Attention & Relaxation Enhancement using Meditation as an Intervention: A Psychological and Physiological study

A dissertation submitted in partial fulfillment of the requirements for the award of degree of

Master of Engineering
In
Electronic Instrumentation and Control

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DECLARATION

I hereby certify that the work which is presented in dissertation entitled, **"Attention & Relaxation Enhancement using Meditation as an Intervention: A Psychological and Physiological study"**, in partial fulfillment of the requirements for the award of the degree of Master of Engineering in Electronic Instrumentation and Control, submitted to Electrical & Instrumentation Engineering Department of Thapar University, Patiala is as authentic record of my own work carried under the supervision of Dr. Mandeep Singh. It refers other researcher's works which are duly listed in the reference section. The matter contained in this dissertation has not been submitted neither in part nor in full to any other degree to any other university or institute except as reported in text and references.

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It is certified that the above statement made by the student is correct to the best of my knowledge and belief.

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ABSTRACT

Background: Attention is a process of focusing on particular information while ignoring other information. Paying attention makes all the difference, in both professional and personal lives. This cognitive attribute therefore needs to be enhanced. This enhancement can be done with the help of intervention. To measure the enhancement it is essential that the cognitive attribute of attention be assessed before and after intervention. Here in this research work we are observing how the attention of 14 subjects change while performing various attention tasks. Also we are analyzing the change in EEG and task performance for relaxation and attention enhancement after giving meditation as an intervention.

Method: We have taken fourteen subjects and made them perform attention task from The Psychology Experiment Building Language (PEBL). Electroencephalography (EEG) readings of these subjects are taken while they are performing task on PEBL. The EEG readings of these students are also taken while they are doing nothing with closed and opened eyes. The readings with eyes closed and eyes opened are taken as the baseline. Alpha power which is an indicator of relaxation is extracted from EEG and analysed for relaxation. The students are then divided in two groups: 1) Control group consisting of seven students on which no intervention is given. 2) Meditators group consisting of seven students on which meditation is given as an intervention. Similar readings are taken for these students after 15 days. Comparative study is done on the pre and post-intervention psychological and physiological data of both control and meditators group.

Result: It is observed through the scores of psychological tasks that attention of the meditators is improved in various attention tasks after intervention. It is also observed that alpha power increases post-meditation indicating that the meditators’ group is more relaxed while performing attention tasks post-intervention. Therefore we can conclude that meditation improves attention as well as relaxation.

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LIST OF ABBREVIATION

ADHD- Attention Deficit Hyperactivity Disorder

APGR- Appearance, Pulse, Grimace, Activity, Respiration

ECG- Electrocardiography

EEG- Electroencephalography

FFT- Fast Fourier Transform

FDS- Forward digit span

GRE- Graduate Record Examination

GSR- Galvanic Skin Response

HMD- Head Mount Device

HRV- Heart Rate Variability

In- Inion

IQ- Intelligence Quotient

LAN- Local Area Network

LCT-Letter Cancellation Test

Ns- Nasion

PAL- Left Pre-auricular point

PAR- Right Pre-auricular point

PCPT- PEBL Continuous Performance Task

PEBL- Psychology Experiment Building Language

PEPPE- Prevention and Early intervention Programme for Psychoses

PSD- Power Spectrum Density

RDS- Reverse Digit Span Test

RFFT- Ruff Figural Fluency Test

TM- Transcendental Meditation

TTA- Trail making test ‘A’

TTB- Trail making test ‘B’

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CHAPTER 1:
INTRODUCTION

1.1 Neural correlate

The neural correlate of mind is an important concept. It is believed that all mental states are equivalent to states of brain. According to materialists, there is a direct neural correlate of all properties attributed to the mind including consciousness, emotion, beliefs, and desires. This pragmatic view has been adopted by many scholars [1]. While other neuroscientists feel that minds inaugurates actions which are causal in nature, rather than exclusively being able to merely continue previously initiated causal sequences. These neuroscientists describe mind as percipient agency, the mind's very agency or causal aptitude being deemed unrelated to any neural correlate [1]. Neural correlate of attention shows how attention is represented by brain cells. A neuron has a definite response to a stimulus when the animal is not attending to it. This neuron's response will be enhanced when the animal does attend to the stimulus, even if the physical characters of the stimulus remain the same [1].

1.2 Cognition

Oxford dictionary defines cognition as the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses [2]. In science, cognition refers to mental processes. These processes include attention, memory, solving problems, making decisions, calculations, producing and understanding language reasoning.etc Cognition is studied in various disciplines such as linguistics, psychology, science , philosophy and computer science [3]. Thus, Cognition may be defined as the process that organism uses to organize information. This includes selection (attention), acquiring information (perception) retaining information (memory), representation (understanding), and using it to guide behaviour (reasoning and coordination of motor outputs) [4].

1.3 Attention

Attention is the behavioural and cognitive process of concentrating on a discrete aspect of information, whether subjective or objective, ignoring other perceivable information. Attention is also referred as the allocation of restricted processing resources [5]. Attention can be divided majorly into 3 parts:

1. Sustained attention
2. Selective attention
3. Divided attention

1.3.1 Sustained attention

It is an ability to direct and focus your cognitive abilities on to a specific task or stimuli. In order to complete any planned activity, any series of action or an idea, sustained attention is used. For example: the act of reading newspaper article. To complete the task of reading the newspaper one must focus on reading the article long enough. Problems occur with distraction. A distraction can interfere in sustained attention. Sustained attention enables a person to stay on one task for long period of time. The attention of the person in this case does not move away from a given task.

1.3.2 Selective attention

This type of attention in other words can be called as "freedom from distractibility". It enables a person to focus on the task even when distraction is present. It can also be called as the ability to maintain a behavioural or cognitive set in the face of competing or distracting stimuli. For example: While playing in the field, a player should selectively focus on the game while ignoring other factors like noises, tension and anxiety.

1.3.3 Divided attention

It is considered as the highest level of attention. It is the ability to respond simultaneously to many tasks. It is also called as multitasking. Multitasking can be defined as the attempt to perform two or more tasks simultaneously; however, research shows that when multitasking, people make more mistakes or perform their tasks more slowly [6] because in that case attention is divided among all the component tasks to perform them. Vast research on selective attention is being done on students while they were doing two tasks simultaneously. Study was done on subjects who were doing two tasks together, like driving and listening to the radio or attending a phone call. It was found that human attention system has limits to what it can process. Driving performance of human is reduced if he is engaged in some other task simultaneously like listening to music or attending a phone call. Multitasking while driving thus increases the risk of accidents.

1.4 Neural correlate of attention

Neural correlate of attention is enhanced firing. It is found that a neuron has specific response to a stimulus when an animal is not attending to it. This response to stimulus is enhanced when the animal is attending to the stimulus even though the stimuli's physical characters remain the same. Four processes that are fundamental to attention are:

(i) Working memory
(ii) Top-down sensitivity control
(iii) Competitive selection
(iv) Automatic bottom-up filtering for salient stimuli.

All the above processes make an important contribution to attention.

Working memory is a highly dynamic memory that temporarily stores information for processing. Competitive selection is a selection process in which the information competes among them for accessing the working memory. The information with higher signal strength gets access to working memory. Top down sensitivity control regulates the signal strength of information that is competing among them for access to working memory. Salient filters automatically enhance the strength of those signals which are infrequent in time and space or are of learned biological importance. All this leads to increased behavioural sensitivity and shortened response latency and other cognitive benefits associated with attention. The proposed framework of attention is inspired by the model of Desimone & Duncan (1995) and Miller & Cohen (2001) and is shown in Figure 1.1.

The central nervous system contains important information of the world like memories and inner state of the animal. The information which will gain access to the working memory is selected by a competitive process from this collection of information on the basis of relative signal strength. Signal strength reflects the collective effects of the quality of set information, top-down bias signals, and bottom-up salience filters. Information with the greatest signal strength enters the circuit of working memory and competes with already existing information for control over working memory. The information that controls working memory directs top-down bias signals as well. These signals modulate the signal strengths of appropriate ascending representations which forms a recurrent loop that underlying voluntary attention [7].

Processes contributing to attention have been shown in red. World information (green ellipse) is transduced by the nervous system and is processed by salience filters that react differentially to rare or significant stimuli (bottom-up). Neural representations in many hierarchies programme information about the world, actions, memoirs, the animal's emotional state, etc. The competitive process selects the depiction with the maximum signal strength for entry into the circuit underlying working memory. Working memory directs top-down bias signals which amend the sensitivity of representations being processed in working memory. The selection process also directs top-down bias signals that reflect competitive selection results. Working memory and competitive selection direct movement of eyes and other orienting behaviours that alter the effects of the world on the nervous system of animals. Corollary discharges linked with eye movement control transform sensitivity control. Deliberate attention involves working memory, top-down sensitivity control, and competitive selection working in a recurrent loop (dark arrows) [7].

1.5 Relaxation and alpha waves

Relaxation is a state of being anxiety and tension free. It is refreshes your mind and body. Alpha wave of brain is associated with relaxation. Increase in alpha waves increases relaxation and reduces anxiety and tension. People who are more stressed become incapable of producing alpha waves. Increase in alpha wave balances mood, calms down the mind, increases creativity, daydreaming, immune system, peak performance, positive thinking, problem-solving capacity, super learning and visualization [8].

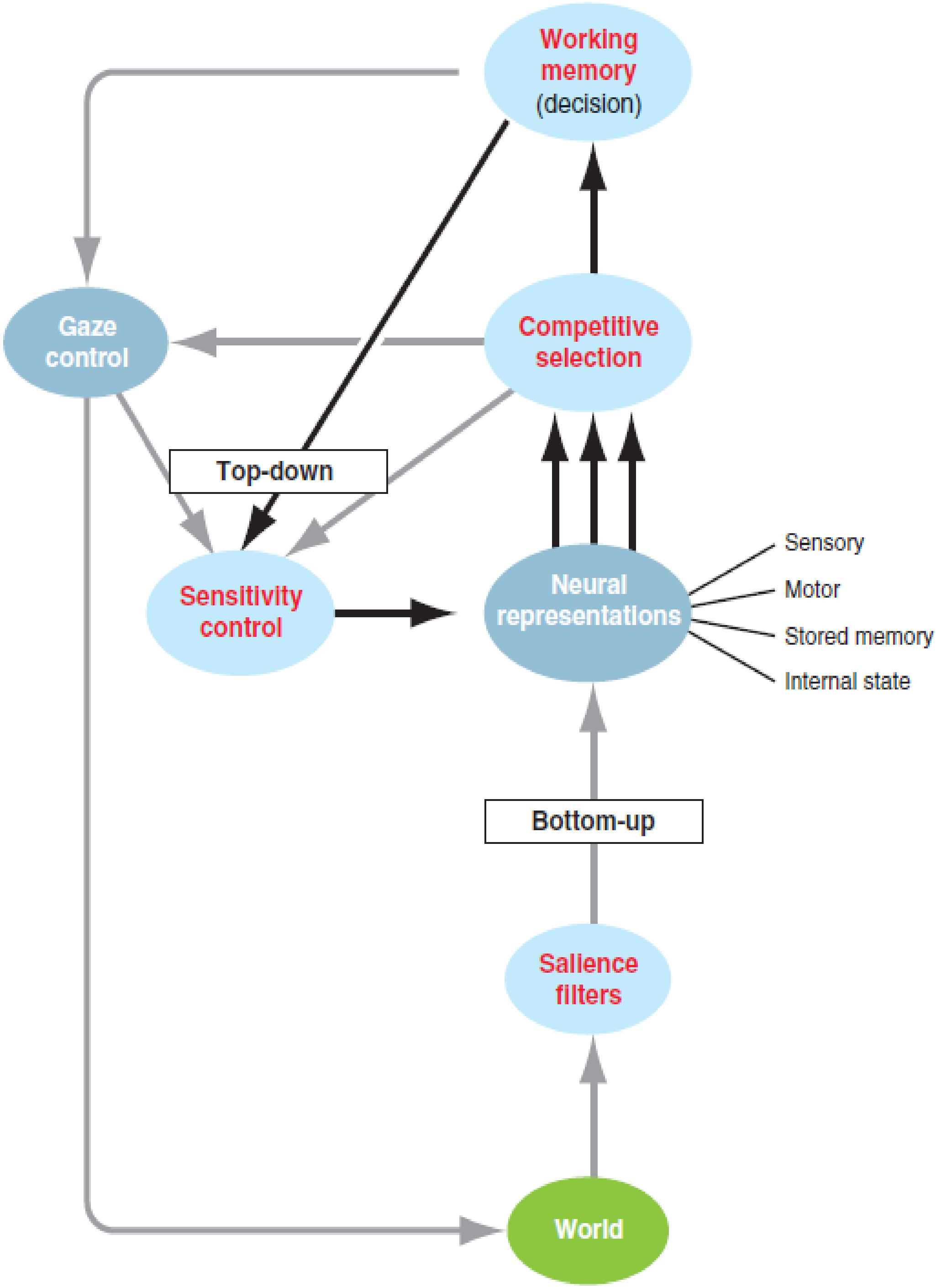


Figure 1.1: Functional components of attention [7]

CHAPTER 2:
ATTENTION ASSESSMENT

2.1 Cognitive assessment

Cognitive assessment is an examination that is conducted to determine level of cognitive functioning of brain [9]. Cognitive assessment is broadly divided into two groups:

1) Psychological assessment

2) Physiological assessment

2.1.1 Psychological assessment :

In psychological assessment the candidate who is to be assessed is made to undergo various tests. Performance of the candidate in the task produces the task score that determines how well the candidate performed in the task. It also gives an idea of psychological parameters like response time of an individual.

Such assessment can be done with paper-pencil or with the help of psychological test batteries available like Psychological Experimental Building Language (PEBL), Prevention and Early Intervention Program for Psychoses (PEPP) etc.

We have used PEBL for psychological assessment of the subject. The subjects are made to undergo 3 psychological tasks related to different types of attention.

1. PEBL continuous performance task (PCPT): For selective and sustained attention.
2. Go/No-Go: For sustained attention and selective attention.

1) PEBL continuous performance task (PCPT):

A continuous performance task (CPT), is a psychological test that measures sustained and selective attention. It is a 14 minutes long task in which the participant is supposed to respond to all the characters using space bar except for ‘X’.

Given in Figure 2.1 is the instruction that appears on the screen before the PCPT task starts.

You are about to take part in an experiment that involves attending to stimuli on a screen. It will take approximately 14 minutes. You will see letters presented on a screen briefly. Your goal is to press the spacebar as quickly as possible after each letter, except if the letter is an 'X'. DO NOT RESPOND to X stimuli. To begin, press the spacebar.

Figure 2.1: Instructions for performing PCPT

Given in Figure 2.2 is the screenshot of how a single alphabet will flash on the screen during PCPT.

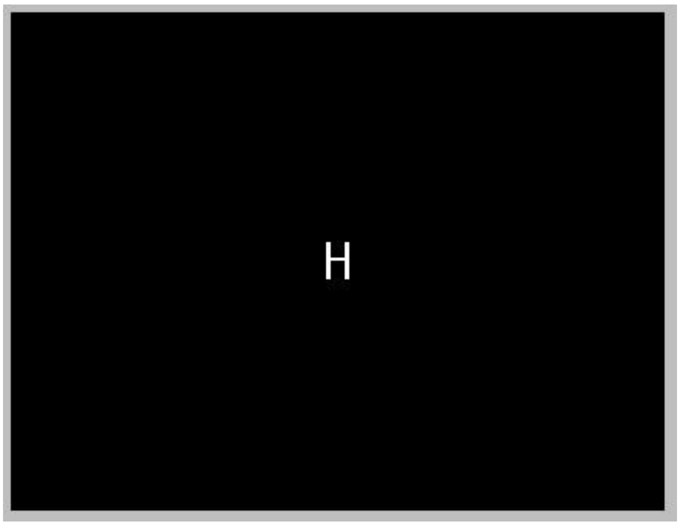


Figure 2.2: PCPT Screenshot

2) Go/No-Go:

It is also a task for selective and sustained attention. This task is carried out in two phases. Both the phases are 4 minutes long. In the first phase, the participant is supposed to respond only to ‘P’s flashing on the screen and ignore ‘R’s. We will call this task Go/No-GoP. In the second phase, the participant is supposed to respond only to ‘R’ appearing on the screen and ignore ‘P’s. We will call this task Go/No-GoR. Go/No-GoR is more difficult to be performed than Go/No-GoP as the task is immediately performed after Go/No-GoP and has instructions completely opposite to Go/No-GoP therefore it takes time to unlearn the instructions of Go/No-GoP and learn instructions of Go/No-GoR

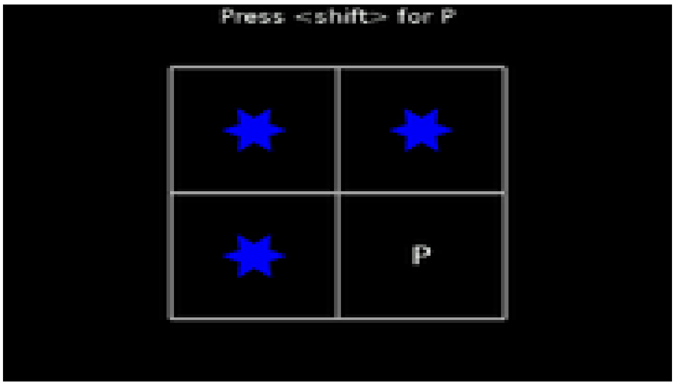


Figure 2.3: Go/No-Go task

2.1.2 Physiological assessment

Cognitive assessment can also be done by using Physiological methods like Electroencephalography (EEG), Electrocardiography (ECG), Galvanic skin response (GSR), Heart rate variability (HRV) etc. [10]. EEG which was previously used for detecting pathological conditions is nowadays used to quantify emotions. [11]. EEG is used to acquire neural activity from the scalp of a person in a non invasive manner with the help of electrodes. The EEG signal is de-noised and processed and various features are extracted from the signal like alpha, beta, delta and theta. It is found that activity in different regions of brain changes when the task is performed. As in case of attention task power of theta, beta 2 band decreases and alpha 2 increases and with age power of frontal theta increases [12-13]

Andrzej Wróbel showed that enhanced beta activity takes place during attentive visual behaviour which further leads to gamma oscillatory events. Beta bursting activity spreads to various visual centers including lateral posterior and pulvinar complex and higher cortical areas. They put forward the hypothesis claiming appearance of oscillation within alpha beta and gamma bands to different activation of visual system. According to this hypothesis, alpha activity characterizes idle arousal of the system, while beta bursts shift the system to an attention state that consequently allows for gamma synchronization and perception [14].

