FINAL YEAR PROJECT 1 (EDB4012)

Extended Proposal

TITLE: DEVELOPMENT OF APPS TO IMPROVE MOOD STATES

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ABSTRACT

It is normal to experience a range of moods which is high and low in daily life. Bad emotional states often link to the stress which is common in the workplace. Employees' moods, emotions and overall dispositions have an impact on job performance, decision making, creativity, turnover, teamwork, negotiations and leadership at work. Their organisations are less successful in a competitive market. [1] Positive mood leaders also more likely to encourage and notice positive behaviours performed by group and reinforce the group while negative emotions make anti-social behaviours more likely. [2] One study shows the discreet negative emotions that is induced in unjust and stressful environment increase likelihood of frequency of anti-social or deviant organisational behaviours. [3] Besides, people with higher emotional intelligence is also perform well on problem- solving tasks. [4] Hence, the needs for portable system which can detect emotional state is very important to improve the workers' productivity and reduce risk of getting neuropsychiatric disorders. In this project, we therefore intend to study about the 1) how mood states induced prefrontal cortex activity 2) changes of mood states when exposed to nature sound and environmental sound. Based on the study we intent to create a 3) phone application which can detects emotional state using wearable fNIRS and able to improve mood states of the users.

1.0 INTRODUCTION

1.1 BACKGROUND STUDY

There are many equipments that can be used to determine brain activities like electroencephalography (EEG), functional Near-Infrared Spectroscopy (fNIRS), and functional Magnetic Resonance Imaging (fMRI). Emotional response affects many different areas of brain which includes prefrontal cortex and parts of the limbic system. [5-8]. EEG studies shows that left frontal inactivation shows that subject has a negative emotion while right frontal inactivation shows that subject feeling positive. [9] The studies of severe major depressive disorder (MDD) also shown that left dorsolateral prefrontal cortex (DLFPC) of the MDD patients is hypoactive while right dorsolateral prefrontal cortex is hyperactive. [10] In addition, psycho-physiological research also shown that a more active left frontal area indicates positive reaction while right frontal area activation means negative effect. [11] According to Yu (2017) , the right areas of prefrontal cortex increase in oxy-haemoglobin when the urban picture is shown. [12] These studies consistent with the valence-specific hypothesis which is left cerebral hemisphere specialized for positive emotions and right hemisphere specialized for negative emotions. [13-15] FNIRS uses near infrared spectrum which is between 700-900nm to create an optical window where skin and tissue are almost transparent and utilises light absorption properties of oxyhaemoglobin (HbO) and deoxy-haemoglobin (HbR) to measure the concentration of HbO and HbR inside the superficial layer of scalp. [16-17] FNIRS has many advantages which makes it suitable for detecting the blood oxygen level dependent(BOLD) over the other techniques such as fMRI and positron emission tomography (PET) which we will discuss later. [18]

1.2 Problem Statement

The problem statements of the project are as follows:

i. There is no application able to detect stress currently and alert user
ii. No apps able to reduce stress when the user is under stress due to lack of stress monitoring system
iii. Current stress reduction application depends on the music or video which is not efficient in reducing stress

1.3 Objectives

i. Determine the suitable stimuli to measure the mood state of the users based on task
ii. Create an application which can detect stress based on the data collected using fNIRS
iii. Create an application which able to simulate a virtual forest which comes with natural sound to reduce stress

1.4 Scope of Study

The project starts by studying the following items to gain deeper understanding on the project so that the comparison of theory and practical studies can be made:

1. Brain anatomy and the terms used to describe the position of the brain
2. Differences between fMRI, fNIRS and EEG and each of their working principal
3. How stress and mood affects prefrontal cortex
4. Ways to improve mood states
5. Different types of test to stimulate brain for the measuring of the brain signal
6. Ways to develop an apps
7. Development of a virtual reality forest to reduce stress

After research phase is all done, the development of the apps for the portable fNIRS should be start immediately. Once the development of the apps is done, the apps is required to be tested by testing subjects. This is done to verify the hypothesis is matched with the conclusion.

