Cognitive Enhancement using Meditation as Intervention

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 is being presented in this thesis work entitled "**Cognitive Enhancement using Meditation as an Intervention**" in partial fulfillment of award of degree of Master of Engineering in Electronics Instrumentation & Control in Electrical & Instrumentation Engineering Department, Thapar University, Patiala is an authentic record of my own work carried under the supervision of **Dr. Mandeep Singh**, Associate Professor, Department of Electrical & Instrumentation Engineering, Thapar University, Patiala, Punjab.

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

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"Achievement is finding out what you would be doing, what you have to do. The higher the summit, higher will be the climb." It has been rightly said that we are build on the shoulders of others but the satisfaction that accompanies the successful completion of any task would be incomplete without the mention of the people who made it possible.

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ABSTRACT

Cognition refers to all the processes that organism uses to organize information. This includes cognitive abilities like memory, attention, language, visual and spatial processing, logic and reasoning, interpersonal and intrapersonal reasoning. It has been scientifically proved that cognitive abilities can be improved upon by certain interventions. Meditation is one of the methods with which we can enhance the cognitive ability of a person. There are several other methods by which cognitive enhancement can be done, like using odor, music, etc. EEG based improvements in cognitive abilities like attention and working memory using custom designed meditation is proposed. EEG records electrical activities from the scalp. Different parts of brain show different electrical activities during various mental processes. We focus on enhancing these cognitive abilities of brain. The study is divided into two parts. In first part activities of brain are recorded during various tasks related to attention and working memory. Similar tests are repeated after subjects are exposed to meditation as an intervention for 15 days for half an hour daily. For checking the level of enhancement various parameters of physiological signals are considered, like for attention alpha power and beta power are considered and for working memory alpha power and theta power are considered. The 5 subjects are made to do the same tasks after 15 days. Both the signals of pre and postinterventions are compared on account of these parameters. The post meditation results show enhancement in both attention as well as working memory. These enhancements are observed in the task performance scores as well as in the corresponding EEG frequency band powers.

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LIST OF ABBREVIATIONS

BCE- Before the Common Era

BPM- Breath per Minute

D-span- Digital Span

ECG- Electrocardiograph

EEG- Electroencephalography

FA- Focused Attention

GRE- Graduate Record Examination

GSR- Galvanic Skin Response

HRV- Heart Rate Variability

IQ- Intelligence Quotient

LAN- Local Area Network

MBCT- Mindfulness-Base Cognitive Therapy

MBSR- Mindfulness Base Stress Reduction

MMN- Mismatch Negative

MT- Mindfulness Training

NMDA- N-Menthyl-D-asparitic acid

OM- Open Monitoring

PDA- Personal Digital Assistants

PEBL- Psychological Experimental Building Language

PEPPE- Prevention and Early Intervention Program for Psychoses

PMR- Progressive Muscle Relaxation

TBRT- Triarchic Body-pathway Relaxation Technique

TM- Transcendental Meditation

CHAPTER 1
INTRODUCTION TO COGNITIVE ENHANCEMENT TECHNIQUES

1.1 Cognition

The word cognition comes from the Latin word *cognosco* (con means 'with' + gnōscō which means 'know'), hence cognition means ‘get to know’ [1]. Therefore, we can say that a system is cognitive if it knows something. Humans and animals are good example of cognitive system as humans know how to build houses, communicate, etc and Animals know how to survive. Another example for cognitive system is Autonomous robots they know how to perform certain tasks independently.

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 [2]. 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 behavior (reasoning and coordination of motor outputs) [3].