KooHyoung Lee carried out the experiment on archer's to find out their attention and meditation level. Attention and meditation level is used to define a person's attention and relaxation level during a particular task. The task was conducted on elite, mid-level and novice archers. EEG of the subjects were recorded during shooting process with the help of device with single dry electrode which can be comfortably worn on the forehead without any discomfort while the task is being performed. It was found that elite archers showed increase in both attention and meditation level whereas the mid-level archers showed increase in attention level but decrease meditation level. Thus the level of attention and relaxation were used in Koo Hyoung's paper to categorise archers and give feedbacks in training [15].

Ning Han-Liu et al. presented a paper on recognising the degree of human attention using EEG signals for mobile sensors. The EEG device employed for this study was *Mindset*. In this paper he chose 24 subjects, 12 males and 12 females. The EEG of the subjects was taken in two scenarios. One while performing English test in an attentive environment and one where distraction is provided to the subject who is listening to English phrases by people talking in the background. Video of the subject was taken while he was giving test. The researcher along with subject reviewed the video to tell whether the subject was attentive or not. The places where the subject couldn't judge whether he was attentive or not were discarded i.e. EEG datum for that particular instance was rejected. After removing ambiguous data, 2400 samples each were randomly selected for attentive and inattentive data. EEG signal were converted to energy to classify attentive and inattentive data. The study inferred that the EEG data obtained from different subjects possess identical and similar features which are easier to recognise. The classifier thus developed can be used in multimedia or distant learning. Whereas in case of inattentiveness of student, teacher will be able to adjust teaching content, alert the student to remain attentive [16].

Kridsakon Yaomanee et al. presented a research to find appropriate locations of brain for detecting EEG signals during attention tasks. Three experiments were constructed for this purpose. All 3 experiments made the examiners centre on the definite task to arouse attention. Alpha waves were detected at AF3 and F7. The recommended locations for acquiring Beta wave were FC6 and F8. It was also shown that Alpha wave in the relaxation state was higher than Alpha wave in the attention state and Beta waves in the attention state are higher than Beta wave in the relaxation state [17].

CHAPTER 3:
ATTENTION ENHANCEMENT

3.1 Attention enhancement as a concept

The main aim of attention enhancement is to improve the attention of a person through external interventions.

Attention enhancement can be broadly classified into two categories:

1) Restorative

2) Facilitative

3.1.1 Restorative attention enhancement

This type of attention enhancement technique aims at regaining the attention which has reduced as compared to what it was in the past. This might be due to some neuropsychiatric conditions like Attention Deficit Hyperactivity Disorder (ADHD). This type of enhancement technique is more of a therapy given after a disease.

3.1.2 Facilitative attention enhancement

This type of attention enhancement technique aims at improving the level of attention as compared to the present level of attention. This technique is more like an exercise done by a healthy individual so as to improve fitness.

3.2 Delivery of Attention Enhancement

The aim of attention enhancement techniques is long term enhancement of attention. Following are the ways in which we can maximise the possibility that the intervention is working and is effective:

3.2.1 Dosing

To evaluate the efficacy of interventions for attention enhancement dosing along with its time and duration is to be considered. Interventions can be of two types. They are remedial and pharmacological. Both these interventions have dosing considerations. Pharmacological interventions are administered daily while remediation interventions are administered in session of limited duration. Frequency of these sessions may vary from once in a day to twice or thrice in a week.

In case of remediation intervention, the individuals taking part in facilitative intervention may be highly motivated and may be able to train themselves without any assistance or external motivation daily. However, the person undergoing restorative attention enhancement may not be able to carry out the session all by him and will need assistance of a trainer. This might also limit their frequency of sessions.

Depending on contents and characteristics of medications used for enhancing attention their dosage requires adjustments and consideration. Drugs with short term effectiveness are required to be taken more often while some injectibles are taken at a frequency of 30 days.

3.2.2 Duration

The intervention needs to be continued until any response or futility is acknowledged. Futility is an issue when the intervention has side-effect or has high cost of acquisition. Some drugs may have greater risk with higher doses or long duration of medication. In this case the risk-benefit ratio for remedial intervention is comparatively small. The duration of the trial will be affected by desired treatment outcome. Duration can be changed on the basis of intermediate assessment of an individual’s attention.

3.2.3 Maintenance

After the intervention is given and treatment is completed successfully, the uncertainty that arises is whether the enhancement is temporary or permanent. Most of the drugs do not have restorative effect i.e. the enhancement will be seen only until the medication is continued, especially in case of patients with established illness.

Long-term treatment strategy for attention enhancing intervention may lead to persistent changes. These persistent changes may be as a result of change in neural plasticity of brain which in turn changes the brain function

3.2.4 Adherence

Since the remediation intervention is often delivered in person and can be tracked down easily, its adherence is easy to point. Adherence to pharmacological interventions is difficult to be indexed as one might not confidently say that attention enhancement is associated medications [18].

3.3 Attention enhancement techniques

Many methods have been followed for years to enhance cognition. For example: drinking of caffeine to improve attention.

Cognitive enhancement techniques are broadly classified as:

1) Psychological Intervention

2) Medical Intervention

3.3.1 Psychological intervention

Psychological intervention includes brain training through games, strategies, education and learning. This is a conventional type of intervention as it does not have any side-effects and is widely accepted.

1) Training

In this the brain is trained and educated in a way to enhance attention.
Rui Nouchi et al. studied the beneficial effects of brain training games (brain age) and their transfer effect to various cognitive functions. They recruited 32 volunteers and randomly divided them in group of 16. One group was selected to play Brain Age while the other played Tetris. Participants in both the games were asked to play for 15 minutes, at least 5 times a week for 28 days. Cognitive functions were measured before and after the training. It was found that the brain training game improves supervisory functions, working memory, and processing speed in young people. The popular puzzle game can cause improvement in attention and visio-spatial ability in comparison to playing the brain training game [19].

Baek-Hwan Cho et al. developed cognitive teaching tasks using VR technology. He took thirty subjects and assigned them into three groups: VR, non-VR and the control group. The VR group made use of the head-mounted display (HMD) and position sensor whereas the non-VR group used nothing. Both the VR group and non-VR group performed the training while the control group received no special training. All the participants took eight session tasks over 2 weeks. Participants were made to perform continuous performance task (CPT) before and after the training sessions. It was found that immersive VR with cognitive training affects attention enhancement. It confirmed that our cognitive training can develop the attention span of children with behavioural issues and help them focus on some tasks [20].

Mental training and visualization techniques are practiced in various sport and rehabilitation so as to improve performance. In this, the sportsman imagines himself performing a task like running a race, repeatedly imagining each and every movement and also how it feels. Such exercise activates those set of neuron which are activated while the game is being played actually, thus hardwiring the neuron chain involved when the sport is being played. This hardwiring of neural network is called neuroplasticity. Thus the performance improves due to optimization of neural network [21].

2) Education

What we learn in school is “mental software” for managing different cognitive domains: reading, writing and understanding language, problem solving in particular subject like mathematics etc. This type of mental software reduces mental load by clever encoding, organization, or processing [22]. From Wikipedia, education is defined as a form of learning through teaching, research or training group of people transfer skill, habits and knowledge from one generation to the other. Education can be considered as an experience which has effects on the way someone thinks, acts or feels. Education is conventionally separated into five stages starting from preschool, then primary school, then secondary school, then college, then university or apprenticeship [23]. Education enhances cognitive abilities including attention. To improve the speed or efficiency of performance for any particular task special efforts are to be made. Abacus is a simple mechanical calculation device used to store numbers during mental calculations and increase the speed of calculations. In abacus, the beads are moved up or down on various rods to simplify the mathematical calculations involving subtraction, addition, division, multiplication, etc. With education and training of abacus the person is able to solve mathematical problems without using any physical abacus, by mentally picturing the abacus in hand. Children trained to do calculation with this technique are able to do calculations faster than those done with the help of electronic calculators. Learning mathematical problem solving this way can therefore be classified as a cognitive enhancement technique.

3) Enriched Environment

It is a technique by which we can enhance cognitive ability like attention. Enriched environment is the stimulus for brain by its social and physical surroundings [24].

There are various ways of enriching the environment around us. This includes learning new games like – chess, poker, listening to music, learning musical instrument or a new language. Travelling is another way to enrich the environment. Travelling provides enrichment as it breaks a person's daily routine and provide a new routine both for him and for his neurons.

Studies have shown positive effect on the brain of animals which lives in enriched environment. A single rat in normal cage was compared with a group of rats in a cage with toys, ladders, running wheels. It was found that growing up in enriched environment affects enzyme cholinesterase activity and hence helps neurons to return to their resting state after activation, thus relieving stress [25].

Stimulation-seeking children, who are creating enriched environment for themselves get higher score on Intelligence Quotient (IQ) test and perform better at school than less stimulation seeking children [26]. It is recommended that cognitive ability of children might improve if they are provided an enriched environment that makes learning and exploring much more appealing for them. Enriched environment also makes brain more resilient to stress and neurotoxins [27].Some of the interventions have both cognitive enhancement and therapeutic effects. For example, an optimized enhanced environment will help avoid specific pathology and deficits apart from promoting the growth of the developing nervous system to enhance its core capacities [4].

Dr. T Mythily-chief music therapist, Apollo hospital, Chennai has reported that music ensures smooth delivery and increases the chance of high attention, grasping concepts and mathematical abilities, spatial and depth perception and significantly high APGR scores (calculated on five simple criteria Appearance, Pulse, Grimace, Activity, Respiration) of children. She believes that prefrontal lobe facilitates efficient and easy learning and application of intelligent thinking and it also develops rapidly in foetus in the womb of mother by providing music stimulation. These babies are ahead of most their counterparts in every field in life

3.3.2 Medical Intervention

Medical intervention on the other hand is labelled as unconventional as they make use of certain drugs, gene therapy and neural implants which are still in the phase of experimentation.

1) Drugs

Drugs like nicotine and caffeine are most commonly used to enhance cognition. Diet and dietary supplements can also enhance attention. For example, continuous working of brain requires glucose which is the most essential energy source. Increase in glucose availability in brain also improves memory [28].

Also the nutrient that improves energy availability increases the overall cognitive performance and reduces mental fatigue [29]. Food not only provides energy, it also contributes to cognition by providing amino acids required in the manufacture of neurotransmitters, which is mostly important during stress or sustained attention.

Attention can also be modulated by a variety of drugs. For example, Modafinil which was originally developed for treating narcolepsy, and can be used to reduce performance decrements which occur due to sleep loss with small side effects and slight threat of addiction [30]. This drug improved attention in sleep-deprived physicians.

There are variety of drugs used for increasing concentration and stamina for studying or cramming. These drugs are called “study drug”. Study drugs are prescription stimulant like Adderall and Ritalin which are used improperly by a person with a prescription or illegally by a person without any prescription [31]. Attention Deficit Hyperactivity Disorder (ADHD) and Attention Deficit Disorder (ADD) which affects impulse control, attention span, hyperactivity and self-discipline can be treated using this medication. For people with ADHD or ADD this medicine has calming effect. For people without such illness this might cause euphoria and restlessness because these people already have dopamine.

2) Gene Therapy

It is the therapeutic delivery of nucleic acid polymers into a patient's cells as a drug to treat disease. The polymers are expressed as proteins. They interfere with protein expression and possibly correct genetic mutations [32]. In rats and mice it has been demonstrated that gene modification leads to enhanced memory. NR2A, which is linked with low plasticity of brain (neuroplasticity is the ability of brain to change based on new experience). While normal animal is growing up, synthesis of NR2B is replaced by NR2A; therefore memory is low in adult animals. The NR2B ‘‘Doogie’’ mice showed improved memory performance, in terms of both acquisition and retention [33].

CHAPTER 4: MEDITATION

4.1 Meditation

Meditation is defined as a practice in which an individual trains up his mind and induces consciousness to realize some benefit or for the mind to acknowledge its content [34]. It can also be defined as a state of thoughtlessness with full awareness. It involves internal effort to self regulate and control the mind.

4.2 Origin of word Meditation

In the Old Testament of bible, hāgâ means to murmur or sigh, to meditate [35]. When the Hebrew bible was translated into Greek the word hāgâ became the Greek word melete, and when bible was translated into Latin it became Latin word meditatio [36]. Meditation is derived from meditatio, meaning to think, contemplate, devise and ponder [37]. Meditation is also referred to as dhyāna in Buddhism and in Hinduism, it comes from Sanskrit root dhyai, meaning to meditate or contemplate. It is also referred in Jewish kabbalah, Islamic Sufism, Christian hesychasm and many other traditions. Meditation was introduced as a translation for eastern spiritual practices. The practice of mediation has a pre-historical origin. Its history is closely bound up with the religious context with in which it was practiced [38]. The earliest references to meditation are seen in the Hindu Vedas during the Vedic period (Iron Age India) [38]. Around 6th to 5th centuries Before the Common Era (BCE), other forms of meditation developed are Buddhist in India and Taoist in China.

4.2 Types of Meditation

Though the meditative practices have existed for centuries but the use of meditation has increased in the last few decades particularly in the east due to increase anxiety and stress in modern life. There are different kinds of meditation to relax body and mind and to keep them healthy.

Apart from spiritual growth meditation can be used for many other purposes:

1) Meditation for anxiety

2) Meditation for pain relief

Different types of meditation practices have evolved from various religions like Hinduism, Buddhism, Christianity and Jainism and can be classified as follow [39]:

1) Concentrative meditation

2) Reflective meditation

3) Mindfulness meditation

4) Creative meditation

5) Heart-centered meditation

4.3.1 Concentrative Meditation

This type of meditation is the heart of all the other types of meditation. In this mediation the focus is mainly on building concentration. Concentration is very important in this type of meditation because you need to learn to concentrate and control your mind in order to gain the benefits of meditation. This allows your mind to awaken beyond your sense of self. It positively affects all the beings and can lead to wellness and greater goods. Concentrative meditation includes several other types of meditation which helps overcome distraction from within and outside your mind and increases mental focus.

Different types of meditation techniques which involve concentration as its core practice are as follow:

1) Zen meditation
2) Transcendental Meditation
3) Om meditation
4) Shine Meditation or Samadhi
5) Chakra Meditation

Zen meditation

Zen or zazen is a meditative discipline that gives you insight into nature of existence. Zazen or zenis considered the heart of Japanese Soto Zen Buddhist practice. The aim of zazen is sitting and suspending all any judgemental thinking and letting ideas, words, thoughts and images pass without getting involved in them. In this meditation the person sits with his legs and hands folded and spine erected. The hands are folded in a Mudra over the belly. The practitioner breathes from the centre of gravity of belly called the 'hara'. Eyelids are half close so that the person is neither distracted by the external stimuli and nor does it turn away from it. In initial stages of training in zen usually emphasizes on concentration by keeping a focus on the breath at the hara, which is often aided by counting. The counting meditation is called susokukan and it has several variations. This practice builds concentration or joriki [40].

Transcendental meditation

Transcendental meditation can also be called as mantra meditation. It is used for relaxation and self-development. It makes use of sounds and mantra and is practices for 15-20 minutes twice per day with eyes closed. It is one of the most widely practiced meditations. This practice is centered on repetition of mantras. However, unlike other mantra mediations, any one does not concentrate on the meaning of mantra but is trained to appreciate the sound value of the mantra at more refined 'levels' [41].

Chakra meditation

In Hindu traditions and other belief systems, a chakra is an energy point or node in the subtle body (not physical body). Chakra is the meeting point of the subtle channels of energy called nadis. These Nadis are channels in our subtle body (non-physical) through which the life force (prana) or vital energy begins to flow. There are many chakras in the subtle body of human being according to the texts, but there are seven important chakras.

- Sahasrara: It is denoted by a lotus with thousand multi-coloured petals and is located either at the crown of the head or above it. It is represented by the colour white and it involves issues such as inner wisdom and the death of the body. Its similarly to that of the pituitary gland which secretes hormones to connects to the central nervous system(CNS) via the hypothalamus [42].

- Ajna: It is called the third-eye chakra and is symbolised by a lotus with two petals. It is represented by violet, indigo and deep blue but it is traditionally described as white. It is linked to the pineal gland which may inform a model of its envisioning [42].

- Vishuddhi: It is the throat chakra and is depicted by a silver crescent in a white circle with sixteen light or pale blue or turquoise petals. It is related to growth and communication through expressions. It is paralleled to thyroid gland which is located in the throat and produces thyroid hormone, which is essential for growth and maturation. Vishuddha governs communication physically, independence emotionally, fluent thought mentally and governs a sense of security spiritually [42].

- Anahata: It is the heart chakra and is symbolised by circular flower with twelve green petals which are called the heartmind. It is related to the thymus which is located in the chest. Thymus is responsible for fending off disease and may be adversely affected by stress. It is related to green or pink color [42].

- Manipura: It is the solar plexus/navel chakra and is symbolised by a triangle pointing downwards with ten petals in yellow color. This chakra is related to the metabolic and digestive systems. It is paralleled to Islets of Langerhans which are groups of cells in the pancreas, the adrenal cortex and the outer adrenal glands [42].