2.0 LITERATURE REVIEW

2.1 Stress

According to WHO Collaborative Study of Psychological Problems in General Health Care, there are about 10.4% of patients is suffered from depression or stress-related anxiety. [19,20] Poor heartrate outcome is all related to the stress, lower education level, low income and social isolation. [21] Patients who suffered from myocardial infarction also has a high mortality rate when they are depressed. [22] According to Mental Health Foundation in United Kingdom [23], British Industry has spent over 3 billion British Pound annually for the stress related problems. This especially happened for high profile nature job which a slight mistake can cost a huge amount of losses. Hence, stress must be monitored from time to time to ensure that the work demands and pressure must be matched to their knowledge and abilities to face the challenges given. [24] The workers' stress data can also be used as an analytic tool to analyse the stress when different type of jobs is given. This can provide the employers an insight on the kind of task the employee is suitable for and distribute the task accordingly. This kind of analytical data is very important to enhance the productivity of the workers and increase the competitiveness of a company in the market.

Stress increases risk of depression and evoke negative emotion for a long period of time. [25] Hence, we can determine stress by studying emotion and depression using self-reported emotional state test.

There are many other questionnaires that can be used to measure emotional states as well:

i. Self-Assessment Manikin (SAM) [26]
ii. Positive and Negative Affect Scale (PANAS) [28]
iii. Profile of Mood States (POMS) [29]

2.1.1Self-Assessment Manikin (SAM)

Self-Assessment Manikin (SAM) is a questionnaire based on cognition on arousal and valence which is proposed by Lang [26].

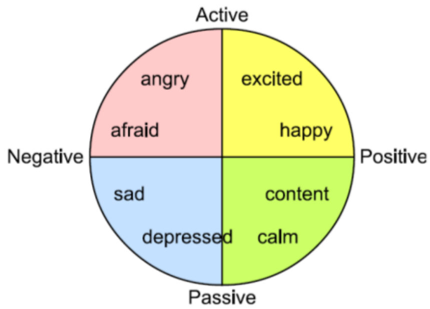


Figure 1 Arousal-Valence Model

This arousal-valence model *shown in figure 1* is used in many research studies as well as Self-Assessment Manikin (SAM) which is a self-evaluation test for the affective dimension of valence, arousal, and dominance. It provides a fast, intuitive and simple way of evaluating emotional state. The participants are required to fill in this questionnaire based on rating of 1-9 for each category.

For the valence scale of 1-9:

i. 1-3 : Negative
ii. 4-6 : Neutral
iii. 7-9 : Positive

For the arousal scale of 1-9:

i. 1-3 : Passive
ii. 4-6 : Neutral
iii. 7-9 : Active

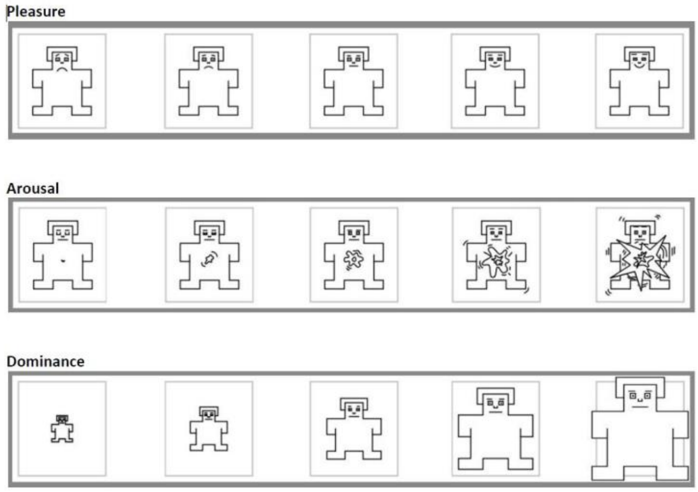


Figure 2 Self-Assessment Manikin with Valence(negative-positive), Arousal(passive-active), Dominance(dominated-dominant)

According to new scale mapping, the system provides 9 states of classification which is shown in figure 3.

