

Effect of Video and Image as Positive Feedback in Neurofeedback for Stressed Elderly

M. Kalaivani, M.S Jeyalakshmi, M. Thanga Aarthi

Abstract—Slowing down of thought, memory and thinking is a normal part of aging. Mental exercise can help the brain to stay sharp. Neurofeedback training is a mental exercise which can improve the cortical activity. The neurofeedback process is a self-regulation training which allows the central nervous system to function better. Neurofeedback training is helpful with certain classes of problem such as attention, anxiety and depressions and also helps in improving the flexibility and resilience of brain. The training is given to elderly patients to treat age related cognitive decline such as stress. The brain wave frequencies are measured and analyzed in the course of training and the patients gradually learn to stay in the desired brain wave state by visualizing image and animated video cues designed using LabVIEW software which are fed back to the subject via computer screen. 12 subjects were trained whose age range from 55-65. During the course of training beta wave is enhanced and theta wave is suppressed. As the training progresses, the threshold value is increased which is based on beta/theta ratio. After 30-40 sessions, the efficacy is analyzed using the threshold and time

Index Terms— Animated videos, beta, cognitive, neurofeedback training, stress, theta, threshold, time.

1 INTRODUCTION

The brain and the nervous system regulate our senses, thoughts and even a miniature body movement. As people age, brain and nervous system goes a gradual change. This may ultimately lead to lower conductivity of nerve cells than the past. Neurofeedback can be used to overcome this, thereby improve the cortical performance of brain. Neurofeedback is a biofeedback that measures brain wave to produce a signal that can be used as feedback for self-regulation of brain function. This self standardization allows the central nervous system to function better. Neurofeedback is commonly provided using image with positive feedback to obtain desired brain wave state. Neurofeedback is also called as EEG biofeedback because it is based on electrical brain activity.

Our objective is to increase the cognitive performance of elderly stressed patients by EEG neurofeedback technique using image and video cues designed in LABVIEW software by increasing the beta/theta ratio which eliminates age related cognitive performance decline. The brain comprises of several billion of neurons which generate electrical impulses. When these neurons work in synchronous, electrical potentials occur in the synapses which are specialized junctions

between the neurons. The faster the neurons work together, higher the frequency measured in volts.

Brain activity is measured with electroencephalograph. The neurofeedback equipment is connected to the individual with electrodes that are placed on the scalp and ears using conductive paste. After proper connection to the scalp and ears are made, the individual's brainwave activity can be monitored on a computer. Beta are known as high frequency low amplitude brain waves that are commonly observed while we are awake. They are involved in conscious thought, logical thinking, and tend to have a stimulating affect. The higher beta frequencies are associated with high levels of arousal. Beta waves occur while performing conscious tasks such as: critical thinking, writing and reading. Theta waves are connected to deep emotions. This particular frequency range is involved in daydreaming and sleep. High theta activity may lead to semi-hypnotic state and also involved in restorative sleep. The positive effects of the training includes

- Enhances mental clarity to think more clearly,
- Increases attention and concentration for improved learning and memory,
- Regulates emotion, thinking and behavior balanced daily functioning,
- Improves overall brain function,
- Many individuals seek Neurofeedback because it is a medication free alternative,
- No side effects,
- Increases the flexibility and resilience of brain.

Our procedure involves analyzing beta/theta ratio to improve the cognitive performance. Our current work gives us a better idea of the neurofeedback training and understanding the complexity of the neural dynamics

- Dr M. Kalaivani is Head of Department, Biomedical Engineering, Jerusalem College of Engineering, E-mail: jaigane263@gmail.com
- Mrs M.S Jeyalakshmi, Assistant Professor, Biomedical Engineering, Jerusalem College of Engineering, Ph : 9500183208
- Mrs M.Thanga Aarthi, JRF, Biomedical Engineering, Jerusalem College of Engineering, E-mail: rthy1488@gmail.com

involved in the self regulation technique. LiminYang states that Beta /theta ratio based neurofeedback training effects on spectral topography on EEG. In this work the subjects were treated for low beta values alpha theta ratio for the improving the cognitive performance by calculating the beta theta ratio using spectral topography technique.[1] NFB training is to teach the brain to obtain an appropriate state and also to hold this state [2]. Numerous studies were conducted for positive effects of NFB training [NFT] [3] in clinical purpose such as neurological or psychological disorders. Each study contributes to a precise performance enhancement [4]. The purpose of this work is to assess the hypothesis of the effect of NFB (the 'awakened mind' model) on the memory performance of subjects aged over 60 for the stress [5]. It deals with the entity's cognitive performance enhancement.