- Svadhishthana: It is the sacral chakra which is symbolized by a white lotus which has in it a crescent moon with six orange petals. It is situated in the sacrum that corresponds to the testes or the ovaries that produce the different types of sex hormones which are involved in the reproductive cycle. Svadhishthana deals with key issues like relationships, pleasure, violence, addictions and basic emotional needs. Physically, Svadhishthana governs reproduction physically, creativity mentally, joy emotionally and enthusiasm spiritually [42].

- Muladhara: It is the root chakra and is denoted by a red lotus with four petals. It is situated in coccygeal region at the base of the spine. It relates to the gonads and the adrenal medulla which are responsible for the responses like fight and flight. It is related to basic human potentiality, survival, security and instinct. It governs sexuality physically, stability of mind mentally and emotionally it governs sensuality and spiritually it governs a sense of security spiritually [42].

Figure 4.1 shows seven basic chakras in our body.

Figure 4.1: Seven Basic Chakras in our Body.

The chakra meditation works on cleaning of these chakras for mind and body wellness.

4.3.2 Reflective meditation

It is also known as analytical meditation and works on disciplining your thoughts. For starting reflective meditation you need to choose a question or topic and focus your analysis or reflect upon it. In the beginning your thoughts may wander from one topic to another but you need to train your mind to come back to the original topic in question. To do this you need to learn to concentrate. With practice your mind will be controlled in some time and will not wander here and there. It calms your mind, stimulates transformative power while giving you great conviction and strength to change your way of life [39].

There are many questions to focus and reflect upon:

- Who am I?
- What is the true purpose of my life?
- What is my role in this universe?

- How can I be a help to others?

4.3.3 Mindfulness meditation

Mindfulness meditation emphasises on building a receptive and mindful attention toward any object or action within a sphere of influence. This meditation is said to provide relief in pain and help those suffering from depression and anxiety. In this meditation any kind of thought, feelings and sensations are allowed to arise while maintaining a specific attentional stance: awareness of the phenomenal field as an attentive and non attached observer without judgment or analysis [39]. Different techniques which are present in this category that you can practice are:

- Vipassana meditation
- Deep breathing meditation
- Body scan meditation
- Visualization meditation
- Mindful breathing
- Mindful eating
- Sitting Meditation
- Walking Meditation

4.3.4 Heart-Centered meditation

It is also known as heart chakra meditation. In fills your heart with love and compassion. This type of meditation targets the heart chakra and aims at opening the heart chakra. This type of meditation is done in a quiet place, sitting in right posture and focussing on your while taking deep breathes slowly but smoothly. Through this meditation technique you can connect your heart to heart of someone who is compassionate [39].

4.3.5 Creative meditation

This form of meditation enables you to cultivate and strengthen different qualities of mind. Its main focus is on strengthening qualities such as love, joy, empathy, gratitude, compassion, appreciation, humility, fearlessness, and tenderness and patience among others. In creative meditation the practitioner is allowed to create or visualise places, things which brings positive effect on his mind.

4.4 Attention enhancement using meditation as an intervention

Meditation has been used around the world for attention enhancement. Many research papers have been published around the world validating that meditation has a positive effect on attention. Following are some papers validating the same:

Randye J. simple studied the effect of Benson technique. . Benson technique was developed by Herbert Benson, M.D in Harvard Medical School. This technique follows mindfulness mediation on four components of attention (sustained, vigilance, concentration, inhibition of distraction and execution). Three groups were taken: first group performed mindfulness meditation, second group performed a modified Progressive Muscle Relaxation (PMR) procedure and the third group was taken as control group. Meditation was practiced 20 minutes twice a day for 4 weeks and it was seen that the first group (mediators) shows significant improvement in mindful attention than relaxation or the control group. The assessment of attention was made using Continuous Performance Test, Stroop Test, Digit Symbol Substitution, Spielberger State-Trait Anxiety Inventory and Profile of Mood States before and after intervention. [43].

Fadel Zeidan et al. examined the effect of short term meditation that uses basic Shamatha skills, a mindfulness meditation for enhancing cognitive abilities. In this subjects were divided into 2 groups. First group was asked to perform mindfulness meditation for 20 minutes daily while the second group which was taken as control group listened to audio book The Hobbit by JRR Tolkien. The intervention was given for 4 days. In the first and second session, the focus was maintained on flow of breath occurring on tip of nose, in second and third sessions focus was maintained on full breath and in last session whatever learnt in previous session was repeated, but the greater time was spent in silence. It was assessed that after 4 days mindfulness training significantly increased sustained attention. Such findings suggested that brief meditation training also give benefits that have been found with long term meditation. Assessment of these cognitive abilities was made using Controlled Oral Word Association Test, Symbol Digit Modalities Test, Forward and Backward digit span and computer adaptive n-back task before and after intervention [44].

VK Sharma studied the effects of Yoga on cognitive functions like memory, vigilance and anxiety levels. In his study 30 patients suffering from Major Depression in age group of 18 to 45 years were randomly divided into two groups:

Group 1: This group has 10 males and 5 females who practised Sahaj Yoga meditation and also took usual anti-depressant medication.

Group 2: This group has 9 males and 6 females who only took usual antidepressant medication.

Group 1 patients were made to take Sahaj Yoga practice for 8 weeks. Pre and post tests were taken on neuro-cognitive test battery consisting of Letter cancellation test (LCT), Trail making test 'A' (TTA), Trail making test 'B'(TTB), Ruff figural fluency test (RFFT), Forward digit span (FDS) & Reverse digit span test (RDS) for assessing cognitive domains like attention span, visuo-motor speed, short-term memory, working memory and supervisory functions. After 8 weeks, both Group 1 and Group 2 showed significant improvement in LCT, TTA & TTB but improvement in LCT was marked more in Group 1 subjects. The results showed that Sahaj Yoga practice in addition to the improvement in various other cognitive domains [45].

Adam Moore et al. studied the effect of mindfulness meditation on cognitive flexibility; self reported mindfulness along with other attentional functions. Selected subjects were divided into 2 groups. First group was taken as meditators group and the second group was taken as Meditation- naïve control group. In meditation group, subjects were Buddhist meditators taken from Buddhist centre. These subjects had completed 6- week beginners' course on meditation. It was found through this study that cognitive flexibility and attention performance are positively correlated with meditation practice. It was seen that self reported mindfulness was higher in meditators as compared to non-meditators. Also meditators performed better than the control group in all measures of attention. [46].

Shruti Baijal et al. investigated the brain oscillatory changes during Sahaj Samadhi meditation. This meditation is a part of Sudarshan Kriya yoga. It is seen that brain oscillatory activity is associated with different cognitive processes. Subjects were divided into two groups. First group was considered as meditators. These meditators were trainers of Sahaj Samadhi meditation at art of living and practiced meditation daily from 3 to 7 years. Second group was that of non- meditators known as control group. It was found that theta power is more in frontal region of meditators as compared to the control group [47].

CHAPTER 5:
PROBLEM DEFINITION

Meditation is carried out not only for spiritual but also for physical and mental well being. In our research work, we are finding out whether taking a short-term guided meditation enhances attention or not. It is also known that alpha activity is a marker for relaxation and it increases with increase in relaxation [17, 48]. We are also observing the changes in alpha activity during various attention tasks pre and post-intervention.

We can summarize our problem definition as:

1. Comparative study of performance of the participants in attention tasks pre and post-meditation
2. Observing the EEG alpha power while performing tasks and finding out changes in EEG alpha power after the intervention has been given to participants

CHAPTER 6:

PROPOSED WORK

In this research program fourteen participants are selected. These participants are made to perform attention tasks from PEBL. EEG of these participants is acquired while performing attention tasks. EEG of the participants will also be acquired during relaxed state.

6.1 Selection of Participants

Fourteen students who are taking part in the research work have been screened on the basis of following criteria:

1) Participant should be in the age group of 20-25.
2) Participant should not have any illness related to central nervous system including multiple sclerosis, thyroid, diabetes and severe hypertension.
3) Participant should be willing to participate.

The participants volunteering in the research work are informed about the objective, protocol and time taken by each task before starting the tests. Written consent is taken by the students before the test.

6.2 Experimental setup for participants

The experiment should be conducted on the participants in a quiet room. The participant should be made to sit on a comfortable chair in front of the computer screen. The screen should be at a comfortable distance from participant. Figure 6.1 shows the experimental setup of how EEG data will be acquired from the participants during the experiment. It should also made be made sure that there is no other electronic device in the vicinity of the EEG acquisition machine that could interfere with the EEG signals while the reading is being taken.

6.3 Baseline data acquisition

EEG should be acquired for all the participants with their eyes closed for two minutes. EEG should also be acquired from the participants with their eyes opened for two minutes. This EEG from the participants with their eyes closed and open will be considered as baseline.

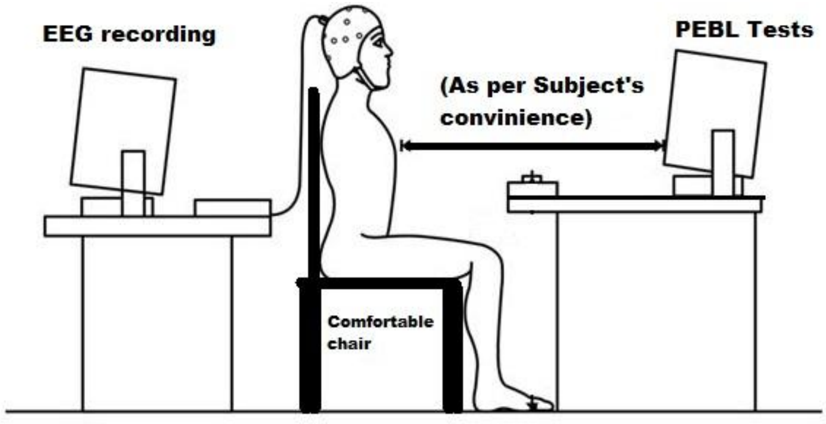


Figure 6.1: Experimental setup

6.4 Data Acquisition

1. **PEBL data:** Scores/accuracy of the participants while performing Go/No-go and PCPT should be calculated and saved for comparison with post test results.
2. **EEG data:** EEG data should be acquired for the participants while they are performing attention tasks.

6.5 Experimental Design

The participants are asked about their interest in meditation. Participants interested in meditation will be made part of meditators group while the participants who have showed no interest in meditation will be made part of the control group.

1. **Meditators' group:** This group will undertake guided meditation for 15 days.
2. **Control group:** This group will undergo no such intervention.

Figure 6.2 shows the experimental setup of the research to be carried out.

Figure 6.2: Experimental Setup

6.5.1 Pre-Test

During pre-tests all the participants of both the groups will perform Go/No-Go and PCPT and the data acquired from PEBL and EEG will be saved for comparison with post-test results.

6.5.2 Meditation as an intervention

Meditation will be given as an intervention to the meditators' group. Meditation given will be custom designed 20 minutes long guided session that leads to progressive relaxation of muscles as well as mind. This meditation has reportedly been used earlier for cognitive enhancement [49]. This audio clip of guided meditation will be given to each participant in the meditators group so that they can practice it at any time in the day according to their comfort for 15 days, everyday. The participants will further be advised to practice meditation in a quiet room. No such intervention will be given to the control group.

6.5.3 Post-Test

These tests will be taken after the completion of intervention. The participants will be made to perform the same tasks which they performed prior to intervention and the results will be compared with pre-test results.

CHAPTER 7:
IMPLEMENTING THE PROPOSED METHOD

7.1 Data Acquisition through EEG

An electroencephalogram is a recording of brain's spontaneous electrical activity. This is controlled by billions of neurons. These neurons continually send messages to each other which can be picked up as electrical impulses from the scalp. The process of picking up and recording the impulses is known as an **EEG**. Neurons communicate by passing an electrical signal by the movement of ions flowing in and out of the cell.

Shown below in the Figure 7.1 is the basic block diagram of a neuron

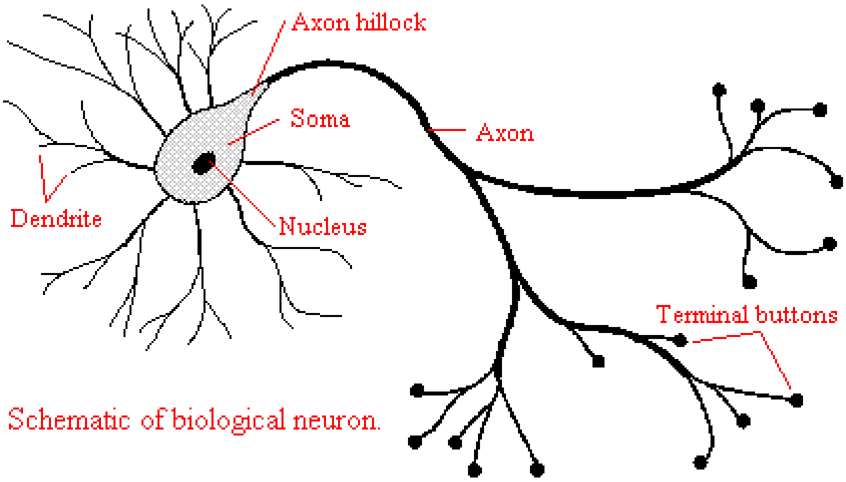


Figure 7.1: Basic neuron diagram

First electrical signals are transmitted from the dendrites to the cell membrane where they meet the axon hillock. In the axon hillock, summation of the charges is done. It is a point where summation of excitatory post synaptic potentials and inhibitory post synaptic potentials meet. If the summation of these potential reaches the threshold, the signal passes. Axon hillock is also known as the gate keeper of neuron as it decides whether or not the signal should be passed to the axon terminal. The neuron has a resting membrane potential of about -70mV. Voltage gated sodium channels will open when the membrane potential becomes more positive or depolarises. When this occurs, the sodium rushes into the cell, transmitting the depolarisation down the axon. This occurrence is called the action potential. However a single action potential is not big enough to be detected by EEG as the action potentials can cancel each other. When several ions are pushed out of several neurons at the same time, they will push their neighbours because ions of similar charges repel each other,

which will further push their neighbours. This will create a wave. Electrodes are then placed on the scalp which will push or pull electrons from the wave of ions when they reach the electrodes. Voltmeter is used to measure the difference in push or pull voltages between any two electrodes. EEG is the recording of these voltages over time [50]. The electric potential produced by an individual neuron is too small to be pulled out up by EEG [51].
EEG can be divided into 4 basic frequencies:

1) Delta- Between 0.5-4 Hz
2) Theta- Between 4-8 Hz
3) Alpha- Between 8-13 Hz
4) Beta- Between 13-30 Hz

Figure 7.2 shows the 4 basic frequencies into which EEG can be divided [52].

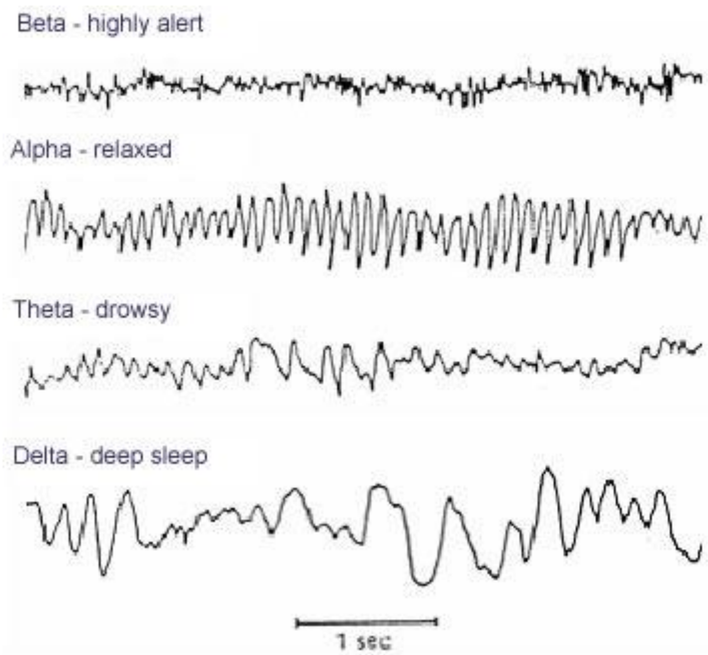


Figure 7.2: Four basic frequencies of an EEG

7.1.1 Placement of Electrodes

For electrode placement basic 10-20 system of electrodes was used. It is an international standard method for placement of electrodes on a scalp. The “10” and “20” actually signifies that actual distance between any two adjacent electrodes will be either 10% or 20% of total right to left distance or front to back distance of the skull. Two anatomical positions which are used for positioning of the electrodes in 10-20 system are: first is the nasion, which is the depressed area just above the bridge of the nose between the eyes; second is the inion, normally indicated by a prominent bump at the lowest point on the skull from the back of the head. The entire distance between nasion and inion are divided into six segments at a distance 10%-20%-20%-20%-20%-10% as shown in Figure 7.3 B. Figure 7.3 shows 10-20 system of EEG electrode placement [50]. Originally 10-20 system contained only 19 electrodes as shown B section of Figure 7.3. An extension of 10-20 system was then proposed to place over 70 electrodes in standard positions as shown in Figure 7.3 C. 10-20 system is based on subdivision of arcs on the scalp. It starts from craniometric reference points: Left pre-auricular (PAL), Right (PAR) pre-auricular points, Nasion (Ns) and Inion (In). The intersection of the longitudinal (Ns-In) and lateral (PAL-PAR) arc is called the Vertex.

