Neurofeedback Training Content For Treatment Of Stress

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***Abstract*—Stress is one of the major problems in society and is being treated using medicine and neurofeedback therapy. Neurofeedback therapy is usually successful. The contents as stimuli for neurofeedback training are not available for stress and anxiety. This paper focuses on giving a comprehensive and critical summary of available contents for neurofeedback training. It also establishes a need for the development of content as a stimulus for neurofeedback which trains the subject on how to control his brain activity, especially in stress condition. The developed content consists of audio and game. The game is used to reduce the power of high−beta brain activity and the audio is used to enhance the amplitude of alpha brainwaves in left−prefrontal lobe. The experimental results show significant improvement in reducing stress level. The outcome is a proposed content for neurofeedback training to reduce stress, and it also improves the neurofeedback training efficacy.**

I. Introduction

Stress is one of the major issues in today's world. It can be defined as, "Stress is a feeling that we have under pressure". Sometimes the way of response to a challenge may also be a type of stress [1]. In the case of stress, the amplitude of alpha (8−12 Hz) brainwaves in left−prefrontal lobe is low. When the relative amplitude of alpha brainwaves in right prefrontal is high as compared to alpha brain activity in left−prefrontal; the subject is in the state of stress [2]. High−beta (22−30 Hz) brainwaves power over the sensorimotor cortex also causes stress [3], [4]. Brainwaves and their associated functions are presented in Table I.

Neurofeedback training is one of the treatments of stress which enables the subject to train himself to control his brain activity during stress and anxiety [5]. Neurofeedback trains the subject to control his brainwaves in normal mental state or in case of stress. Mostly, audio is used as content for neurofeedback training to increase alpha in left−prefrontal lobe [5], [6]. Neurofeedback is also used to decrease the high−beta using the game as content [7]. Generally, there is not a content as a stimulus for neurofeedback training which effectively increases the alpha power in left−prefrontal cortex and decreases high−beta in sensorimotor cortex.

Content is developed for neurofeedback training which consists of soothing music (audio) and game. This content is helpful during neurofeedback training to increase alpha activity in left−prefrontal and reduce high−beta activity over motor cortex. The content is an effective stimulus for neurofeedback which trains the subject to control his brain activity.

The proposed content for neurofeedback will assist the therapist by auto selecting the threshold, the right audio (soothing music), and game level for the subject. The selection of threshold, audio, and game level depends on the previous training scores and current power of alpha and high−beta brainwave.

The neurofeedback content will also improve the training efficacy by including the multiple electrode placements over scalp and reduce the number of training sessions.

II. Neurofeedback Treatment

The Neurofeedback involves recording, analysing, and presenting results of measured electroencephalogram (EEG) analyses to the subject in the form of reward (play/pause of the content) to show the changes in brain electrical activity [4]. The basic principle of the Neurofeedback is to measure the brain activity (EEG signals) using electrodes connected on the scalp. It identifies the brainwaves by using quantitative EEG analysis and then provides the subject with feedback (play/pause of content) as a reward, depending on the desired levels of the brainwaves. In neurofeedback systems, the most used recording technique for the brainwaves is the EEG. EEG data are used to monitor real−time brain activities [8]. The feedback is provided to the user in the form of visual, audio, game, reading, or spell checking. It can be implemented as colour change, bar increase/decrease, vibration, and sound. It can be integrated into the Neurofeedback game as character/object appearance, etc. The feedback determines the condition of the brain state whether brainwaves power is in the desired level of threshold or not [9]. Several studies uncover the fact that the Neurofeedback training has restorative impacts of treating some neurological and psychological issues such as attention deficit hyperactivity disorder (ADHD) [10], epilepsy [11], and some addictive cognitive disorders [6]. The Neurofeedback is also found useful for the treatment of anxiety, stress, affective disorders [12], depression [13], fibromyalgia [14], and obsessive−compulsive disorder [15]. The Neurofeedback is also being used to enhance attention and memory performance in healthy subjects [16]. The Neurofeedback training has also been applied to healthy users. This training has demonstrated its ability to improve certain cognitive aptitudes [8], [17]. The latter studies targeted the enhancement of the upper section of the alpha band (10 – 12 Hz), which is traditionally linked to performance [18].