1.2 Cognitive abilities

Brain based skills are cognitive abilities. These are used to carry out simplest to the most complex task. In other words, abilities that are concerned with some of cognitive task are known as cognitive abilities. Any task is cognitive task if major determination of its successful performance is dependent on processing of mental information [4].
Some of the cognitive abilities are listed as:

1.2.1 Memory

Memory is that cognitive ability which stores and recalls information. Memory is of two types: short term (or working memory) and long term memory. Storage capacity of short term memory is limited; usually it holds about seven items for not more than 20 to 30 seconds. Short term memory is the ability to store information in immediate awareness while performing a simultaneous mental operation. As an illustration, we take example of a student who has weak short term memory. As a result, while copying a text, he will see text again and again; while solving a mathematical problem, he will read the data repeatedly; while following multiple instructions, he will refer to instructions more often. Storage capacity of long term memory is unlimited and remains for indefinite time. Information in short term memory is transferred into long term memory if it is used repeatedly. Symptoms for weak long term memory are like forgetting phone numbers, names etc.

1.2.2Attention

Attention is the ability to continuously focus on a particular action, thought or object. It is classified into three prime types

- Sustained attention: it is the ability to maintain focus on a particular task over sustained period of time. Symptom for weak sustained attention skills is that student will drift from one activity to another without completing it.
- Selective attention: it is the ability to remain focussed on a task while ignoring any irrelevant information or distraction. Student with weak selective attention have problem in studying or carrying a conversation while there is any type of distraction in surrounding area.
- Divided attention: it is the ability to focus on more than one thing. Problems faced by person having weak divided attention are difficulty in making good notes and following multiple instructions.

1.2.3 Language

Language is the cognitive ability to translate sound or sight into verbal output and vice versa. It provides us with listening skills, reading skills, comprehension and formulation. Comprehension means converting language to thought, while formulation means converting thought to language.

1.2.4 Visual and spatial processing

Visual processing is the cognitive ability to perceive and analyse the incoming visual stimuli. This also includes visualizing, which is the ability to create pictures and scenarios in mind. Persons with lack of visual processing abilities may have problems in reading maps, solving word problems (referred to mathematical exercise in which necessary information for solving a problem is written in text rather than in mathematical notations), following instructions etc. Spatial processing is the ability to distinguish differences among similar objects or forms.

1.2.5 Logic and reasoning

Logic and reasoning are cognitive abilities that make concepts, help in solving problems using unfamiliar procedures or information. Problem solving ability can further be extended to draw conclusion and come up with solution using deductive reasoning (the process of reasoning one or more general statements to reach a logically general conclusion) by analyzing the relationship between given conditions. Underdeveloped logical and reasoning skills cause trouble in solving word problems in maths and other abstract learning (involves understanding concepts) challenges.

1.2.6 Interpersonal skills

Interpersonal skills are the skills that are used every day while interacting and communicating with other people in group or individually. In workplace strong interpersonal skills are required. Employees with strong interpersonal skills will work well in team and be able to communicate effectively with costumers, colleagues and clients. Interpersonal skills are beneficial not only in workplace but also in social and personal life.

1.2.7 Intrapersonal skills

Skills found within a person's mind are known as intrapersonal skills. These skills are the foundation of successful career. For example, emotional intelligence (to understand, manage and know your own emotions), self confidence, knowing your own strengths and limits, ability to control emotions likes anger and frustration, knowing what drives and inspires you etc.

Apart from the above listed classes of cognitive abilities, several other abilities are also provided by researchers and include language, reasoning, memory and learning, visual perception, auditory reception, idea production, cognitive speed, knowledge and achievement [4].

1.3 Cognitive Enhancement

Cognitive enhancement may be defined as amplification or extension of core capacities of the mental processes through improvement or augmentation of information processing systems. Some sort of intervention is used to bring about these improvements. Cognitive enhancement, thus, aims to improve the cognitive functioning of brain like improved learning, more focus, better memory, faster reaction time, better perception, improved reasoning capacity etc.

Cognitive enhancement comprises of three steps. It begins with assessment of cognitive abilities, detail of which is given in section 3.2, followed by intervention aimed at improving the cognitive abilities. Intervention may be given for several days and can be in the form of drugs, meditation, odor, color, videogames, or any other kinds of stimuli.

Finally the validation of improvement takes place by again assessing the cognitive abilities after intervention. The second assessment is compared with the first assessment to know the extent of cognitive enhancement. The entire procedure is conceptually shown in figure 1.1.