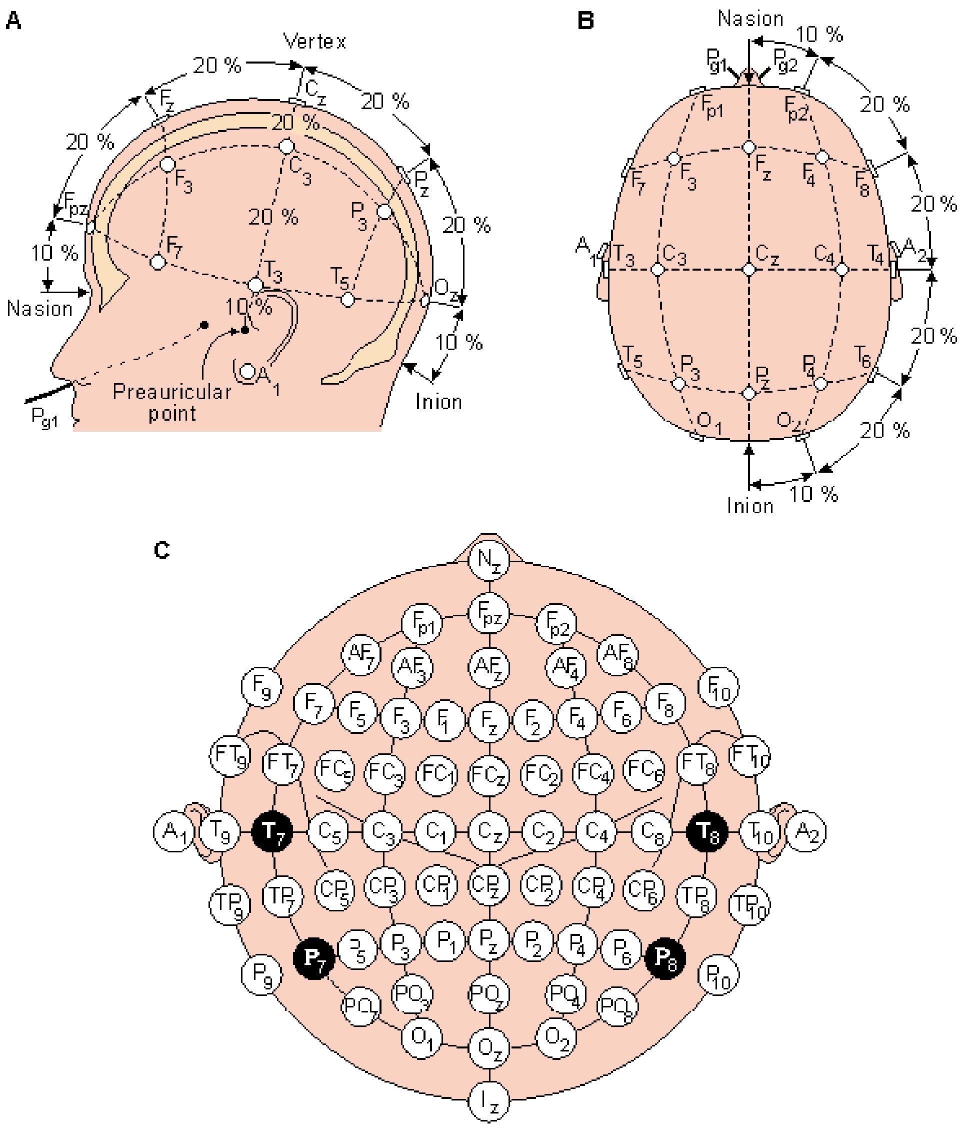


Figure 7.3: 10-20 system of EEG electrode

The electrodes used for EEG are small metal contacts which are attached to the scalp with the help of conducting gel or paste. Silver/silver-chloride (Ag/AgCl) and tin(Sn) electrodes are most commonly used. Gold (Au) and platinum (Pt) electrodes though expensive are also used at times because of their high electrical conductance. The EEG is measured by taking voltage difference between any two points on the scalp. In this way there are two types of measurement. First is the unipolar measurement in which second electrode is common to all the channels of EEG which is called as "reference" In bipolar measurement reading is taken between any two points on the scalp and not with reference to any one common electrode.

EEG data in our research has been acquired from 6 electrodes or channels placed according to international 10-20 system. EEG data has been acquired at acquisition rate of 1000 sample per second and sampled at the sampling rate of 500 Hz for each channel. The electrodes selected for attention assessment are FP1, FP2, F3, F4, O1 and O2. FPZ is taken as the ground electrode whereas left ear mastoid is taken as the voltage reference. Impedance of each electrode is compared with reference to ground of cap and is set up approximately below 10 KΩ. Electrodes from which data are recorded have been shown in red whereas the ground electrode is shown in grey in Figure 7.4.

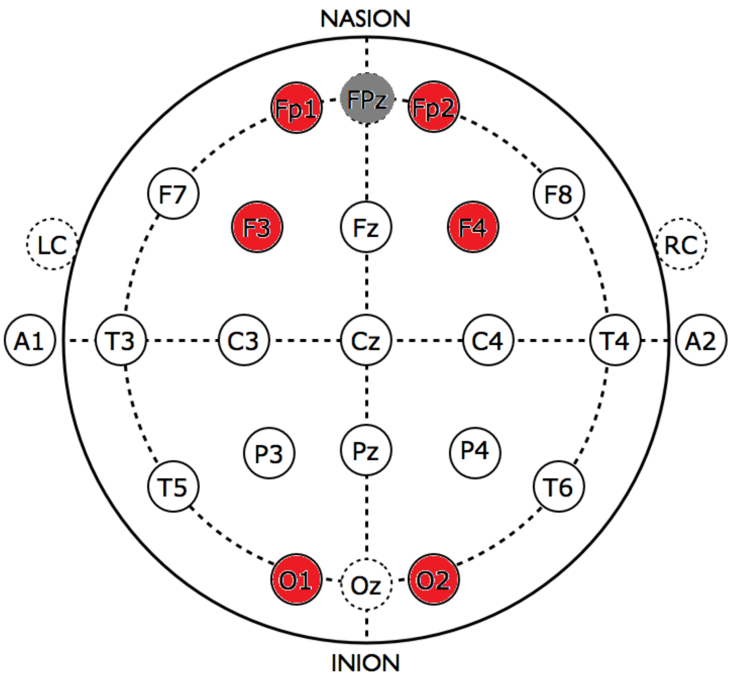


Figure 7.4: Selected electrodes for EEG extraction

7.1.2 Hardware for Data Acquisition

MP150 BioPac (Figure 7.5) is used for EEG data acquisition. The MP System (MP150 or MP36R) is a complete data acquisition system which contains both hardware and software for acquiring and analysing life science data. It is used for data acquisition, analysis, storage and retrieval. The data acquisition unit is the heart of the MP System (MP150 or MP100). The incoming signals can be converted into digital signals with the help of the MP Unit. These digital signals can be easily processed with the help of computer.

Figure 7.5: MP150 BioPac system

The MP150 utilizes new Ethernet technology with high-speed data attainment system. The MP150 is compatible with any Ethernet (UDP) ready PC running Macintosh or Windows. It accesses numerous MP150 devices located on a local area network and record data to any computer linked to the same Local Area Network. It can record numerous channels with variable sampling rates to maximize storage efficiency. Recording is done at a speed up to 400 KHz. MP150 has an internal microprocessor to control the data acquisition and communication with the computer. It has two analog channels (output), 16 digital channels (output or input), 16 analog input channels and an external trigger input. The digital lines can be programmed as either outputs or inputs. Block 1 (I/O lines 0 through 7) can be programmed independently of block 2 (I/O lines 8 through 15) as all inputs or all outputs [52].

7.1.3 Signal Conditioning and Feature Extraction

AcqKnowledge software is used for signal conditioning and feature extraction. AcqKnowledge software not only does the data collection, but also performs analyses easily and quickly. AcqKnowledge makes use of point-and-click interface which is common to all

Windows and Macintosh applications. [53]. It performs complex work like digital filtering or fast fourier transformations (FFT). It also has an inbuilt notch filter which is used for signal conditioning.

Power Spectrum Density calculations is shown in steps from figures (7.6- 7.10)

1. Go to Analysis on toolbar and click Power Spectrum Density as shown in Figure 7.6.

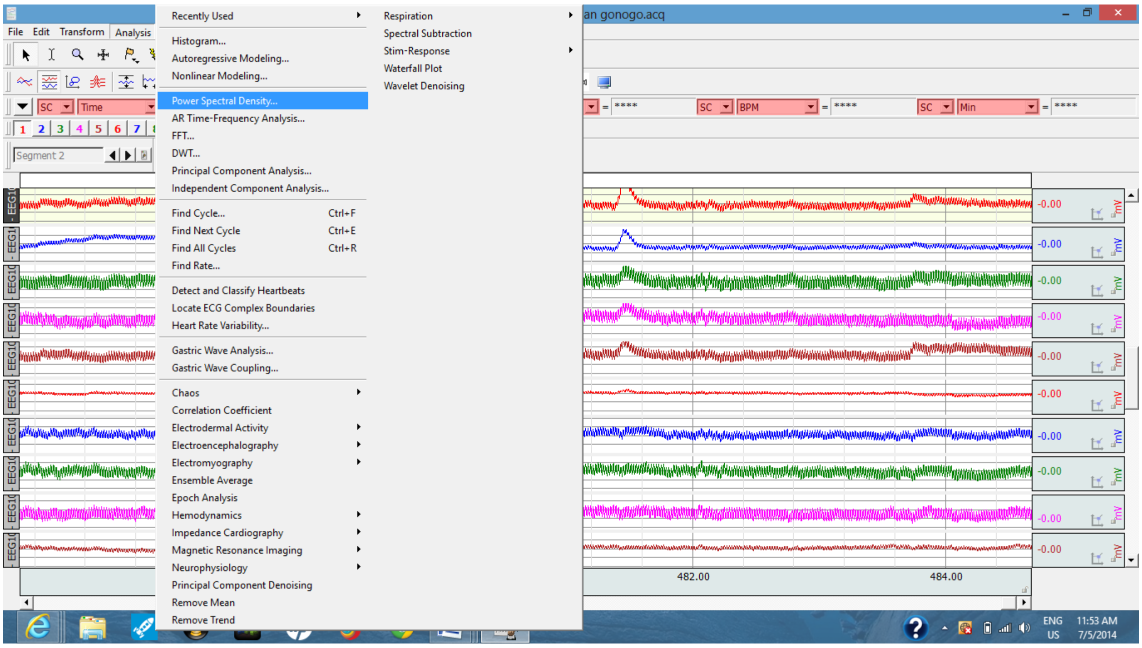


Figure 7.6: Applying Power Spectrum Density on data

2. Clicking Power Spectrum Density will open up a box as shown in Figure 7.7. Set the window to hamming window and click OK.