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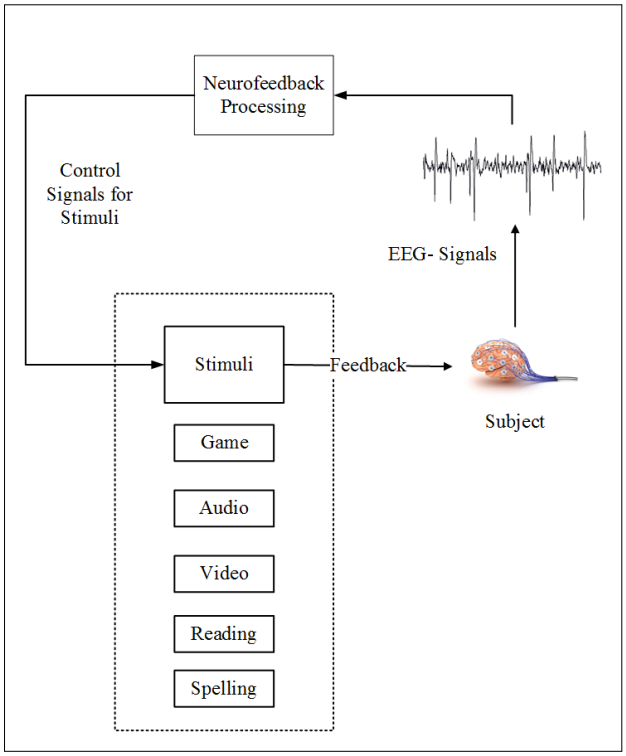

Fig. 1: Neurofeedback process

The most used neurofeedback content for training the subjects in the treatment of ADHD is a game and video [19]. It is normally observed that theta increases [20], [21] and beta decreases [21] in the youngsters with ADHD as compared to the developing youngsters. Increased theta (4−7 Hz) is associated with lower vigilance, and decreased beta (13−30 Hz) is associated with reduced attention [22]. Also, behavioural inhabitation is related to the sensorimotor rhythm (SMR; 12−15 Hz) [23]. As Neurofeedback aims to reduce ADHD symptoms such as diminished vigilance, attention, and inhibition, most Neurofeedback protocols train to inhibit theta (4 – 8 Hz) and increase beta (12 – 20 Hz) or SMR (12 – 15 Hz) over the vertex Cz [20], [24]. A complete Neurofeedback intervention typically comprises 20−40 training sessions [20]. Effective Neurofeedback treatment for ADHD is debated in [25].

Neurofeedback training has been done by some researchers to train their subjects to mitigate their stress level [26]. Beniodakis [5] and Peniston [27] have used audio as neurofeedback stimulus to reduce the stress level. They found out that subjects have reduced their stress levels.

Neurofeedback has been observed as an effective treatment for depression [7], [28]. Choobforoushzadeh [7] used game and audio to decrease the alpha/theta ratio in frontal lobe but has not included multiple brain parts. Choi [28] used audio to decrease the alpha near the vertex in frontal lobe to increase left brain activity. The factors include in the cause of depression can be a biochemical element, biogenetic element, psychosocial element, mental element and/or natural element. The victims can be alerted before going deep into depression by measuring EEG brainwave pattern [29].

TABLE I: Brain lobes and associated functions

Brain Lobes	Associated Functions
Frontal Lobe	Movement, thinking initiation, reasoning (judgement), behaviour (emotions), memory, speaking.
Temporal Lobe (left side)	Analysis of speech, monitoring speech, reading and writing, verbal memory, letter recognition.
Temporal Lobe (right side)	Decoding non-verbal patterns, visual decoding, Interpreting and remembering visual information.
Parietal Lobe (left side)	Smooth speech, writing skills, understanding math, reading skills, naming of objects, verbal memory.
Parietal Lobe (right side)	Drawing skills.
Occipital Lobe (left side)	Object recognition, visual recognition, reading numbers and letters, memory for written information.
Occipital Lobe (right side)	Attending to left visual field.

A. *Neurofeedback Softwares*

Therapists and researchers use Brain Computer Interface systems (BCI) world widely. BCI can offer a new way for playing video games in 2D or 3D virtual environments (VE). In VE, it is easy to navigate, modify the selection, and manipulate the virtual objects [3].

VE feedback games include sports, puzzles, or training. Nowadays, universities and laboratories are developing games and interactive puzzle in BCI to provide more interaction with the virtual world. For example, the alertness level of car drivers is increased by using virtual driving environment. The project is done by researchers at the University of Tokyo. In this project, BCI hearing system monitors the state of alertness of drivers and warns them if they lose their concentration.