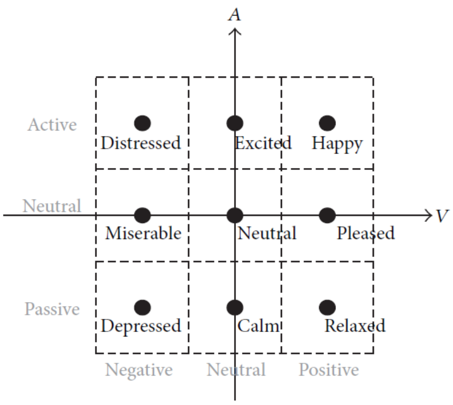


Figure 3 9-states emotion classification[27]

2.1.2 Positive and Negative Affect Scale (PANAS)

This emotional state study is a self-assessment based on Dutch-English translation. The translation is done by Engelen (2006) [28]. The PANAS is a list of 20 adjectives used to describes different emotional states which consisted of:

- 10 states of Positive Affect (PA)
- 10 states of Negative Affect (NA)

PA is used to measure activity and pleasure while NA is used to measure fear and stress. Due to its length of questionnaire, PANAS is more suitable to measure longer lasting emotional states. The participants are required to fill in the questionnaire on a rating scale from 1-5:

1= not at all or very slightly

2= a little

3= moderately

4= a lot

5= extremely

PANAS Scale

	Original PANAS items	Dutch translation
NA1	Distressed	Bedroefd[1]
NA2	Upset	Terneergeslagen[1]
NA3	Guilty	Schuldig[1]
NA4	Scared	Angstig[1]
NA5	Hostile	Vijandig[1]
NA6	Irritable	Prikkelbaar[2]
NA7	Ashamed	Beschaamd[1]
NA8	Nervous	Nerveus[2]
NA9	Jittery	Rusteloos[2]
NA10	Afraid	Bang[1]
PA1	Interested	Geïnteresseerd[1]
PA 2	Excited	Opgewekt[1]
PA 3	Strong	Sterk[1]
PA 4	Enthusiastic	Enthousiast[1]
PA 5	Proud	Zelfverzekerd[1]
PA 6	Alert	Alert[1]
PA 7	Inspired	Geïnspireerd[2]
PA 8	Determined	Vastberaden[1]
PA 9	Attentive	Aandachtig[1]
PA 10	Active	Energiek[1]

[1] = from Engelen et al., 2006

[2] = from Peeters et al, 2006

2.1.3 Profile of Mood States (POMS)

POMS test is a questionnaire for psychological test that are widely used in research. This questionnaire is developed by Douglas (1971).[29] The participant are required to fill in each of the areas based on rating of 0 (not at all)-4(extremely). The questionnaire is divided into seven subscale which consists of : tension(TEN), anger (ANG), fatique (FAT), depression (DEP), esteem-related affect (ERA), vigour (VIG) and confusion (CON). Then the total scores of the questionnaire is calculated using Total Mood Disturbance (TMD) formula:

TMD=[TEN+DEP+ANG+FAT+CON] – [VIG+ERA]

The score is calculated by summing up negative emotion (tension, depression, fatique, confusion, anger) and the subtracting the positive emotions (vigor and esteem-related affect). Grove and Harry (1992) have done an experiment using this POMS test. They require netball player to fill in the POMS questionnaire twice which once is during post win and another one during post loss experience. The experiment found out when the player lost in the game, the negative emotion (tension, depression, anger, confusion) is higher compared to winning a game while the positive emotion (vigour and esteem) is exactly the opposite. [30] This shows that the POMS test can determine the mood states of the participants quite well.