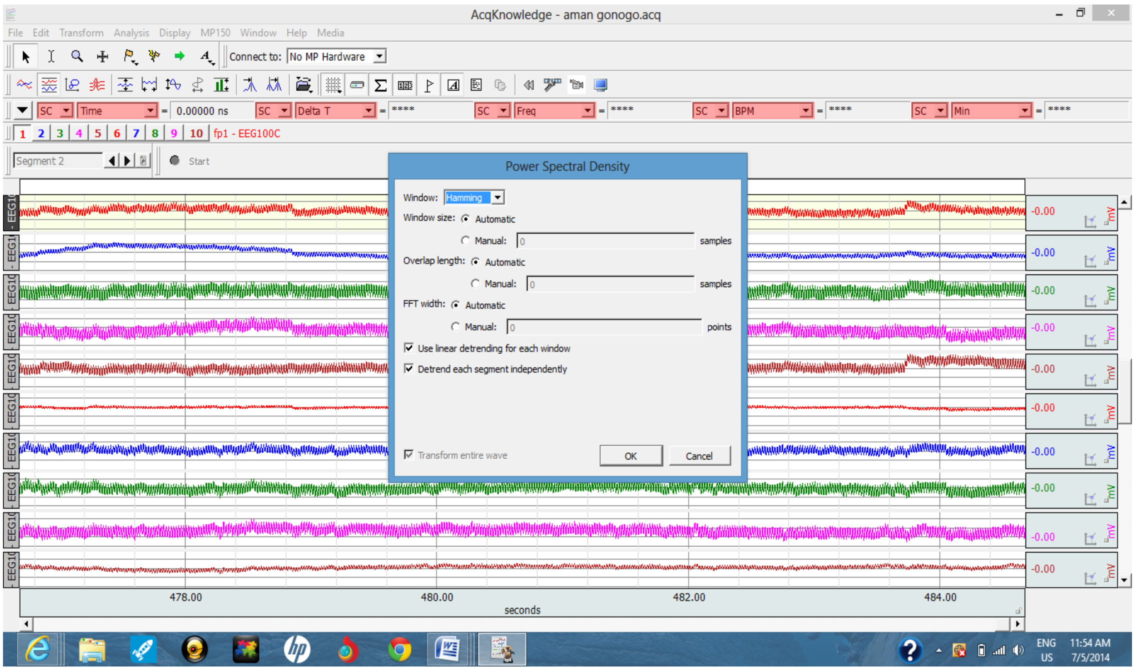


Figure 7.7: Selecting Hamming window for PSD calculation

3. Clicking OK will open up a window as shown in Figure 7.8 showing the Power Spectrum Density of the selected EEG data

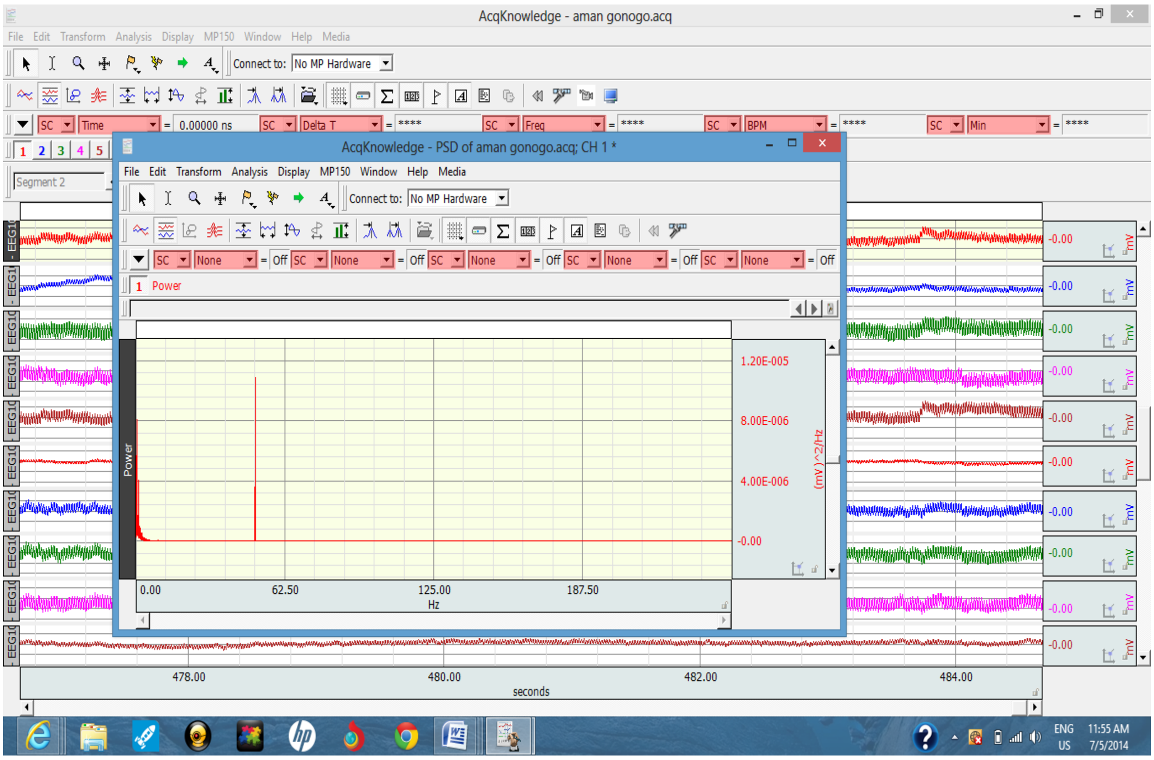


Figure 7.8: Graph of PSD

4. Click on ‘file’ on the window of PSD and save it as Excel sheet. This excel sheet will appear as shown in Figure 7.9.

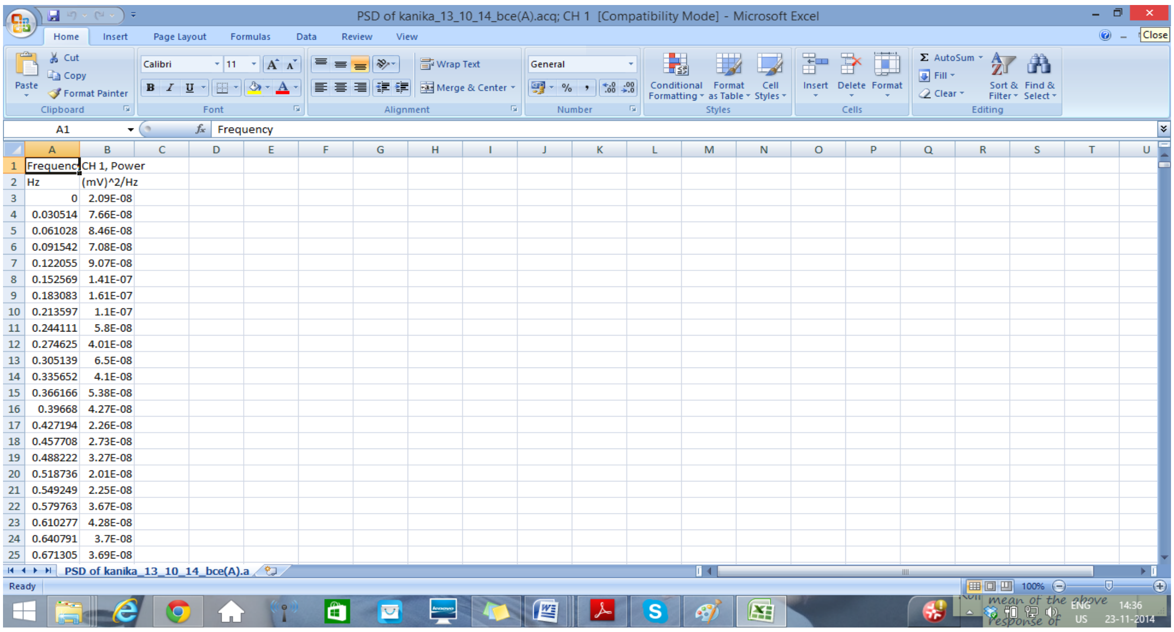


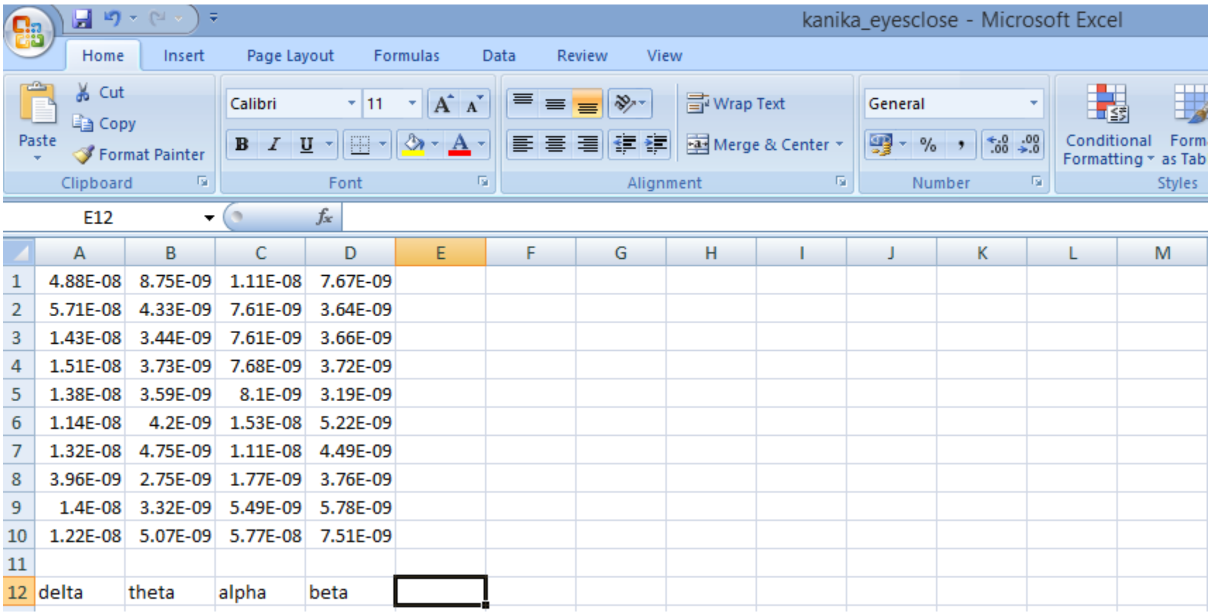
Figure 7.9: Excel sheet of power spectrum density

5. The power of various band of frequency is calculated by exporting the .xlsx file to Matlab and writing a code to divide the frequency spectrum into various bands like
   - Delta: 0.5 – 4 Hz
   - Theta: 4-8 Hz
   - Alpha: 8-13 Hz
   - Beta: 13-30 Hz

The power is estimated from power spectrum density with the help of 7.1:

$$power = \frac{\sum \frac{mv^2}{Hz}}{no\ of\ samples} \times frequency\ range \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ \ldots\ldots\ldots\ldots \ (7.1)$$

Figure 7.10 shows how code is implemented on EEG of each electrode to extract alpha, beta, delta and theta.



	A	B	C	D
1	4.88E-08	8.75E-09	1.11E-08	7.67E-09
2	5.71E-08	4.33E-09	7.61E-09	3.64E-09
3	1.43E-08	3.44E-09	7.61E-09	3.66E-09
4	1.51E-08	3.73E-09	7.68E-09	3.72E-09
5	1.38E-08	3.59E-09	8.1E-09	3.19E-09
6	1.14E-08	4.2E-09	1.53E-08	5.22E-09
7	1.32E-08	4.75E-09	1.11E-08	4.49E-09
8	3.96E-09	2.75E-09	1.77E-09	3.76E-09
9	1.4E-08	3.32E-09	5.49E-09	5.78E-09
10	1.22E-08	5.07E-09	5.77E-08	7.51E-09
11				
12	delta	theta	alpha	beta

Fig 7.10: Alpha, beta, delta and theta extracted from frequency spectrum

7.2 Data Acquisition through PEBL tasks

Scores and accuracies are acquired after the participant performs the PEBL tasks. These scores are given according to the performance of the participant in the two tasks.

7.2.1 Score in PCPT

In PCPT, the participant is given a reward point of 1 on responding to any character except 'X'. A reward point of 1 is also given on not responding to 'X'. Different characters are flashed 360 times on the screen. A score at the end of the task is given out of 360 [54].

7.2.2 Score in Go/No-Go

In Go/No-Go task the score given for each student is the accuracy with which he has responded to the P's and Q's on the screen. In the first task of Go/No-Go where the participant is supposed to press right shift key when "P" is flashed on the screen. On each press of right shift key on flashing of "P" and no press of any key on flashing of "R", a reward point of 1 is given. In any other situation 0 is given. The task continues for over 4 minutes and at the end accuracy with which response to which P and R is given is calculated. This task is addressed as Go/No-GoP [54].

In Go/No-GoR, on each press of right shift key on flashing of "R" and no press of any key on flashing of "P", a reward point of 1 is given. In any other situation 0 is given. Accuracy of responding to P and Q is given in (7.2) and (7.3)

Accuracy of responding to "P" = $\frac{correct\ response\ on\ P}{total\ number\ of\ P's\ flashed}$ (7.2)

Accuracy of responding to "Q" = $\frac{correct\ response\ on\ Q}{total\ number\ of\ Q's\ flashed}$ (7.3)

7.3 Statistical Analysis

Statistical analysis has been done using Pearson coefficient and T-test.

7.3.1 Pearson coefficient

This coefficient determines correlation between two vectors. Pearson coefficient lies in the range from -1 to 1 [55].

It can be given by (7.4):

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})\,(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\ \sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}} \quad (7.4)$$

Where r Pearson Coefficient, x_i is first vector, y_i is second vector, $\bar{x}, \bar{y}$ are mean values.

Table 7.1 shows Pearson coefficient and their correlation.

Table 7.1: Pearson coefficient and their correlation

Pearson Coefficient	Correlation
|0.1| to |.3|	poor
|.3| to |.5|	moderate
|.5| to |1|	strong

7.3.2 T-test

T-test between the two populations signifies whether the two populations are statistically same or different. The T-test gives a P-value which determines how likely the results could have come by chance. If the P-value is less than 0.05, it means that there is less than 5 percent chance that the two populations are same. Typically, if the P-value is less than 0.05, we consider that there is statistical difference between two groups. T-test can be one tail and two-tail. One-tail t-tests are used for asymmetrical distribution with a single tail whereas two tailed t-tests are used for normal distribution or two-tails. T-test can also be paired and unpaired. Paired t-test is applied to samples of same group at two different times. The two samples in our case are pre-and post intervention readings for meditators and control group. Unpaired t-test is applied to two independent groups. In our case, unpaired t-test is applied between meditators and control group.

CHAPTER 8:

RESULTS AND DISCUSSION

Following are some of the observations from our research work:

8.1 Correlation between attention tasks

There are several types of tasks that may vary by a shade for assessing attention. We have selected three tasks from PEBL related to selective and sustained attention. We are finding out whether these tasks are required to be performed separately or not. If these tasks are correlated then they need not be performed separately for attention assessment. Pearson coefficient is found between the accuracy of Go/No-Go tasks and scores of PCPT for 14 subjects.

Table 8.1 shows the scores of PCPT and accuracy in range of 0 to 1 in case of Go/No-go. Mean of the accuracies of P's and R's in the two Go/No-go task is also calculated.

For convenience let

Go/No-GoP(P) = A, which is the accuracy of P in Go/No-GoP task.

Go/No-GoP(R) = B, which is the accuracy of R in Go/No-GoP task.

Go/No-GoR(P) = C, which is the accuracy of P in Go/No-GoR task.

Go/No-GoR(R) = D, which is the accuracy of R in Go/No-GoR task.

Thus

$$\text{Mean Accuracy of Go/No} - \text{GoP is} = \frac{(\text{A+B})}{2} \tag{8.1}$$

$$\text{Mean Accuracy of Go/No} - \text{GoR is} = \frac{(\text{C+D})}{2} \tag{8.2}$$

Table 8.1: Scores of PCPT and accuracy of Go/No-go

S. No.	A	B	Mean Go/No-GoP	C	D	Mean Go/No-GoR	PCPT
1	1	0.78125	0.890625	0.98437	1	0.992185	347
2	0.99218	0.46875	0.730465	0.97656	1	0.98828	323
3	1	0.6875	0.84375	0.9218	1	0.9609	337
4	1	0.9375	0.96875	1	1	1	348
5	1	0.40625	0.703125	0.97656	1	0.98828	346
6	1	0.75	0.875	0.95312	1	0.97656	354
7	0.99218	0.6875	0.83984	0.99218	1	0.99609	347
8	1	0.65625	0.828125	0.99218	1	0.99609	343
9	0.99218	0.9375	0.96484	1	1	1	337
10	1	0.5625	0.78125	0.99218	0.9375	0.96484	323
11	1	0.40625	0.703125	0.95656	1	0.97828	345
12	1	0.84375	0.921875	0.97656	1	0.98828	348
13	1	0.875	0.9375	0.99218	1	0.99609	348
14	0.99218	0.8125	0.90234	0.99218	1	0.99609	326

Table 8.2: Pearson Coefficient between PCPT and Go/No-go

Tasks	Pearson Coefficient
Mean Go/No-GoP-Mean Go/No-GoR	0.448924194
Mean Go/No-GoP-PCPT	0.271126652
Mean Go/No-GoR-PCPT	0.238558289

Conclusion

It can be seen from Table 8.2 that Go/No-GoP and Go/No-GoR have a moderate correlation between them with Pearson coefficient of 0.44. The two tasks are almost similar; still the correlation between the two task score is not high. This is because Go/No-GoR is immediately performed after Go/No-GoP and it takes time to unlearn the task of Go/No-GoP and learn Go/No-GoR. Go/No-GoP and Go/No-GoR have a very low correlation with PCPT with Pearson coefficient less than 0.3. This is because of the duration for which a subject sustains attention. The Go/No-go tasks are approximately 4 minutes long whereas PCPT is 14 minutes long. A weak correlation between the Go/No-Go tasks and PCPT shows that a person who has a short duration of attention span (as in Go/No-go) might not have an attention span as long as that required in PCPT and vice versa. Since correlation in no two tasks is high therefore it can be concluded that all the three tasks will required to be performed.

8.2 Alpha activity during eyes close and eyes open

Alpha activity is said to increase in eyes close and decrease in eyes open. We have validated the same with our observations. Table 8.3, 8.4 and 8.5 shows the mean alpha power of pre-frontal, frontal and occipital region during eyes close and eyes open. Also shown along with the alpha power is the difference between the alpha power during eyes closed and eyes open.

Table 8.3: Alpha power of Pre-frontal region during eyes close and eyes open with their difference

FP1			FP2		
Eyes Close	**Eyes Open**	**Difference**	**Eyes Close**	**Eyes Open**	**Difference**
2E-09	4.8E-09	-3E-09	1.4E-09	6.2E-09	-5E-09
1.1E-08	2.6E-09	8.5E-09	1.3E-08	3.8E-09	8.8E-09
2.6E-08	2.6E-10	2.6E-08	3.3E-08	7.5E-10	3.20E-08
6.5E-08	2.4E-08	4.1E-08	4.6E-08	1.5E-08	3.1E-08
5.4E-08	5.1E-08	3.3E-09	4.9E-08	4.7E-08	1.1E-09
3.4E-09	2.5E-09	8.8E-10	2.9E-09	1.6E-09	1.3E-09
1.2E-09	4.5E-10	7.6E-10	2.6E-09	8.8E-10	1.8E-09
1.1E-09	3.4E-10	8E-10	2E-09	9.8E-10	1E-09
7.2E-09	2E-09	5.2E-09	9.4E-09	2.4E-09	7E-09
2.8E-08	5.3E-09	2.2E-08	2.1E-08	2.6E-09	1.9E-08
2.6E-09	2.1E-09	4.6E-10	2.8E-09	1.9E-09	9.3E-10
2.8E-09	3.4E-09	-6E-10	2.5E-09	3.6E-09	-1E-09
7.3E-09	6.3E-09	9.9E-10	6.5E-09	8.1E-09	-2E-09
3.2E-09	3.3E-09	-6E-11	2.8E-09	3E-09	-2E-10

Table 8.4: Alpha power of frontal region during eyes close and eyes open with their difference

F3			F4		
Eyes Close	**Eyes Open**	**Difference**	**Eyes Close**	**Eyes Open**	**Difference**
3.6E-09	3.3E-09	3.4E-10	1.5E-09	1.5E-09	-2E-11
1.6E-08	3.1E-09	1.3E-08	4.9E-08	7.7E-09	4.1E-08
1.1E-07	2.1E-09	1.1E-07	6.4E-08	8.9E-10	6.3E-08
4.9E-08	1.6E-08	3.3E-08	4.6E-08	1.4E-08	3.1E-08

2.1E-08	1E-08	1.1E-08	3.6E-08	1.6E-08	2E-08
7.6E-09	3.3E-09	4.3E-09	8.2E-09	3.8E-09	4.4E-09
1.6E-09	5.5E-10	1.1E-09	2.6E-08	7.9E-09	1.8E-08
1.7E-09	5.2E-10	1.2E-09	3.1E-09	9.1E-10	2.2E-09
1.2E-08	2.3E-09	1E-08	2.7E-08	4.3E-09	2.2E-08
2.3E-08	3.3E-09	2E-08	1.1E-08	4.7E-09	6.8E-09
5.4E-09	3.1E-09	2.3E-09	3.6E-09	2.2E-09	1.4E-09
3.3E-09	5.5E-09	-2E-09	3.4E-09	4.6E-09	-1E-09
7.5E-09	2.9E-09	4.6E-09	2.8E-08	8E-09	2E-08
2.5E-09	2.4E-09	3.7E-11	2.1E-09	2.1E-09	2.3E-11

Table 8.5: Alpha power of Occipital region during eyes close and eyes open with their difference

O1			**O2**		
Eyes Close	**Eyes Open**	**Difference**	**Eyes Close**	**Eyes Open**	**Difference**
4.7E-09	1.1E-09	3.6E-09	1.8E-09	8.6E-10	9.5E-10
6.2E-08	8.3E-09	5.3E-08	1.7E-07	3.8E-08	1.3E-07
3.8E-08	4.1E-10	3.8E-08	1.1E-07	7.4E-10	1E-07
1.3E-07	2.6E-08	1.1E-07	1E-07	2.4E-08	7.8E-08
2.7E-07	2.2E-08	2.5E-07	2.3E-07	2E-08	2E-07
5.2E-07	2.9E-08	4.9E-07	2.6E-08	1.5E-09	2.4E-08
1.8E-08	9.3E-10	1.7E-08	1.2E-08	7.5E-10	1.1E-08
3.1E-08	5.6E-09	2.6E-08	1.2E-08	1.6E-09	1.1E-08
2.8E-07	1.1E-08	2.7E-07	5.4E-07	1.6E-08	5.3E-07
4E-08	6.5E-09	3.4E-08	8.2E-09	7E-09	1.2E-09
9E-09	3.7E-09	5.4E-09	7.2E-09	3.9E-09	3.3E-09
8.4E-08	2.8E-08	5.6E-08	2E-07	4.2E-08	1.6E-07
3.6E-08	2E-09	3.4E-08	3.6E-07	1.9E-08	3.4E-07
8E-09	5.2E-09	2.8E-09	1.7E-08	1.6E-08	1.2E-09

It can be seen from Figure 8.1 that mean alpha value of eyes close is more than mean alpha value of eyes open. But the average value alone cannot not give us a generalised inferential proof that alpha power during eyes close is greater than alpha power during eyes open, so we have also applied one-tail, paired T-test on eyes open and eyes close data. Table 8.6 shows P-value from the T-test on 14 students during eyes closed and eyes open.

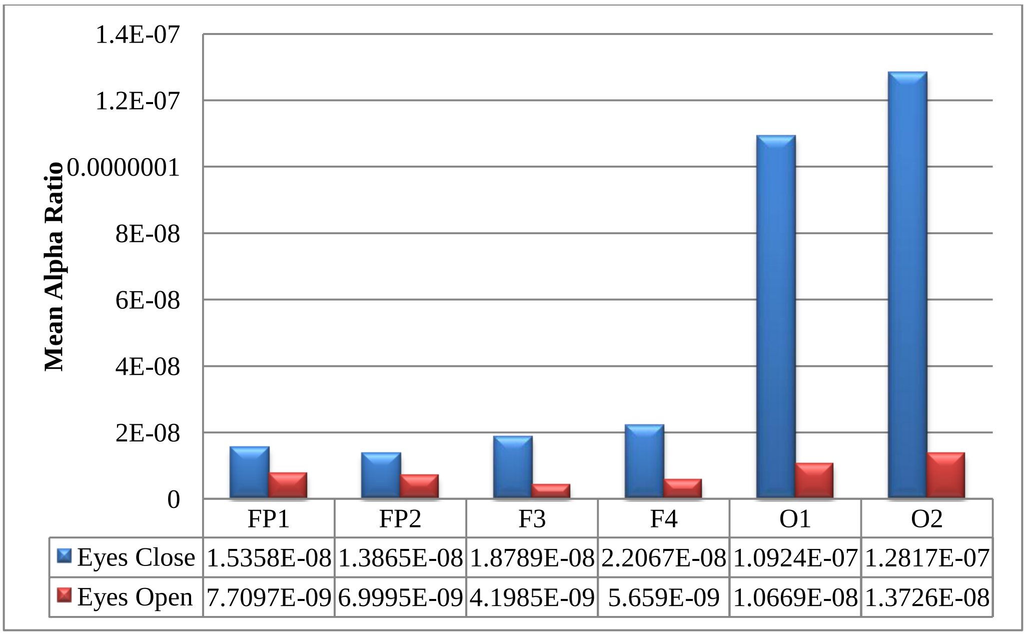


Figure 8.1: Mean Value of Alpha power during eyes close and eyes open

Table 8.6: P-value between eyes closed and open at different electrodes

Electrode	FP1	FP2	F3	F4	O1	O2
P-Value	0.02276	0.02519	0.03678	0.00299	0.01054	0.00826

Conclusion

It can be seen in table 8.6 that P-value at all the electrodes is less than 0.05. This means that we can statistically infer that alpha power during eyes closed is greater than alpha power during eyes open.