Each cortical activity is associated with the optimum behavior or state [6] and is pertained to one or several frequency bands. Based on their frequency brain waves are divided into 4 categories (delta: 0-4Hz; theta: 4-7Hz; alpha: 8-13Hz; beta: 13-30Hz). In this beta and alpha waves specify their concentration state whereas theta and delta waves are related to dream sleep or unconscious state. These weak electric signals can be measured by scalp electrodes using a conductive paste [6].

NFB training for memory performance enhancement is provided through playing games with positive feedback to obtain the desired brainwave state using LabVIEW. In this participants were trained on beta theta ratio [2]. Subjects were trained to suppress the theta value [4Hz-8Hz] and increase the beta value [2Hz-32Hz] thus leading to cognitive performance improvement [7]. Theta waves are associated with relaxation whereas beta waves are associated with the concentration process, so the subjects could enhance their beta activity [7] and selectively reduce their theta activity. This beta theta training protocol involve the recording of beta and theta wave activity in the electroencephalogram by placing the electrodes in the central, frontal and temporal region.

Numerous methods [4] are there in NFB training for cognitive performance [6] and holding the attentive state. [8] Eugene G. Peniston, Paul. J Kulkosky work dates back to 1989 to experiment about alpha theta training protocol in alcoholics. In this work the session would go for a time duration of 30 mins. Through NFB protocol they were able to decrease the circulation of beta endorphin levels which stimulates stress and caloric intake. Jinn-Rong Wang, Shulan Hsieh has also proved a NFB work relating to attention and working memory performance. In their paper they are considering both normal and elderly persons and their selections was based on attention network test and modified Sternberg recognition task (pretest) and NFB training protocol of twelve sessions were taken in a period of four weeks and a posttest were also considered for the improvement of the subject [2] and in another paper J. Reis A. Portugal, M.R Pereira and N.Dias says the cognitive disabilities in elderly is due to the neuronal interconnectivity and synaptic plasticity, in this paper 14 subjects who are over

55 years were taken as a participant in the NFB training protocol using alpha theta ratio. Their cognitive excellence is identified by neurocognitive tests and psychological tests. EEG signal was taken before and after the session. It's proved that their attentive state is significantly improved by the increase in the amplitude of the alpha wave [9].

Each neurofeedback paper gives a particular concept, some are related to ADHD, dementia, stroke and various cognitive related illness [10], [11]. Kavitha P Thomas, A. P. Vinod and Cuntai Guan explains about the attention skills of healthy individuals. In this proposed training, subjects were asked to play a game with the preset threshold for a period for five days. It is found that the subjects are able to play effectively with the enhanced threshold at the end of the sessions. In this paper they have proved that attention driven games increases the concentration of the subject [11]. They have also explained in another paper of theirs that by calculating the NFT through theta beta training protocol where one will be playing and other will be in a relaxed state. Both EEG signals are acquired and concluded that beta activity increases as the session progresses [12].

Limin Yang, Wenya Nan, Xiaoting Qu, Feng Wan, Pui-In Mak, Peng Un Mak, Mang I Vai, Yong Hu and Agostinho Rosa [13], in this the author briefs about the effect of beta theta ratio training for attention and behaviour enhancement. This study targets the increase in beta theta ratio NFB effects in spectral topography. 25 sessions were carried out and the result proved an improvement in their behaviour and cognitive skills.

Neurofeedback alters the brain activity through neurophysiological method. H.J. Engelbregt, D. Keeser, L. van Eijk, E.M. Suiker, D. Eichhorn, S. Karch, J.B. Deijen, O. Pogarell have explained about a NFB protocol in his paper. In this 25 participants have taken part in this session and each have to undergo 15 sessions for a 3 year follow up. This includes open and closed eye technique test, test for selection criteria and resting state EEG. Finally it is proved that E-NFT improves the beta activity compared to the sham NFT [7].

2 METHODS

2.1 PARTICIPANTS

12 subjects took part in this study. The age group of these subject is 50-70 years. These subjects are competing with the increased stress level [14]. The subjects are selected based on the criterion such as they should be able to sit and see visual cues. They should have the score above 5 in General Anxiety Disorder (GAD) test. NFT is given to the subject with consent of the doctor and participants. These signals are analysed using LabVIEW software which is feedback to the subject in the form of animated videos which can be controlled only by attention related EEG. After 30-40 sessions the cognitive performance increases

2.2 GAD TEST

GAD-7 is a questionnaire to assess the anxiety level of the

participant of this study. Gad-7 aims in measuring the severity of their anxiety level. The subject with the score of 5-9 is considered to be with mild anxiety and with 10-14 is moderate anxiety .In this study participant with moderate to mild anxiety are considered to take part in the session[14].