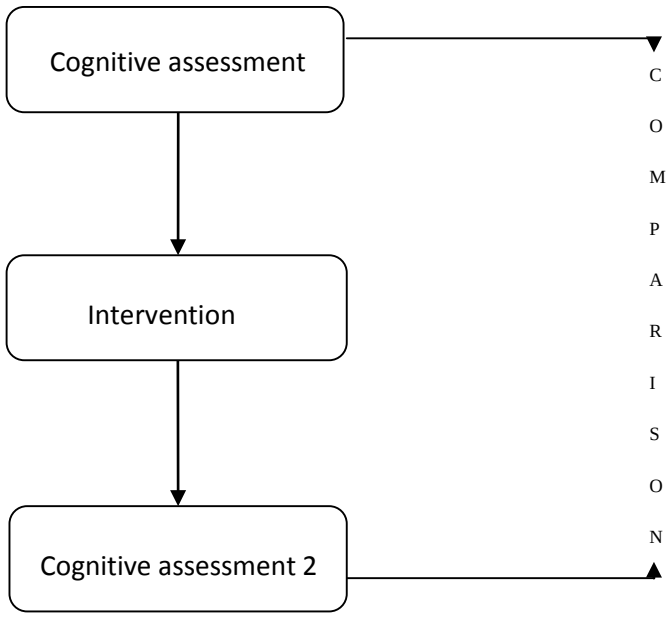


Figure 1.1: Cognitive Enhancement Procedure

1.3.1 Difference between Enhancement and Therapy

In case, the intervention is used to correct a specific pathological condition or defect of cognitive subsystem, then it is referred as a therapy. On the other hand, if an intervention is used to improve a subsystem in some way other than repairing something that is broken or remedying a specific dysfunction, then it comes in the category of enhancement [3].

Let us understand the difference between enhancement and therapy by taking short term memory as the cognitive availability. A common misbelieve is that improvement from abnormal to normal is therapy, while improvement from normal to super normal is enhancement. This misbelieve is dispelled by taking the following example. A person "A" has inborn short term memory of retaining 60 words out of 100 shown to him. On the other hand a person "B" suffering from some identifiable pathology such as earlystage

Alzheimer's disease may be able to recollect 75 words out of 100 shown in spite of disease. His memory score before the disease was 85. Now an intervention is given to improve the score of "A" from 60 to 70. This shall be classified as enhancement. On the other hand, intervention given to "B" to bring memory score from 75 to 85 shall be classified as therapy. It may be noted that pre-intervention score of "B" is more than the post intervention score of "A". Hence irrespective of post intervention performance or pre intervention score, intervention used to correct the harm done by any pathological condition is called a therapy, while bringing about the improvement in cognitive abilities in absence of any disease is called enhancement.

1.3.2 Cognitive assessment

Cognitive assessment is an examination that is conducted to determine level of cognitive functioning of brain [5]. Cognitive assessment is broadly divided into two groups: 1) Task oriented assessment 2) Physiological assessment

1) Task oriented assessment

In this type of assessment, subject will be asked to complete a series of task like matching numbers, word series etc. that require cognitive skills. There are certain standard batteries that are used for cognitive assessment like Psychological Experimental Building Language (PEBL), Prevention and Early Intervention Program for Psychoses (PEPP) etc. In PEBL we can run as well as design computer-based experiments as it is a free crossplatform. Some of the tasks are discussed below [5].

- Go/No-go test

This test is used for assessing attention. In this test, subject will see a serious of "P"s and "R"s on the screen. Whenever subject see a "P", respond by pressing right shift key on the key board and don't respond when see an "R".