	Not at all	A little	Moderately	Quite a lot	Extremely
Tense	0	1	2	3	4
Angry	0	1	2	3	4
Worn out	0	1	2	3	4
Unhappy	0	1	2	3	4
Proud	0	1	2	3	4
Lively	0	1	2	3	4
Confused	0	1	2	3	4
Sad	0	1	2	3	4
Active	0	1	2	3	4
On-edge	0	1	2	3	4
Grouchy	0	1	2	3	4
Ashamed	0	1	2	3	4
Energetic	0	1	2	3	4
Hopeless	0	1	2	3	4
Uneasy	0	1	2	3	4
Restless	0	1	2	3	4
Unable to concentrate	0	1	2	3	4
Fatigued	0	1	2	3	4
Competent	0	1	2	3	4
Annoyed	0	1	2	3	4
Discouraged	0	1	2	3	4
Resentful	0	1	2	3	4
Nervous	0	1	2	3	4
Miserable	0	1	2	3	4
Confident	0	1	2	3	4
Bitter	0	1	2	3	4
Exhausted	0	1	2	3	4
Anxious	0	1	2	3	4
Helpless	0	1	2	3	4
Weary	0	1	2	3	4
Satisfied	0	1	2	3	4
Bewildered	0	1	2	3	4
Furious	0	1	2	3	4
Full of pep	0	1	2	3	4
Worthless	0	1	2	3	4
Forgetful	0	1	2	3	4
Vigorous	0	1	2	3	4

Uncertain about things	0	1	2	3	4
Bushed	0	1	2	3	4
Embarrassed	0	1	2	3	4

Comparison table for three types of questionnaires:

	Self-Assessment Manikin (SAM)	Positive and Negative Affect Scale (PANAS)	Profile of Mood States (POMS)
Ease of use	Easy	Easy	Easy
Analyse	Easy	Medium	Hard
Data Interpretation	Too little data	Medium	Easy
Straightforward	Straightforward	Not Straightforward	Not Straightforward
Time	Very Fast	Slow	Very Slow

Based on the table, the self-assessment manikin (SAM) is recommended for the mobile application as the users might lose interest to do long list of questionnaires. The SAM comes with picture which makes it easy to understand compared to PANAS and POMS which uses different kinds of adjectives which makes it slightly harder to understand. The ease of understand will help reduce the time taken to complete a questionnaire as you can see completion of SAM questionnaire is significantly faster than the rest of the questionnaire.

2.2 fNIRS and other neuroimaging modalities

FNIRS is a neuroimaging technique that able to monitor the brain activity non-invasively. [31] FNIRS uses near infrared light of wavelength 700 to 900 nm to create an optical window where infrared light can easily penetrate living organisms. Absorption of near infrared light decreases in water as the wavelength getting longer than 900nm. Therefore, it is safe to use fNIRS as it does not internally penetrate living organism.

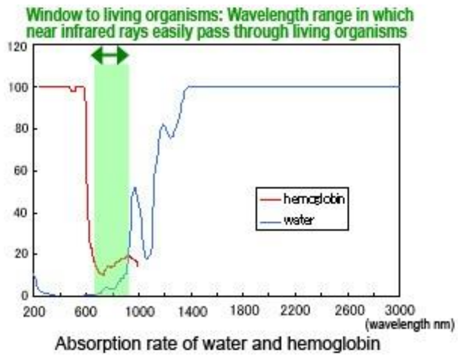


Figure 4 Absorption Rate of Haemoglobin and water at different wavelength

Absorption of light in this wavelength region is caused mainly by oxygenated haemoglobin (HbO) and deoxy-haemoglobin (HbR). Both of the HbO and HbR has different absorbing spectrum and the isobestic point of both is 805nm. Hence the concentration of HbO and HbR can be measured based on the absorption at two different wavelength as shown in figure 5. [32]