The researchers at University College Dublin in collaboration with Media Lab Europe, have developed MIND BALANCE 3D video game using BCI−VE. In this game, the subject has to control the balance of an animated object moving on the thin rope by using EEG−neurofeedback.

INRIA designs several BCI systems for neurofeedback in VE. Use−the−force is one of them in which user has to control the launch of a virtual spacecraft, and his response is studied in challenging environments [30].

III. Discussion

It is inferred that the neurofeedback is clinically proved treatment for ADHD [19], [24], [31] and epilepsy, while it has an effective treatment for stress [5], [32], [33] and depression [34]. On average, two sessions of neurofeedback training per week are performed. So, 6−8 weeks (30−40 sessions) are required to find the efficacy of treatment.

Different contents are being used during neurofeedback training to train the subject so that he can control his stress and anxiety level. There is, generally, not a single content for the neurofeedback training which effectively reduces the high−beta in motor cortex along with the increase of alpha in left−prefrontal.

Alpha waves in left−prefrontal are responsible for good memories and thoughts. While alpha brain-activity in right prefrontal is responsible for bad memories [2]. Alpha reinforcement may result in anxiety and stress reduction. High−beta (22−30 Hz) is responsible for agitation, restlessness, stress and anxiety. The relative decrease in alpha amplitude in left−prefrontal causes dominance of right−prefrontal alpha. It results in bad thoughts and memories which increase the stress and anxiety [2]. The brain parts, brainwaves, and associated functions are shown in Table II.

TABLE II: Brain lobes and associated functions

EEG type	**Occupied frequency bandwidth**	**mental states conditions**
Delta	0.1 Hz− 4Hz	Dreamless sleep, unconscious.
Theta	4Hz−8Hz	Intuitive, recall fantasy, imaginary, creative, dreamlike, switching thoughts, drowsy.
Alpha	8Hz−12Hz	Eyes closed, relaxed, not agitated, tranquil conscious.
Low Beta / SMR	12Hz−15Hz	Relaxed yet focused, integrated.
Midrange Beta	16Hz−20Hz	Thinking, aware of self & surrounding.
High Beta	21Hz−30Hz	Alertness, agitation.

It is also observed that some subjects left or discontinued their neurofeedback training. The number of training sessions are 16−20 to find out the training efficacy and approximately 30−40 sessions for neurofeedback treatment [28].

There is a need to develop content for the neurofeedback training to help the subject to train himself on how to reduce the stress level. The developed content for the neurofeedback helps the subject to train himself how to enhance the amplitude of the alpha ($8-12$ Hz) brainwaves in the left−prefrontal and inhibit the high−beta (22−30 Hz). The algorithm to implement the content for the neurofeedback training could decide the level of difficulty in the content. After some neurofeedback sessions and depending on the performance of the subject brain activity, the algorithm could decide the difficulty level and threshold level of content for further neurofeedback training sessions. The content for neurofeedback especially designed for stress, could improve the training efficacy and reduce the training time for neurofeedback. The total duration of neurofeedback training could also be reduced.

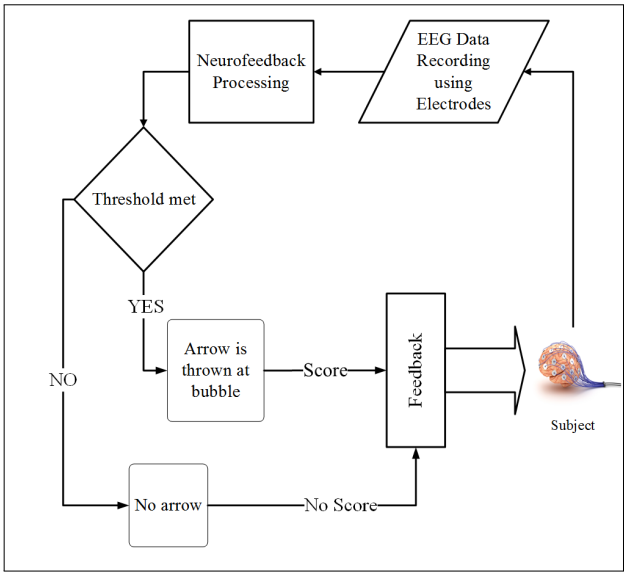

Fig. 2: Neurofeedback Experiment Procedure

IV. Methods

A. Participants

Participants will be recruited who fulfil the inclusion criteria for the experiment. The inclusion criteria are that the participants should have normal or corrected to normal hearing and visual capability, and they fill the stress level questionnaire form and consent form. There should not any discrimination among gender (both male and female should be recruited). The age of participants should not be less than 16 years.