8.3 Assessing Alpha activity in attention and in relaxed state

Here, the alpha power is calculated for all the participants at all the six electrodes during the tasks and relaxed state. Average alpha power is then calculated for each electrode during relaxed state and attention state (PCPT, Go/No-GoP and Go/No-GoR).

The average value alone could not give us a generalised inferential statistics so we have also applied one-tail, unpaired T-test on PCPT, Go/No-GoR and Go/No-GoP to check whether the averages or means of eyes close is reliably different from mean of the tasks. If the P-value is less than 0.05, it shows that there are less than 5 percent chances that we will get this result from random data. The statistically significant cut off for p-value is 0.05. Any value above

0.05 is considered statistically insignificant. The results for various electrodes are shown below:

8.3.1 FP1

It can be seen in Figure 8.2 that for FP1, average alpha power has increased in case of PCPT and Go/No-GoP whereas it has decreased in Go/No-GoR with respect to relaxed state with eyes closed.

Analysis of the task with respect to relaxed state:

- PCPT: P-value is 0.32, therefore the result is not statistically significant and nothing can be concluded.
- Go/No-GoP: P-value is 0.47, therefore the result is not statistically significant and nothing can be concluded.
- Go/No-GoR: P-value is 0.40, therefore the result is not statistically significant and nothing can be concluded.

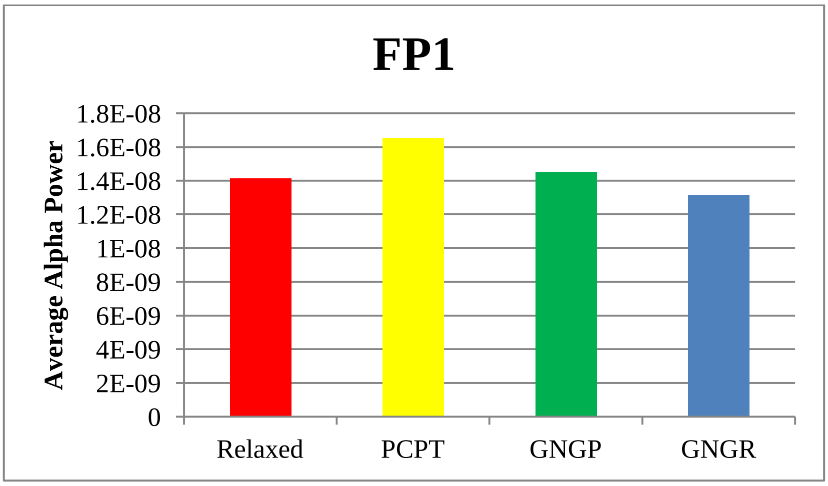


Figure 8.2: Graph of Average Alpha Power at FP1

8.3.2 FP2

It can be seen in Figure 8.3 that for FP2, average alpha power has increased in case of PCPT whereas it has decreased with respect to relaxed state (Eyes Close) in Go/No-GoP and Go/No-GoR. Analysis of the task with respect to relaxed state:

- PCPT: P-value is 0.37, therefore the result is not statistically significant and nothing can be concluded.
- Go/No-GoP: P-value is 0.23, therefore the result is not statistically significant and nothing can be concluded.

- Go/No-GoR: P-value is 0.19, therefore the result is not statistically significant and nothing can be concluded.

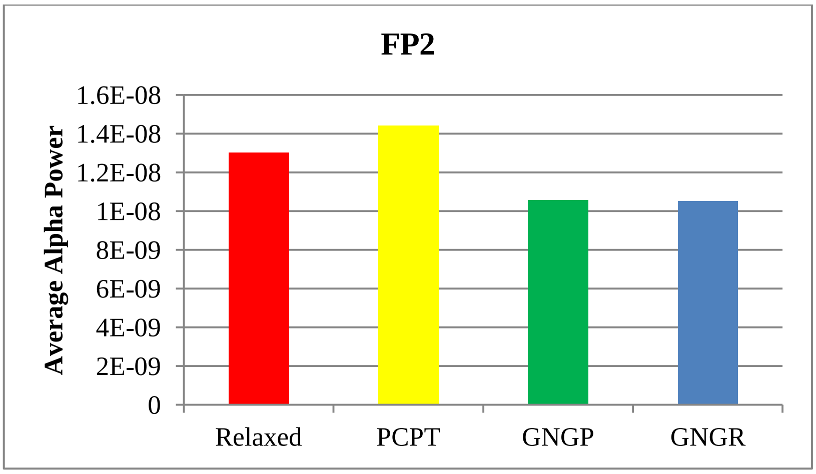


Figure 8.3: Graph of Average Alpha Power at FP2

8.3.3 F3

It can be seen in Figure 8.4 that for F3, average alpha power has decreased with respect to relaxed state in all the tasks. To infer it statistically we find p-value.

Analysis of the task with respect to relaxed state:

- PCPT: P-value is 0.02 which is statistically significant. This shows that alpha power decreases with respect to relaxed state while performing PCPT
- Go/No-GoP: P-value is 0.01. This shows that result is statistically significant and alpha power decreases while performing Go/No-GoP.
- Go/No-GoR: P-value is 0.01. This shows that result is statistically significant and alpha power decreases while performing Go/No-GoR.

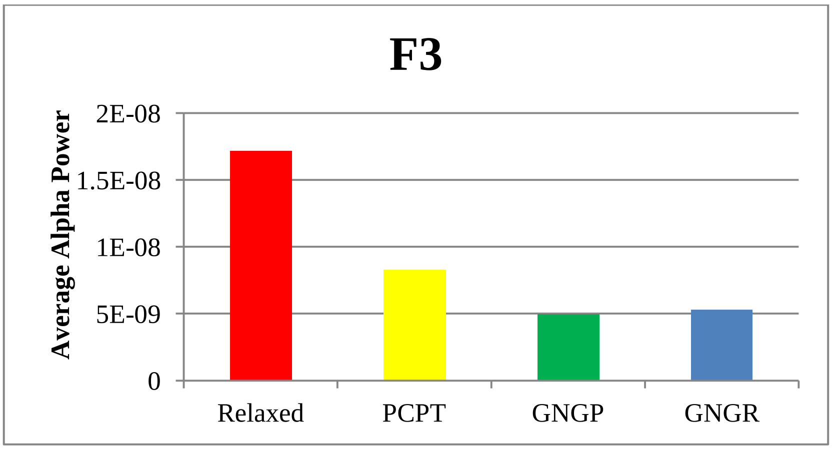


Figure 8.4: Graph of Average Alpha Power at F3

8.3.4 F4

It can be seen in Figure 8.5 that for F4, average alpha power has decreased with respect to relaxed state in all the tasks. To infer it statistically we find p-value.

Analysis of the task with respect to relaxed state:

- PCPT: P-value is 0.001 which shows that result is statistically significant and alpha power decreases with respect to relaxed state while performing PCPT.
- Go/No-GoP: P-value is 0.0006. This shows that result is statistically significant and alpha power decreases while performing Go/No-GoP.
- Go/No-GoR: P-value is 0.0007. This shows that result is statistically significant and alpha power decreases while performing Go/No-GoR.

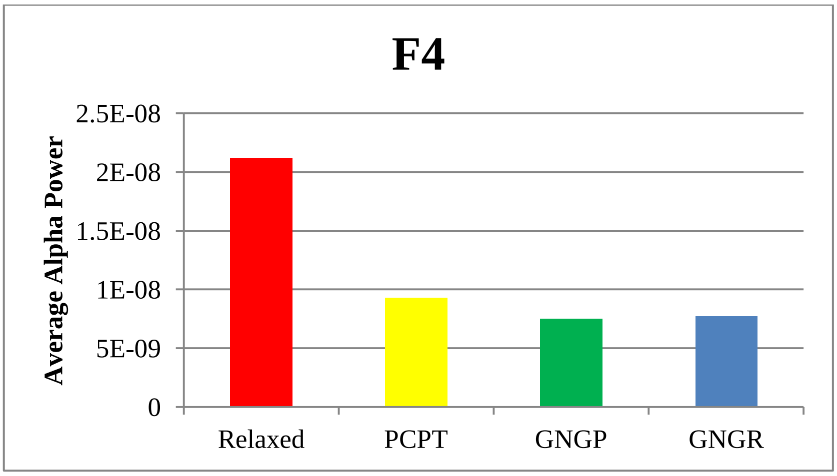


Figure 8.5: Graph of Average Alpha Power at F4

8.3.5 O1

It can be seen in Figure 8.6 that for O1, average alpha power has decreased with respect to relaxed state in all the tasks. To infer it statistically, we find p-value.

Analysis of the task with respect to relaxed state:

- PCPT: P-value is 0.003 which shows that result is statistically significant and alpha power decreases with respect to relaxed state while performing PCPT
- Go/No-GoP: P-value is 0.002. This shows that result is statistically significant and alpha value decreases while performing Go/No-GoP.
- Go/No-GoR: P-value is 0.002. This shows that result is statistically significant and alpha value decreases while performing Go/No-GoR.

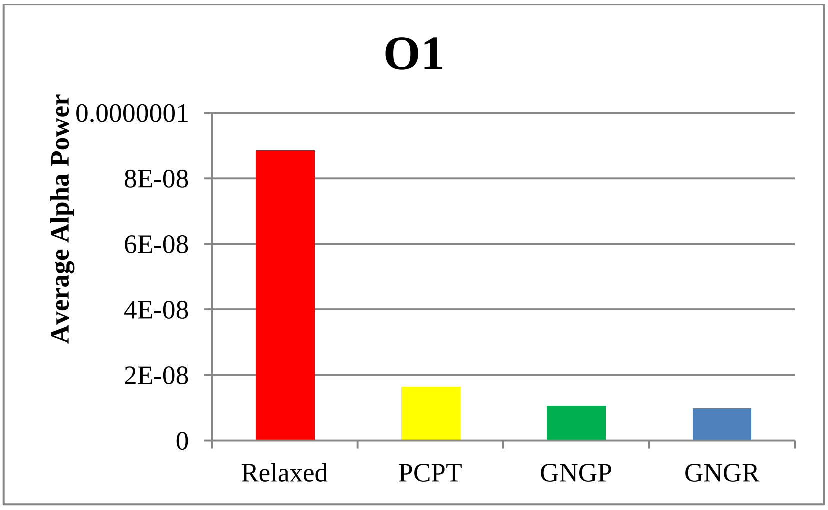


Figure 8.6: Graph of Average Alpha Power at O1

8.3.6 O2

It can be seen in Figure 8.7 that for O2, average alpha power has decreased with respect to relaxed state in all the tasks. To infer it statistically, we find p-value.

Analysis of the task with respect to relaxed state:

- PCPT: P-value is 0.001 which shows that result is statistically significant and alpha power decreases with respect to relaxed state while performing PCPT
- Go/No-GoP: P-value is 0.0009. This shows that result is statistically significant and alpha value decreases while performing Go/No-GoP.
- Go/No-GoR: P-value is 0.0009. This shows that result is statistically significant and alpha value decreases while performing Go/No-GoR.

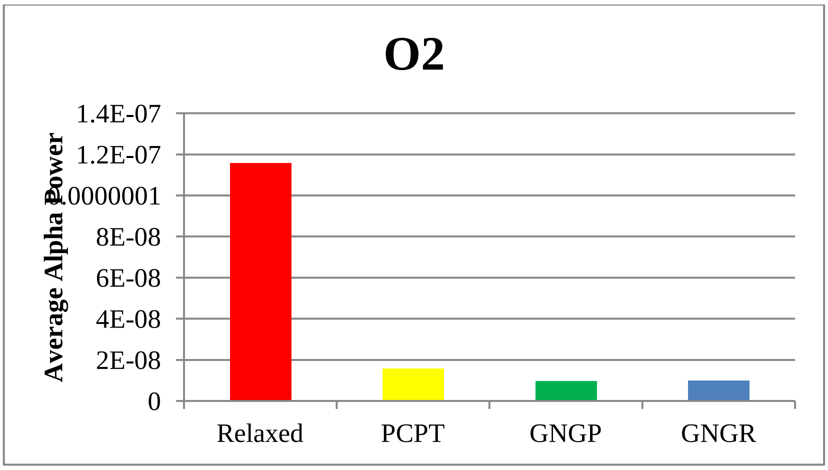


Figure 8.7: Graph of Average Alpha Power at O2

Conclusion

The results did not show any statistically significant change in alpha activity during attention and relaxed state in the electrodes on the prefrontal cortex i.e. FP1 and FP2. It is seen that the electrodes in both the frontal (F3 and F4) and occipital region (O1 and O2) have higher alpha power in relaxed state than in attention state.

8.4 Correlational study of Attention task performance and EEG Alpha power

Here Pearson correlation has been calculated and correlation is found between the scores/accuracy of the task and ratio of alpha power. Figure 8.8 and Figure 8.9 shows graph between task scores and alpha ratios.

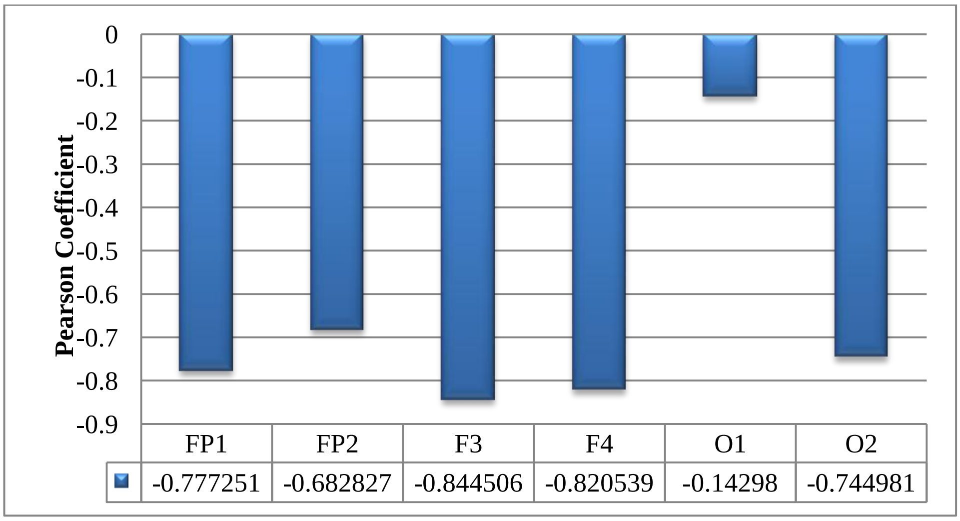


Figure 8.8: Pearson Coefficient between PCPT Score and alpha ratio

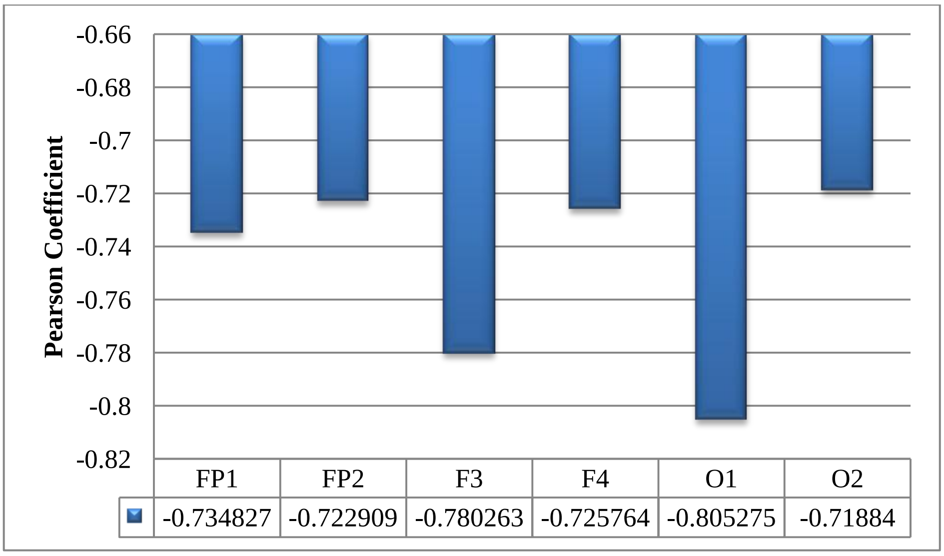


Figure 8.9: Pearson Coefficient between Go/No-Go accuracy and alpha ratio

Conclusion

Pearson coefficient has been calculated between scores/accuracy of tasks (PCPT and Go/No-Go) and the EEG alpha ratio. For PCPT, it is seen that alpha ratio bears a negative correlation with the task score. This correlation is observed to be strongly negative at FP1, FP2, F3, F4 and O2. For Go/No-Go also alpha ratio has a strong negative correlation with score at all the electrodes namely FP1, FP2, F3, F4, O1 and O2. Therefore we can conclude from our research that as the attention task performance increases, alpha ratio decreases. In other words, alpha ratio bears a negative correlation with attention task performance. This correlation is very prominent in pre-frontal, frontal and occipital regions of the brain.