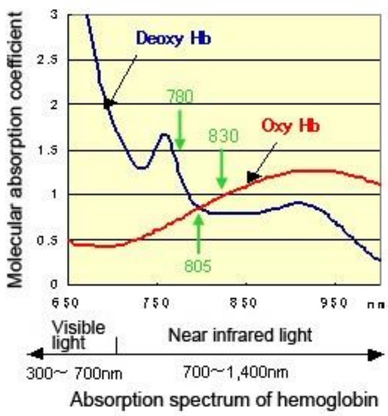


Figure 5 Absorption Spectrum of Oxy-Hemoglobin and Deoxy-hemoglobin and the isobestic point

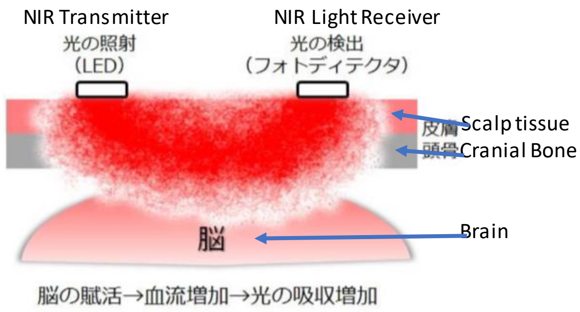


Figure 6 Technique of Fnirs measuring the brain neural activity[36]

As you can see from the figure 6, the fNIRS transmitter is being placed a few centimetre away from the NIR light receiver. This is due to the measuring of the brain neural activity highly dependent on the blood flow rate. The higher the blood flow rate, the absorption of light will also increase. This protable fNIRS system designed by Hitachi has a lightweight of approximately 125gram which make it suitable for daily use and the movement artifact is reduced due to its lightweight properties. The transmission of data from fNIRS system is also done by using Bluetooth. Hence, the movement is less constraint due to lightweight and wireless properties.

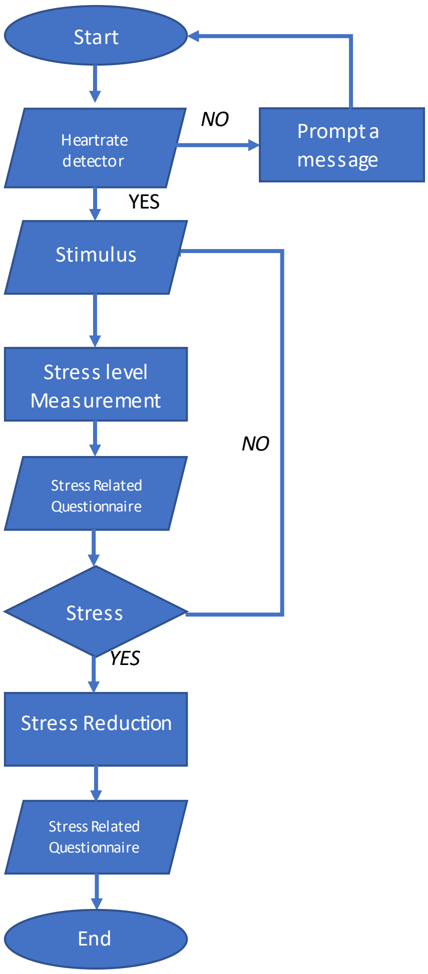
FNIRS has several disadvantages compared to other non-invasive measurement such as it has lower spatial resolution compared to fMRI and PET and temporal resolution if compared to EEG. [31] However, in comparison with other modalities, fNIRS has higher temporal resolution than fMRI and higher spatial resolution than EEG. [35] Besides, the fNIRS does not has movement constraint unlike fMRI which the movement is almost restricted which made it impossible to be made use as portable measurement device and movement constraint will cause environmental stress while taking measurement. [33] Besides, the fNIRS has a superior signal-to-noise ratio compared to EEG system. [34-35] Hence, fNIRS has many benefits including safety, portability and non-invasiveness and suitable to be developed as a tool for measuring emotional-related neural activation in prefrontal cortex.

