp by using monochannel (Cz) EEG measurement with water based electrodes. The electric potential generated by an individual neuron is far too small to be picked up by amplifier. Thus, EEG amplifier will amplify the EEG signal since brain signal is weak (30-100 $\mu$ V) to transmit the data to a laptop or desktop for further signal processing and analysing.

The software used in this project is MATLAB and FieldTrip. The software tools (MATLAB) will be used to interpret and process the signal activity by analysing the ERP signal. For this project, the WPS method will used to analyse and quantify the attention index. Meanwhile, the FieldTrip is open source software to access the brain signal real time. It is used to interface the EEG amplifier with the laptop or workstation. Besides that, it is implemented as the MATLAB software toolbox for EEG analysis so that the analysis protocol can be constructed in MATLAB.