8.5 Attention enhancement using meditation as an intervention

We have done a comparative analysis on pre and post-reading of meditators and control group. In EEG analysis, ratio is found between alpha of task and alpha of eyes closed. This ratio has been addressed as alpha ratio. Alpha ratio is compared for pre and post-values of PCPT, Go/No-GoP and Go/No-GoR for meditators and control group. In psychological analysis, scores/accuracy of pre and post intervention are analysed and compared.

Table 8.7: Pre and post intervention result for PCPT at O1

	PCPT							
	MEDITATOR				CONTROL GROUP			
S. No.	PRE		POST		PRE		POST	
	Alpha Ratio	Score	Alpha Ratio	Score	Alpha Ratio	Score	Alpha Ratio	Score
1	0.07670951	347	0.40979088	353	1.41654915	346	0.123427	333
2	1.81903514	303	0.18365527	309	0.03301595	337	0.262576	312
3	0.14239799	325	0.40309608	339	0.05885892	348	0.113658	346
4	0.12103524	334	0.20617137	337	0.44113345	348	0.173914	344
5	0.10456698	323	0.05885851	314	1.24845441	326	1.060798	317
6	0.73434569	337	1.14681627	349	0.39329574	345	0.485313	346
7	0.29286936	290	1.06521315	320	0.35399890	337	0.187592	339
MEAN	0.47013713	322.71	0.49622879	331.57	0.56	341	0.343897	333.86

Table 8.7 shows the pre and post-meditation data of PCPT at O1. Figure 8.10 and Figure 8.11 shows mean alpha ratios and scores respectively for pre and post-intervention.

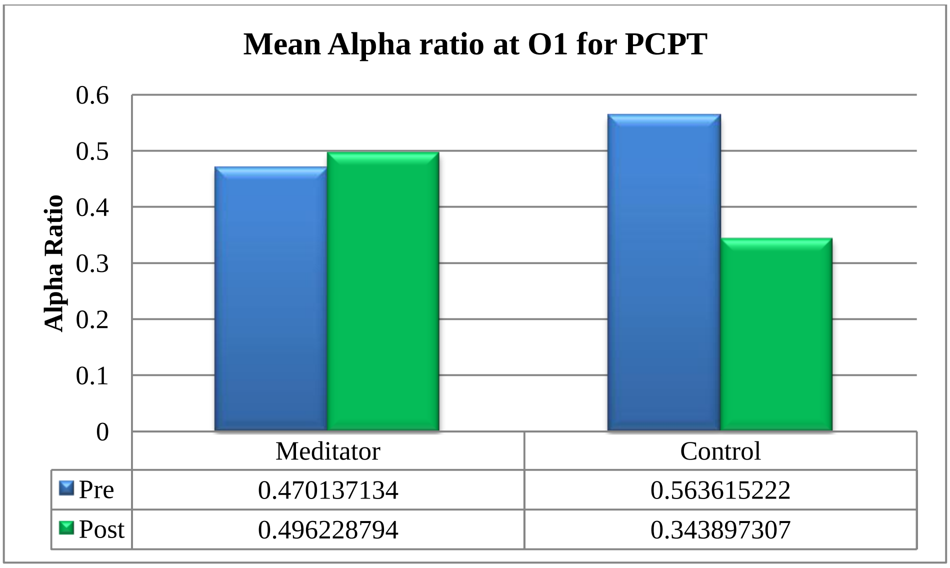


Figure 8.10: Mean Alpha ratio at O1 for PCPT

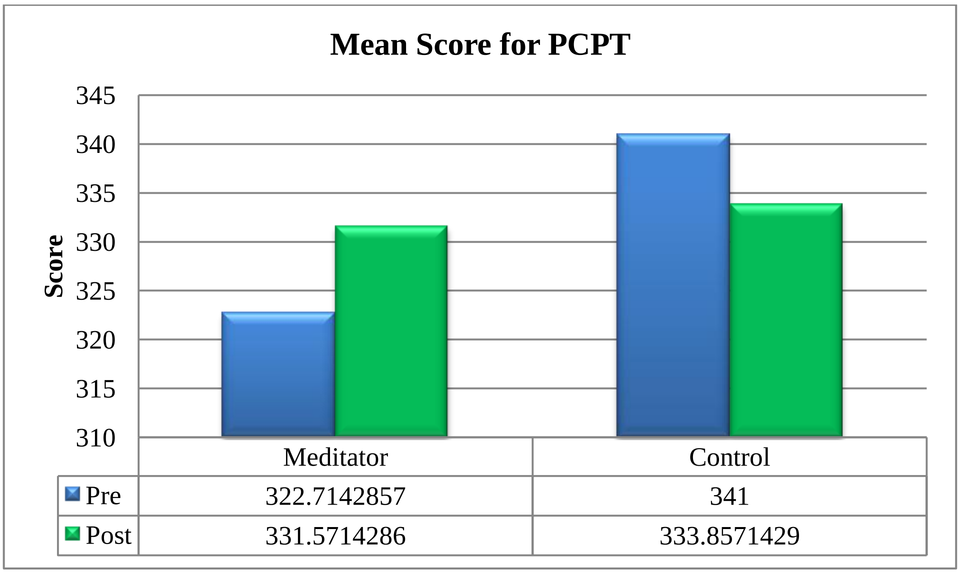


Figure 8.11: Mean Score at O1 for PCPT

Table 8.8 shows the pre and post-meditation data of PCPT at O2. Figure 8.12 and Figure 8.13 shows mean alpha ratios and scores respectively for pre and post-intervention.

Table 8.8: Pre and post intervention result for PCPT at O2

	PCPT							
	MEDITATOR				CONTROL GROUP			
S. No.	PRE		POST		PRE		POST	
	Alpha Ratio	Score	Alpha Ratio	Score	Alpha Ratio	Score	Alpha Ratio	Score

1	0.0626	347	1.3827	353	2.8223	346	0.2715	333
2	0.5803	303	0.0763	309	0.1413	337	1.5486	312
3	0.0956	325	0.0987	339	0.0537	348	0.0590	346
4	0.4902	334	0.2689	337	1.6665	348	0.9860	344
5	0.2765	323	0.0886	314	1.5341	326	0.8203	317
6	0.4874	337	0.6048	349	0.2770	345	0.5099	346
7	0.1475	290	1.1316	320	0.1957	337	0.0862	339
MEAN	0.3058	322.7142	0.5217	331.5714	0.9559	341	0.6116	333.85

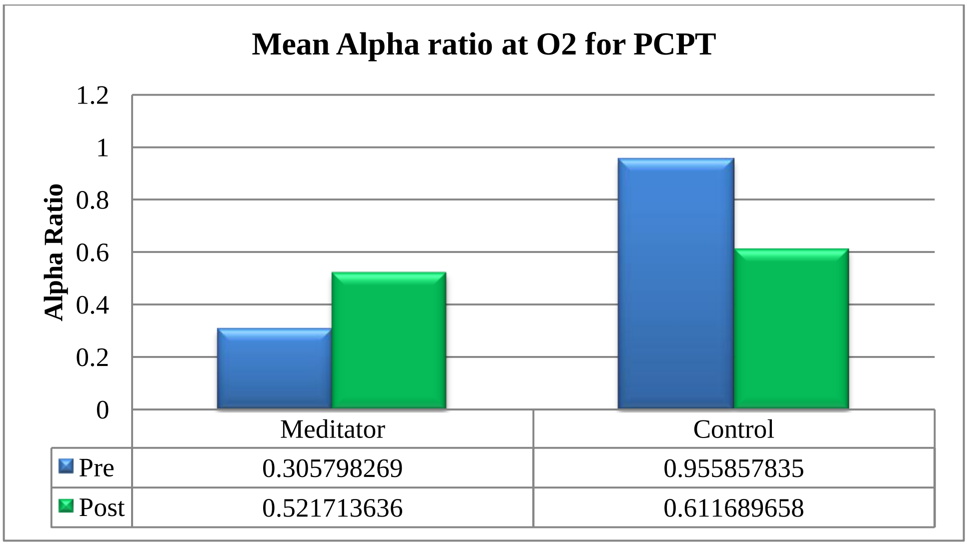


Figure 8.12: Mean Alpha ratio at O2 for PCPT

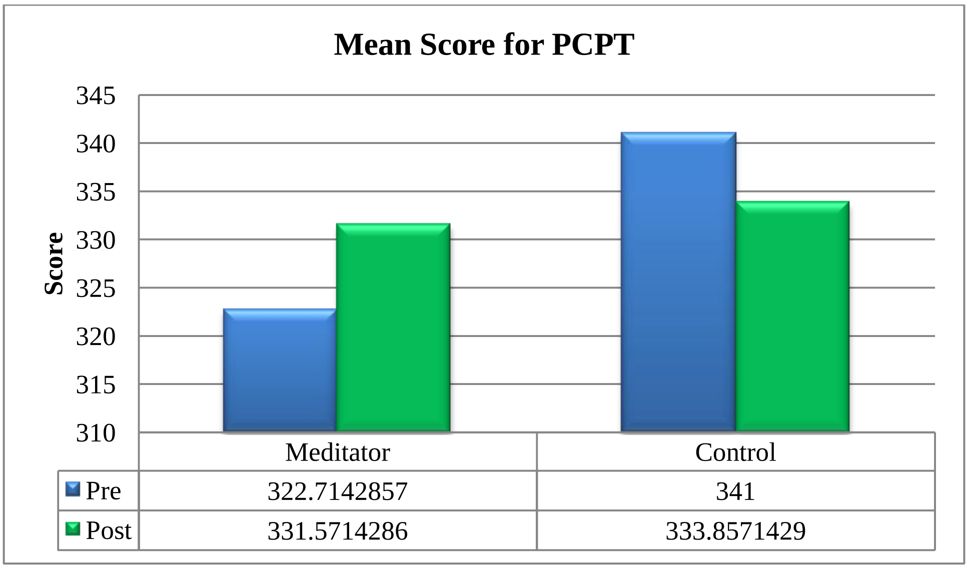


Figure 8.13: Mean Score at O2 for PCPT

Table 8.9 shows the pre and post-meditation data of Go/No-GoP at O1. Figure 8.14 and Figure 8.15 shows mean alpha ratios and scores respectively for pre and post-intervention.

Table 8.9: Pre and post intervention result for Go/No-GoP at O1

	Go/No-GoP							
	MEDITATOR				**CONTROL GROUP**			
S. No.	**PRE**		**POST**		**PRE**		**POST**	
	Apha Ratio	**Score**	**Apha Ratio**	**Score**	**Apha Ratio**	**Score**	**Apha Ratio**	**Score**
1	0.39715889	0.89062	0.18485367	0.890625	0.5291359	0.703125	0.09111	0.84375
2	0.39132013	0.98437	0.20835338	0.984375	0.0378369	0.96484	0.03211	0.828125
3	0.08071818	0.96875	0.03894952	1	0.0435097	0.921875	0.10309	0.953125
4	0.18709488	0.88671	0.24576360	0.980465	0.0401514	0.9375	0.12359	0.87109
5	0.17997672	0.92187	0.03034270	0.9375	0.3900756	0.90234	1.44699	0.742185
6	0.74525844	0.85937	0.81649425	0.96875	0.3508213	0.703125	0.15325	0.84375
7	0.12763842	0.73046	0.81093244	0.828125	0.2254376	0.796875	0.05627	0.828125
MEAN	0.30130938	0.89174	0.33366994	0.9414057	0.2309955	0.8470971	0.286636	0.844307

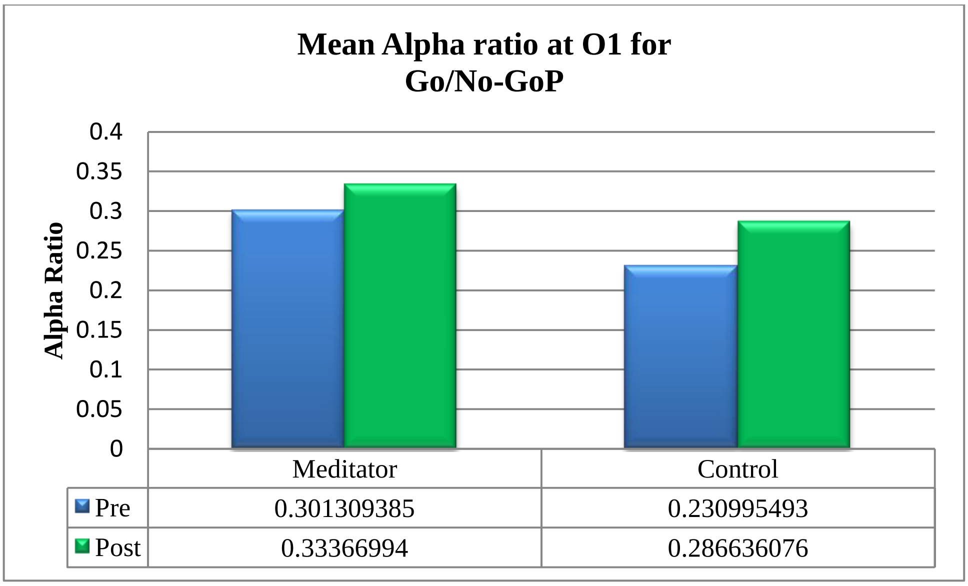


Figure 8.14: Mean Alpha ratio at O1 for Go/No-GoP

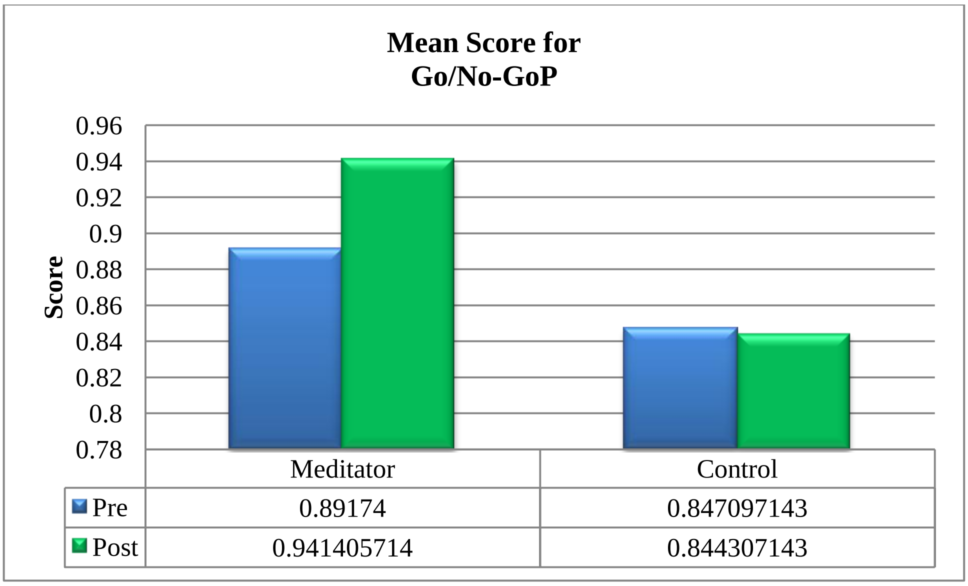


Figure 8.15: Mean Score at O1 for Go/No-GoP

Table 8.10 shows the pre and post-meditation data of Go/No-GoP at O2. Figure 8.16 and Figure 8.17 shows mean alpha ratios and scores respectively for pre and post-intervention.