3.0 METHODOLOGY

The development of apps to reduce stress is divided into four parts:

i. Stimulus
ii. Heartrate detection
iii. Stress Level Measurement
iv. Stress related Questionnaire
v. Stress reduction

Flowchart of the stress reduction application



Before begin of the experiment, the fNIRS tools is being placed at the frontopolar prefrontal cortex (FPPFC) of the participants. In this study, the 2-channel fNIRS is used to detect brain activity in FPPFC. According to 10-20 systems, the two probes is placed directly to FP1 and FP2 as shown in the figure. Since the probes is attached with a flexible headband, it is relatively easy , fast and convenient to wear the fNIRS even by using one hand. It is designed to be portable and for daily use.

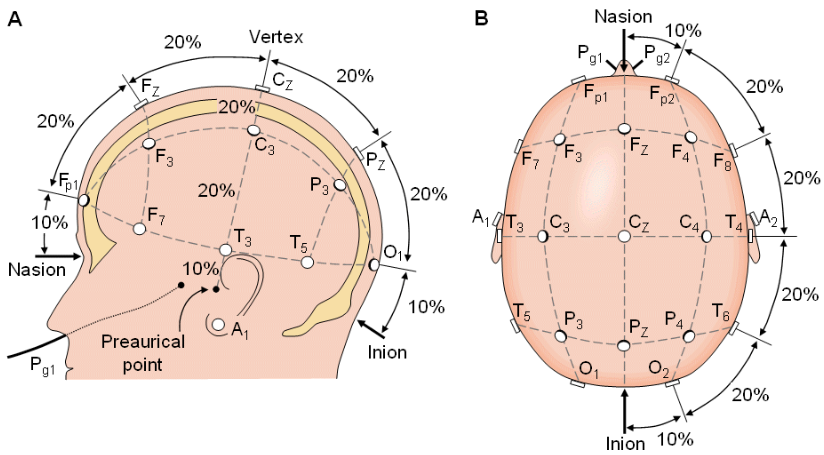


Figure 7 International 10-20 system [37]

3.1 Stimulus

The stimulus will be given to the participant as a task based activity to activate the brain region in this particular study which is FPPFC. This stimulus will be an arithmetic task to do some simple subtraction and participants are required to answer as many questions as possible within 60 seconds.

3.2 Heartrate detection

The heartrate should be presence the moment the participant put the portable fNIRS on head. The absence of heartrate might be due to sensor is not attached properly or the fNIRS is not being used.