2.3 EXPERIMENTAL DESIGN

The electrical impulses are produced by billions of neurons in our brain by working together simultaneously .More the neurons synchronous in action more the amplitude of the electrical potential. Faster the neurons higher is the frequencies .The amplitude and frequencies are vital characteristics of the brain wave. Here the amplitude of beta (13-30 Hz), theta (4-7 Hz) are analysed.

The protocol for NFB training is set up after the ethical clearance from Dr.Kamakshi Memorial Hospital,Chennai.The NFB experimental setup is shown in Fig 1.and designed protocol protocol is displayed in Fig 2. The experimental setup consists of EEG amplifier system and digital acquisition system and computer system to display the images and analysis the electrical activity of the brain. Before the placement of electrodes, the scalp and ears are cleaned using Nuprep gel. Ten20 electrode conductive paste is used to improve the conductivity between the skin and the electrode. The electrodes are connected to the BLOKIT amplifier. This amplifies the acquired EEG signal from the patient.The output of the EEG amplifier is connected to DAQ.

The brainwaves of the subject are monitored to assess the individual’s present state.The evaluation is done by measuring the values of beta and theta waves from the acquired EEG signals.This provides real time information to the central nervous system as a feedback based on the present state.The low frequency in the brain is associated with mental inactivity,inattention and drowsiness; whereas the high frequency in the brain is associated with mental activity and attention.By placing electrodes on the scalp the activity from the brain can be increased or decreased to obtain the desired brain waves.Thus the brain learns to function with greater control and stability.Thus NFB works by re-training the brain to increase the beta/theta ratio on its own.

Neurofeedback is a cutting edge technology that uses operant conditioning (reinforcement) to alter brainwaves . It provides information about nervous system and helps to self-regulate more effectively.This is accomplished by placing electrodes to the subject’s scalp so that the electrical activity of their brain is transformed into real time informationand then it is fed back to them.The individual’s brain can then utilize this information to make appropriate changes that often improves brain functioning and relieves symptoms.

The subject is made to sit in front of the visual screen and a definite threshold is fixed which varies for each subject.The subject then concentrates on the screen and the goal is to increase beta waves associated with focused concentration.If the brain waves exceed the fixed threshold,the subject can play the games in an effective manner.Necessary adjustments have to be made to the threshold value so as to enable the subject undergo an effective therapy.

Once the subject gets involved with the therapy,he/she becomes attentive and concentrates in the visual screen and therefore his/her beta/theta ratio increases.During the treatment the subject is highly attentive and focused.

The EEG signals are picked up using scalp electrodes and the signals are visualised using DAQ. These signals are analysed using LabVIEW software which is fed back to the subject in the form of animated videos which can be controled only by attention related EEG.After 30-40 sessions the cognitive performance increases.After the training session, the electrodes are removed and the scalp is cleaned by using cotton. The recorded neurofeedback data is stored for further analysis.

The selected subjects on the above said criterion is made to undergo 40 sessions for 40 days. Each session goes for a period of 30-40 minutes initially.The duration decreases as the session advances.The EEG acquired from the participants is processed. Initial threshold is set