B. Experiment

The participants will be demonstrated about EEG neurofeedback and experiment. The participant will sit on comfortable chair three feet away from the 24 inches monitor screen in a sound proof room. Two electrodes will be placed on the scalp at Fp1 and C3 according to International 10−20 system of electrode placement. Brain Trainer NFS1182AC amplifier along with software BT11.vb will be used. The built-in game Troi with a soothing music will be used as content for neurofeedback training. The participants will have a keyboard/joystick to control the movement of an object in the game and headphone for the music. The threshold for alpha at Fp1 and high−beta at C3 will be set at 6μV and 10μV respectively. The duration of each session of neurofeedback training will be 20 minutes. Two sessions per week will be performed and total eight (8) sessions will be done.

V. Results

The neurofeedback training by using soothing music and game shows significant improvement. The alpha and high−beta brain activity will be observed in each session. The results can be compared from the first session to last session that the subjects train themselves to increase their alpha brain activity in the left−prefrontal lobe and decrease

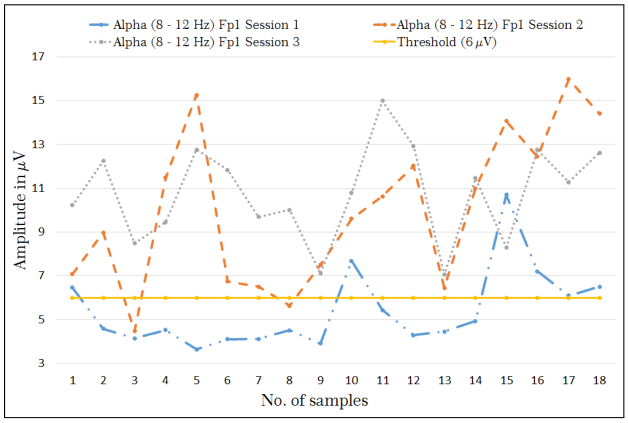

Fig. 3: The alpha brainwaves increases during neurofeedback training. The subject is able to increase his alpha brainwaves in left−prefrontal lobe (Fp1). 18 samples (mean) of alpha at Fp1 are calculated and drawn as; no. of sessions = 3, each session is of 3 periods, every period is 3 minutes long. The sampling frequency of the device is 256, 719 samples are taken in each period, and mean is calculated for every 118 samples.

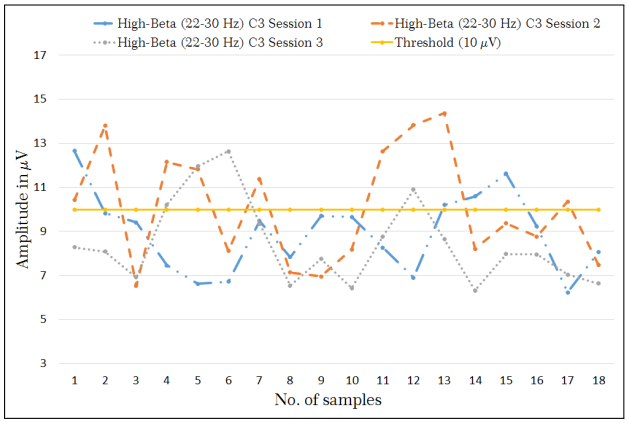

Fig. 4: The high−beta brainwaves inhibits during neurofeedback training, the subject is able to reduce high−beta level brainwave at motor cortex (C3). 18 samples (mean) are calculated and drawn as; no. of sessions = 3 (9 minutes), sampling frequency = 256, samples (mean) = $(719 \times 3)/118$).

high−beta in motor cortex. The results after experiment show improvement in the alpha brain activity at Fp1, Fig. 3 and high−beta brainwave inhabitation at C3, Fig. 4.

VI. Conclusion

To summarise the discussion, the developed content of neurofeedback could assist the therapist during neurofeedback training for the treatment of stress. The subject train himself on how to inhibit the power of high−beta (22−30 Hz) brainwave and enhances the power of alpha (8−12 Hz) in left−prefrontal. The expected outcome of this paper is the knowledge about neurofeedback contents and their applications for different treatments and a proposed content that improves the training efficacy of the neurofeedback and reduces the duration of neurofeedback session, training time, and total duration of neurofeedback training.

VII. Acknowledgement

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