Table 8.10: Pre and post intervention result for Go/No-GoP at O2

	Go/No-GoP							
	MEDITATOR				**CONTROL GROUP**			
S. No.	**PRE**		**POST**		**PRE**		**POST**	
	Apha Ratio	**Score**	**Apha Ratio**	**Score**	**Apha Ratio**	**Score**	**Apha Ratio**	**Score**
1	0.0531	0.8906	0.3319	0.8906	1.1944	0.7031	0.126351	0.84375
2	0.3004	0.9843	0.1845	0.9843	0.1027	0.9648	0.201297	0.82812
3	0.0482	0.9687	0.0437	1	0.0265	0.9218	0.045660	0.9531
4	0.2841	0.8867	0.2813	0.9804	0.3372	0.9375	0.672133	0.8710
5	0.1650	0.9218	0.0324	0.9375	0.8351	0.9023	1.090895	0.7421
6	0.4564	0.8593	0.4347	0.9687	0.0864	0.7031	0.147119	0.8437
7	0.0371	0.7304	0.3464	0.8281	0.1145	0.7968	0.025597	0.8281
MEAN	0.1921	0.8917	0.2364	0.9414	0.3853	0.8471	0.329865	0.8443

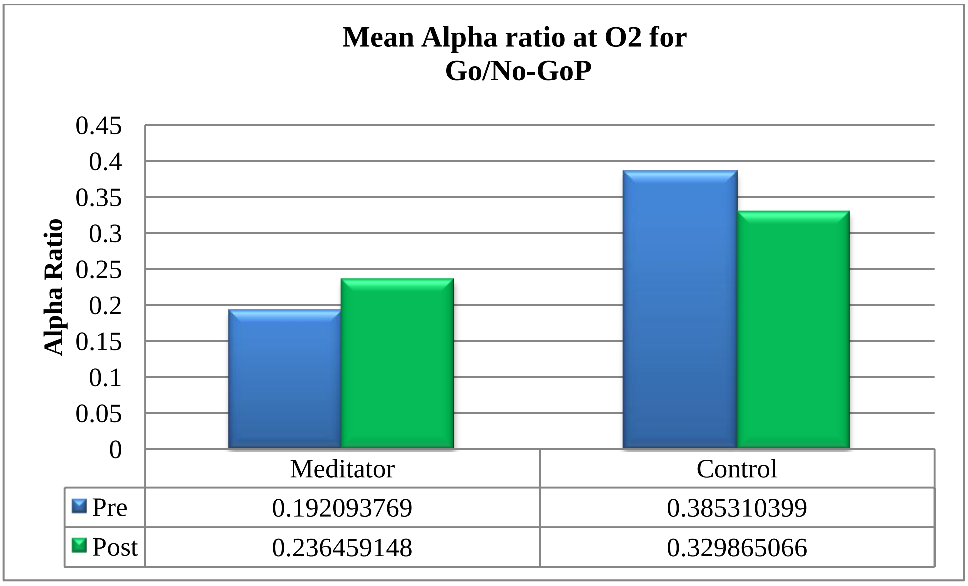


Figure 8.16: Mean Alpha ratio at O2 for Go/No-GoP

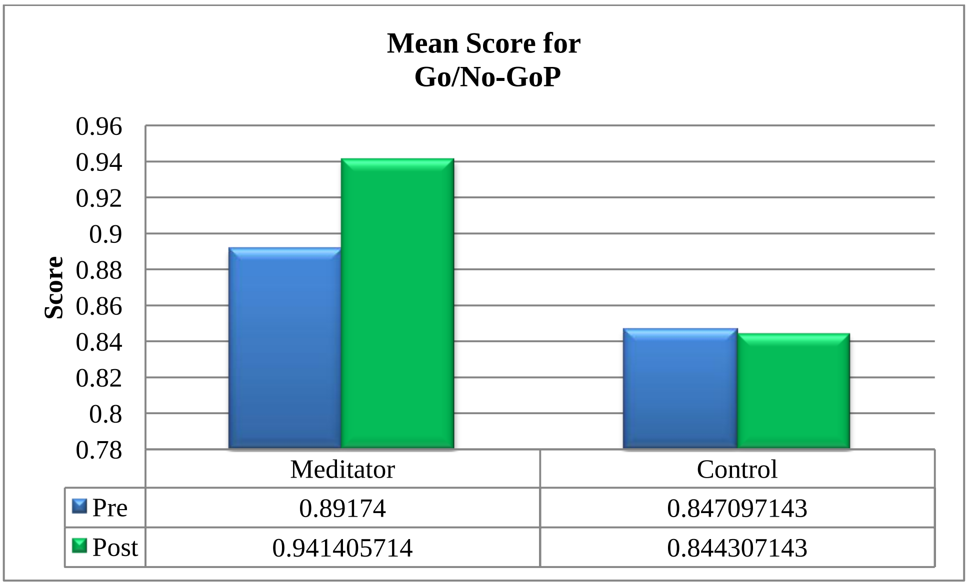
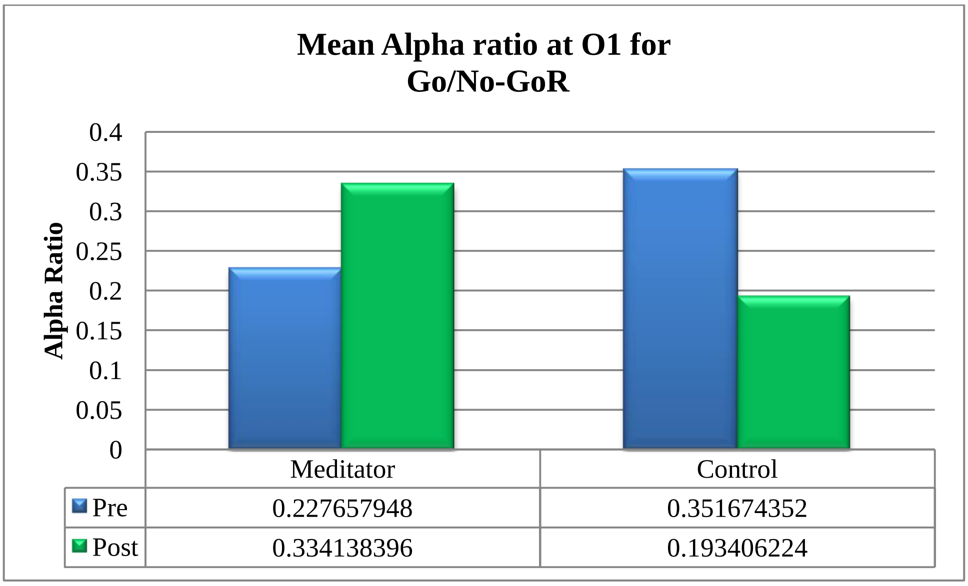


Figure 8.17: Mean Score at O2 for Go/No-GoP

Table 8.11 shows the pre and post-meditation data of Go/No-GoR at O1. Figure 8.18 and Figure 8.19 shows mean alpha ratios and scores respectively for pre and post-intervention.

Table 8.11: Pre and post intervention result for Go/No-GoR at O1

	Go/No-GoR							
	MEDITATOR				CONTROL GROUP			
S. No.	PRE		POST		PRE		POST	
	Apha Ratio	Score	Apha Ratio	Score	Apha Ratio	Score	Apha Ratio	Score
1	0.0776	0.9921	0.1860	1	0.6185	0.9882	0.1369	0.9882
2	0.3172	1	0.2814	0.9960	0.0291	1	0.0323	0.9921
3	0.0907	1	0.0367	1	0.0434	0.9882	0.0996	0.5
4	0.1677	0.9492	0.2316	0.9843	0.2364	0.9960	0.1804	0.9882
5	0.2006	0.9960	0.0264	1	1.1230	0.9960	0.7072	0.9960
6	0.6123	0.9921	0.8410	1	0.1631	0.9782	0.1486	0.9960
7	0.1272	0.9882	0.7355	0.9921	0.2477	0.9726	0.0483	0.9921
MEAN	0.2276	0.9882	0.3341	0.9960	0.3516	0.9885	0.1934	0.9218



	Meditator	Control
Pre	0.227657948	0.351674352
Post	0.334138396	0.193406224

Figure 8.18: Mean Alpha ratio at O1 for Go/No-GoR

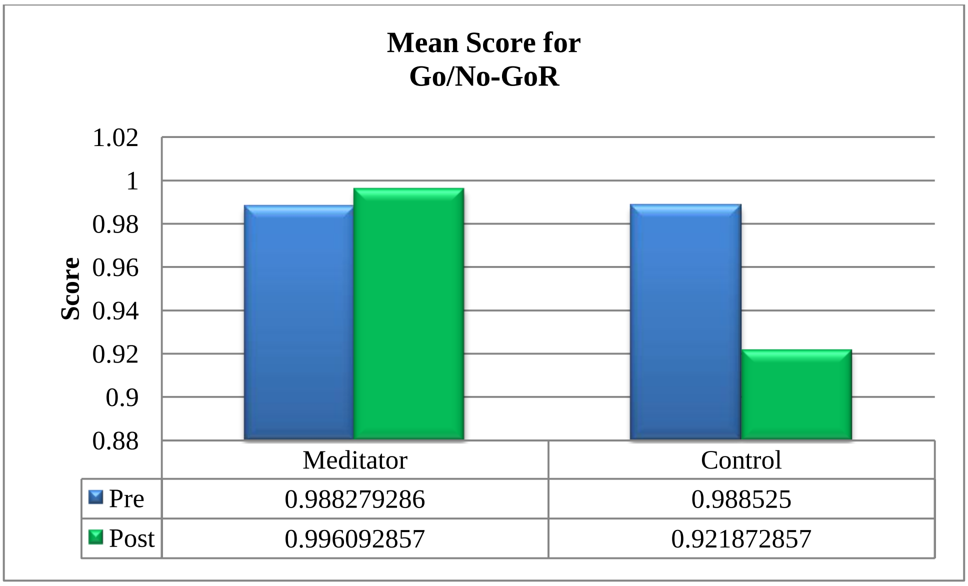
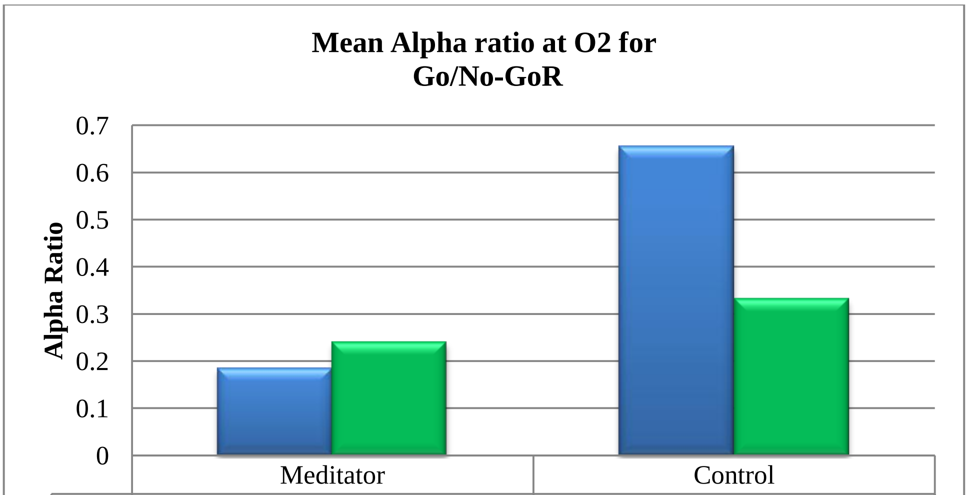


Figure 8.19: Mean Score at O1 for Go/No-GoR

Table 8.12 shows the pre and post-meditation data of Go/No-GoR at O2. Figure 8.20 and Figure 8.21 shows mean alpha ratios and scores respectively for pre and post-intervention.

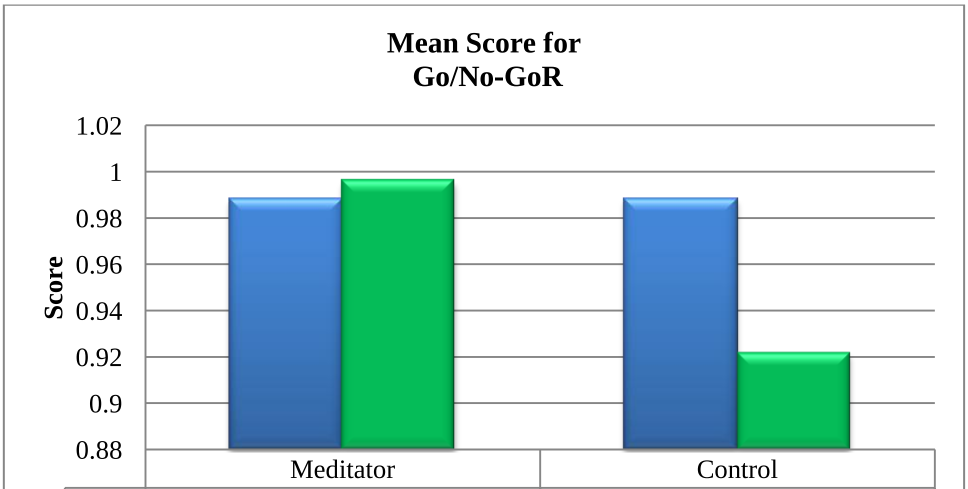
Table 8.12: Pre and post intervention result for Go/No-GoR at O2

	Go/No-GoR							
	MEDITATOR				**CONTROL GROUP**			
S. No.	**PRE**		**POST**		**PRE**		**POST**	
	Apha Ratio	**Score**	**Apha Ratio**	**Score**	**Apha Ratio**	**Score**	**Apha Ratio**	**Score**
1	0.0526	0.9921	0.3870	1	1.2201	0.9882	0.2287	0.9882
2	0.2434	1	0.1899	0.9960	0.1214	1	0.1932	0.9921
3	0.0524	1	0.0520	1	0.0276	0.9882	0.0447	0.5
4	0.3363	0.9492	0.2983	0.9843	1.4570	0.9960	1.1023	0.9882
5	0.1551	0.9960	0.0315	1	1.5310	0.9960	0.5788	0.9960
6	0.4139	0.9921	0.4448	1	0.0900	0.9782	0.1448	0.9960
7	0.0356	0.9882	0.2793	0.9921	0.1357	0.9726	0.0287	0.9921
MEAN	0.1842	0.9882	0.2404	0.9960	0.6547	0.9885	0.3316	0.9218



	Meditator	Control
Pre	0.184224096	0.654736555
Post	0.240427281	0.331637964

Figure 8.20: Mean Alpha ratio at O2 for Go/No-GoR



	Meditator	Control
Pre	0.988279286	0.988525
Post	0.996092857	0.921872857

Figure 8.21: Mean Score at O2 for Go/No-GoR

We can see from Figure 8.10 to Figure 8.21 that mean score and alpha ratio has increased for the meditators' group whereas it has decreased in all the cases for the control group. Mean score cannot statistically infer that alpha ratios and scores improve for meditators and reduce for the control group. Therefore we find out the P-values for pre and post-scores and alpha ratios of meditators and control group.

We applied one-tail, paired T-test for pre and post-readings of alpha ratios and scores for meditators and control group at both O1 and O2.

Table 8.13: P-value of for Pre and Post Alpha ratios for Meditators and Control group at O1

Group	Meditators			Control		
Task	PCPT	Go/No-GoP	Go/No-GoR	PCPT	Go/No-GoP	Go/No-GoR
P-Value	0.466058822	0.395319762	0.156696955	0.14692267	0.3840348	0.0493094

Table 8.14: P-value of for Pre and Post Alpha ratios for Meditators and Control group at O2

Group	Meditators			Control		
Task	PCPT	Go/No-GoP	Go/No-GoR	PCPT	Go/No-GoP	Go/No-GoR
P-Value	0.215039119	0.2675729	0.205258887	0.239036901	0.382462681	0.058226663

Table 8.15: P-value of for Pre and Post Scores for Meditators and Control group

Group	Meditators			Control		
Task	PCPT	Go/No-GoP	Go/No-GoR	PCPT	Go/No-GoP	Go/No-GoR
P-Value	0.0484744	0.01786	0.078160307	0.0470664	0.4769742	0.1901461

Table 8.13 and 8.14 show that the P-value of pre and post-intervention alpha ratio of meditators is greater than 0.05 which means that though mean alpha value is increasing post intervention in meditators; this increase is not statistically significant. Table 8.15 shows that P-Value of pre and post-intervention scores of meditators are less than 0.05, which means that the improvement in score is statistically significant for meditators. Whereas from Table 8.15 we can also see that the P-Value is greater than 0.05 for control group which means that there is no statistical decline or improvement in post readings for control group.

Conclusion

It can be seen that scores are statistically improving in meditators' group and alpha ratio is also seen to be increasing (not statistically) in meditators which means that performance has improved in meditators as can be seen from the scores. Increase in alpha ratio gives us the breakthrough result that alpha power which is a marker for relaxation is also increases post-meditation. This shows that with meditation performance increases whereas the relaxation also increases. In control group, it can be seen that scores are decreasing. This may be due to boredom caused because of repetition of task. Also, alpha ratio decreases which show that relaxation is reduced in post-intervention tasks for control group. This shows that control group was less relaxed during post intervention tasks and their performance also decreased.

CHAPTER 9:

CONCLUSION AND FUTURE SCOPE

Conclusion

We took fourteen subjects and made them perform attention task from The Psychology Experiment Building Language (PEBL). Electroencephalography (EEG) readings of these subjects were taken while they were performing task on PEBL. The EEG readings of these subjects were also taken while they were doing nothing with closed and opened eyes. The readings with eyes closed and eyes opened were taken as the baseline. Alpha power which is an indicator of relaxation was extracted from EEG and analysed for relaxation. The students were then divided in two groups: 1) Control group consisting of seven students on which no intervention is given. 2) Meditators group consisting of seven students on which meditation is given as an intervention. Similar readings are taken for these students after 15 days.

Following were the conclusions drawn:

1) Go/No-GoP and Go/No-GoR have a moderate correlation between them with Pearson coefficient of 0.44. The two tasks are almost similar; still the correlation between the two task score is not high. This is because Go/No-GoR is immediately performed after Go/No-GoP and it takes time to unlearn the task of Go/No-GoP and learn Go/No-GoR. Go/No-GoP and Go/No-GoR have a very low correlation with PCPT with Pearson coefficient less than 0.3. This is because of the duration for which a subject sustains attention. The Go/No-go tasks are approximately 4 minutes long whereas PCPT is 14 minutes long. A weak correlation between the Go/No-Go tasks and PCPT shows that a person who has a short duration of attention span (as in Go/No-go) might not have an attention span as long as that required in PCPT and vice versa. Since correlation in no two tasks is high therefore it can be concluded that all the three tasks are required to be performed separately for attention assessment.

2) We have validated that alpha power during eyes close is more than alpha power during eyes open.

3) It is seen that the electrodes in both the frontal (F3 and F4) and occipital region (O1 and O2) have higher alpha power in relaxed state than in attention state.

4) We observed that as the attention task performance increases, alpha ratio decreases. In other words, alpha ratio bears a negative correlation with attention task performance. This correlation is very prominent in pre-frontal, frontal and occipital regions of the brain.

5) It is seen that scores are statistically improving in meditators' group and alpha ratio is also seen to be increasing (not statistically) in meditators which means that performance has improved in meditators as can be seen from the scores. Increase in alpha ratio gives us the breakthrough result that alpha power which is a marker for relaxation is also increases post-meditation. This shows that with meditation attention increases whereas the relaxation also increases. In control group, it can be seen that scores are decreasing. This may be due to boredom caused because of repetition of task. Also, alpha ratio decreases which show that relaxation is reduced in post-intervention tasks for control group. This shows that control group was less relaxed during post intervention tasks and their performance also decreased.

Future Scope

Current research is done on healthy engineering students in the age group of 20-25. We can do the same research on different demographic group such as people from different educational qualification, age group etc. This research can also be carried out on bigger population. We can also look into other interventions and meditation techniques for performance and relaxation enhancement.

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