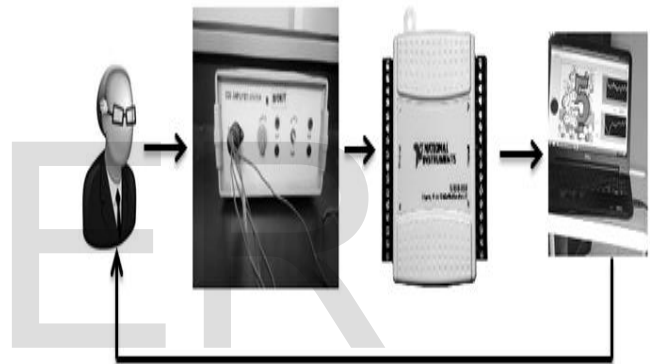


Fig. 1. NFB Training Block Diagram

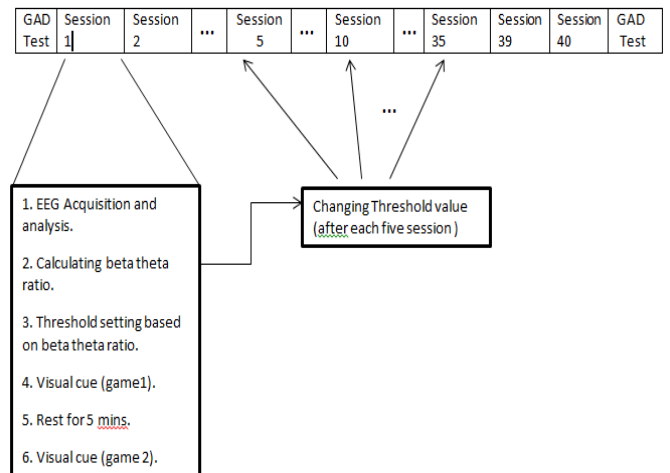


Fig. 2. NFB Training Protocol

2.4 IMAGE SERIES AS POSITIVE FEEDBACK

The beta /theta ratio is calculated and fed back to the gaming environment1 which has 10 images containing a number series in progression .These images turn up from one to another relation to the precise brain signal enhancement when they cross a particular threshold set by the trainer.

Visual cues were identified with the help of the Boolean and beep indicator. If the patient is focused, he/she will see the images moving from one to another without a delay else if the patient loses his concentration, he/she will have a delay till it crosses the particular threshold set by the trainer. This typical session will last till the patient is able to normalize their brainwaves on their own. In initial sessions threshold value set will be a least value but as the sessions go on patient will be trained with the higher threshold value. Then the participant is given a rest of 5 minutes followed by the next visual environment as shown in Fig 3 which contain more number of images. The series of images in the second environment is based on the interest area of the participant. The threshold used in the first visual cue is used for the next cue also. After a set of 5 session threshold of every participant is increased depending on their individual capacity.

video is played. The participant showed keen interest in executing them. Fig 4 shows the handling of the video with respect to the beta/theta ratio. Fig 5 shows the actual visual cue with their EEG pattern



Fig. 3. Image cue



Fig. 5. Video Cue

3 RESULTS AND DISCUSSION

The patterns of brain wave activity vary depending on their mental activity. The Neurofeedback works by helping to restore a better balance of waves from various parts of the brain. The brain waves are acquired by means of an amplifier and processed using LabVIEW program which provide visual feedback.

The EEG acquisition, analysis and visual cue is designed in LABview environment. GAD score is calculated and the subjects are selected. The subject is given NFB training as shown in the Fig 5. The participant are motivated to change the image by concentrating on the screen. For every session the time taken to finish the session and threshold is tabulated. The training session given is shown in Fig 6.

As the session progresses day by day, subjects were also trained in video feedback and given a comparison with the image feedback. Video feedback basically works in a principle such as it was designed with various functions unlike the image feedback it doesn't stop in the present image if the threshold condition was not met. This feedback analyzes the individual's level of concentration and acts accordingly. If the subject's concentration level is low when compared to their level of expectation, video's playing speed comes down whereas if the subject's concentration is little higher than the threshold set by the trainer then the video plays in a normal mode. As the session goes by, when the individual undergoing the training is in a higher concentration level then the video plays in a fast forward mode, this gives the indication that individual's concentration is increased whereas if the subject beta/theta ratio is very low than the threshold set then the video pause till then he/she reaches the particular ratio to attain a slow video state in the least

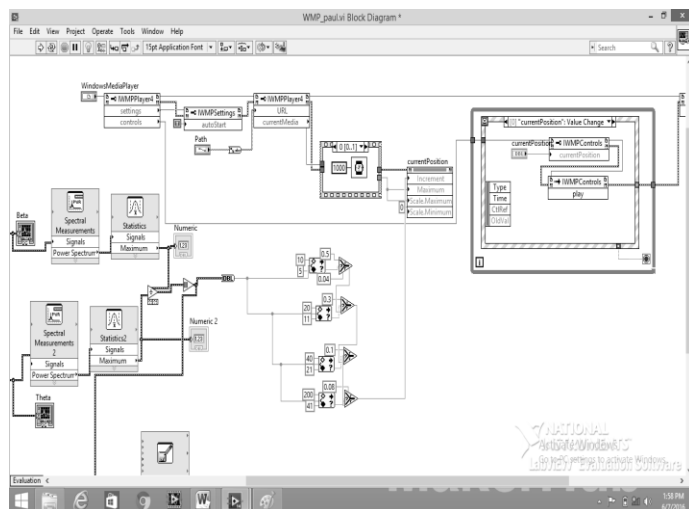


Fig. 4. Video Cue Block Diagram

2.5 ANIMATED VIDEO AS POSITIVE FEEDBACK

Animated video is used as an appreciation instead of changing the image with respect to beta /theta ratio. The beta/theta ratio is used to control the speed in which the



Fig. 6. NFB Recording Setup

The tabulated threshold for image cue and video cue is represented graphically in Fig 7. and Fig 8.