3.3 Stress Level Measurement

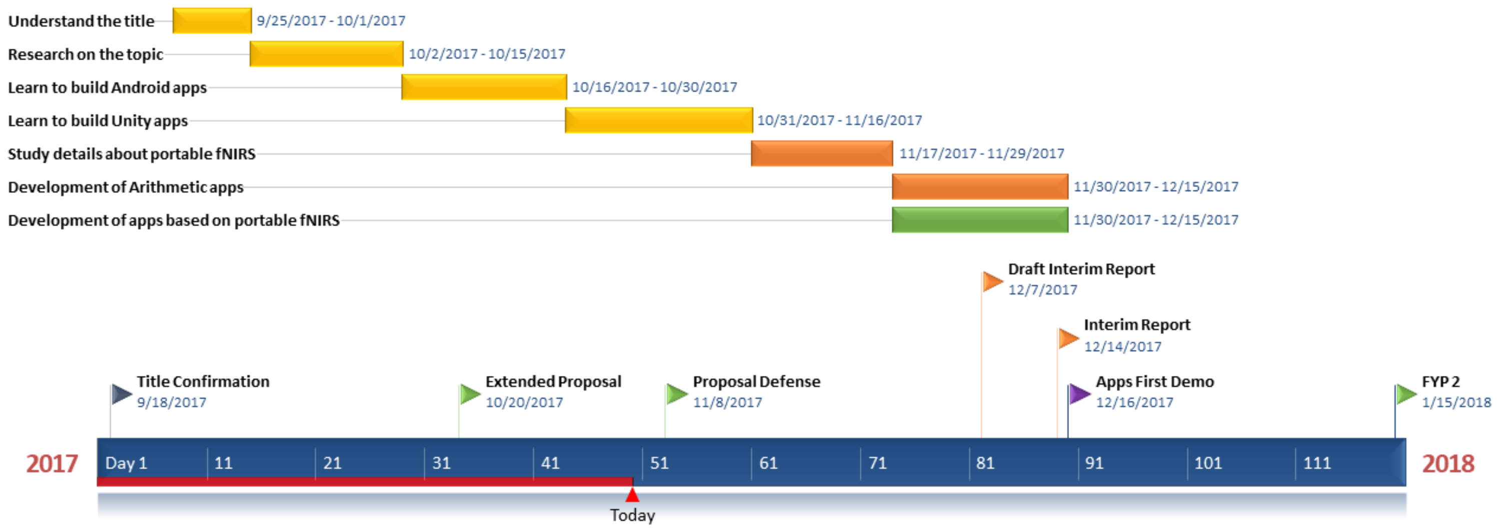
During the mental arithmetic task, the heartrate and the neural brain activity in the FPPFC is recorded throughout the activities for the analysis purpose. The measurement is started before the arithmetic task started to measure the resting state of the brain activity as a baseline. The data is then stored to the smartphone for analysis purpose. The measurement is done by comparing the brain neural activity between left hemisphere and right hemisphere which in this case is left FPPFC and right FPPFC.

3.4 Stress Related Questionnaire

A short questionnaire will be given to the participant to understand the mood state of the participants before the experiment and after the experiment. The questionnaire will be based on Self-Assessment Manikin (SAM) which measure the valence and arousal of the participant to understand the current moodstate of the participants.

3.5 Stress Reduction

If the fNIRS detects stress, it will prompt up with a new activity which is a virtual forest displaying the immersive view of the garden and accompanied by the sound of nature to let the user release tension. The video will last for 2 minutes. After the video is finish playing, the participant is required to fill up SAM again to understand how the apps is helping in stress reduction.


Understand the title
9/25/2017 - 10/1/2017
Research on the topic
10/2/2017 - 10/15/2017
Learn to build Android apps
10/16/2017 - 10/30/2017
Learn to build Unity apps
10/31/2017 - 11/16/2017
Study details about portable fNIRS
11/17/2017 - 11/29/2017
Development of Arithmetic apps
11/30/2017 - 12/15/2017
Development of apps based on portable fNIRS
11/30/2017 - 12/15/2017
Draft Interim Report
12/7/2017
Interim Report
12/14/2017
Title Confirmation
9/18/2017
Extended Proposal
10/20/2017
Proposal Defense
11/8/2017
Apps First Demo
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4.0 CONCLUSION AND RECOMMENDATION

As of now, there is no stress monitoring system for the workers and students and hence many of the stress related disease cannot be prevented. Besides, the stress related disease is hard to be cured without medication. Hence, the portable fNIRS system is introduced for daily monitoring of the brain activity. Once the stress is detected, the user will be prompt with a video to help reducing stress.

This portable fNIRS system is designed to be light hence suitable for daily use. The transmission of data is done via Bluetooth and phone and hence the movement is not restricted at all. The detection of stress is done based on the mood state of the participant. Hence, by comparing the brain activity between left hemisphere and right hemisphere, we able to detect the mood state of the participants. The current portable fNIRS is limited to two probes which might reduce accuracy of the detection of mood state. In future, the probes number of probes can be increased to increase the accuracy of the stress detection.

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