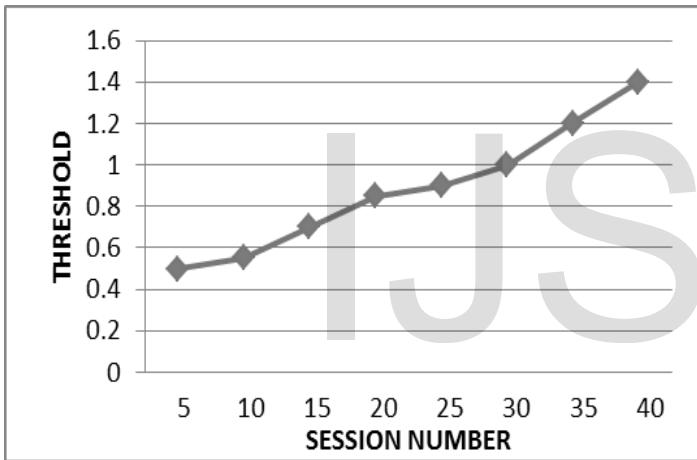


Fig. 7. Threshold plot for Image cue

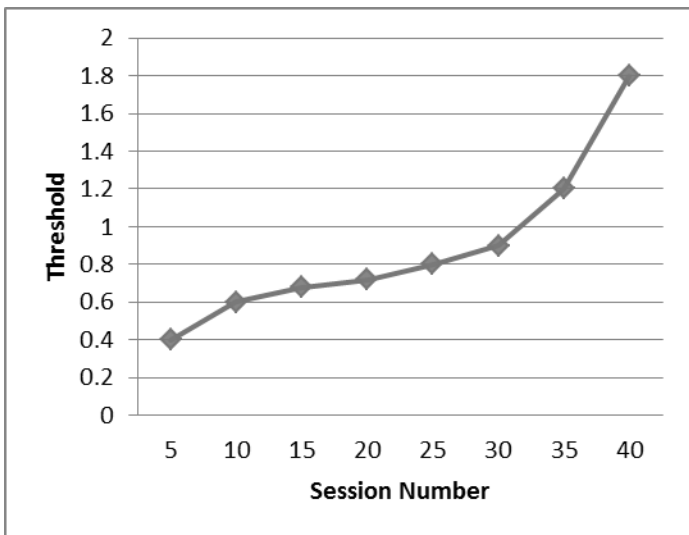


Fig. 8. Threshold plot for Video cue

From Fig 7, Fig 8. we were able to conclude that the stressed elderly showed keen interest in handling the videos than the

images to improve their cognitive performance by increasing the beta waves and suppressing the beta waves even when the threshold for the beta/theta ratio is increased.

Fig 9. shows the comparison of time for image and video cue for a single subject as the session increases the performance of the stressed elderly in improving the beta /theta ratio is also improved much in video cue better than image cue

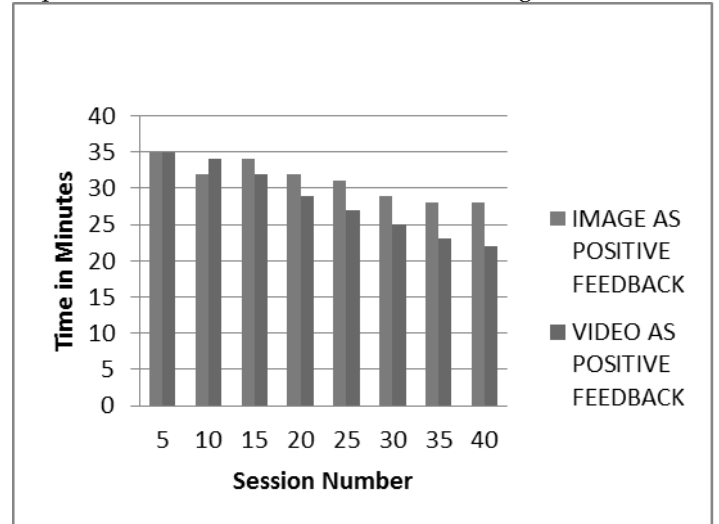


Fig. 9. Time Comparison for Image and Video cue

4 CONCLUSION

The analysis shows that the threshold value is increased and the time taken for completing the session gradually decreased for both image and video feedback for all subjects. When image and video is compared we inferred that the stressed elderly individuals show interest in processing the video rather than the image. The graph also indicated the time taken for the completion of the session using video as a positive feedback was less than the image feedback. This shows that the memory performance increases faster in video processing and has a positive effect to improve the cognitive skills of elderly people.

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