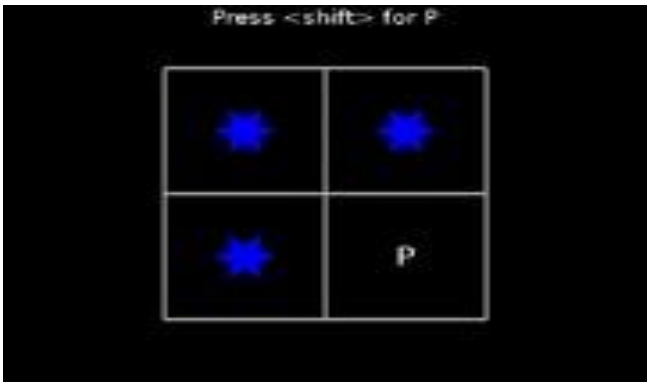


Figure 1.2: Go/No-go test

- D-span test

Digital Span (D-span) test is used for assessing working memory. In Digit Span, subject sees a series of digits presented in a box at the top of the screen and her task will be to remember these numbers in sequence. After a brief period of time, the numbers will disappear and the subject will respond by entering the digits.

Figure 1.3: D-Span test

- Matrix rotation

The test describes how the mind recognizes objects in the surroundings. The subject is shown a square matrix with a pattern and they are instruct to remember that pattern as quickly and as accurately as possible and then press a button on keyboard when they are

sure they know the pattern, and then a second matrix appears. Subject is now instructed to compare both the patterns in their mind. If the pattern is rotated 90 degrees (either left or right), the subject has to press the left shift key on the keyboard otherwise the right shift key has to be pressed.

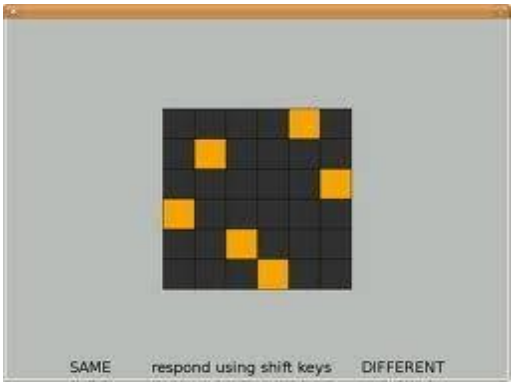


Figure 1.4: Matrix rotation test

- Muller-Iyer Test

The Muller-Iyer Test is an optical misapprehension consisting of a stylized arrow. The Arrow has two arrow heads and it appear as two arrows. The subject has to compare which arrow has longer length and the corresponding key has to be pressed. The lines appear to be same and that is why it is called a misapprehension test.

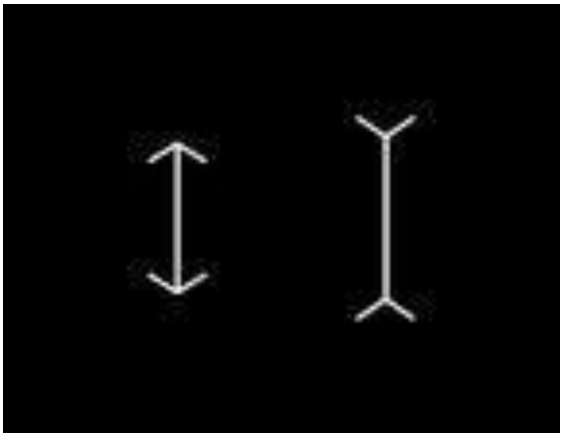


Figure1.5: Muller-Iyer test

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. [5]. EEG is conventionally used to detect pathological conditions like epilepsy [6-10], but nowadays it is also being used to detect and quantify emotions [11-15]. EEG is a record of neural activity, and it acquired in a non-invasive manner by placing electrodes over the scalp of the subject [16]. The signal of EEG is conditioned by de-noising and features are extracted from frequency bands of different ranges like theta, beta, alpha, beta, and gamma [7, 8, and 11]. For emotional detection or for diagnosing any pathological condition like epilepsy, the features extracted from EEG frequency bands are given to a related classifier, that may be rule based, nearest neighbour classifiers, or more advance technique like SVM [17]. It is found that activity of different lobes of brain increases as per the task performed. As in case of attention task power of theta, beta 2 band decreases and alpha2 increases and with age power of frontal theta increases [18-19]. In case of working memory power of alpha increases in posterial and bilateral central areas [20].

1.4 Classification of cognitive enhancement techniques

There are different ways by which we can classify techniques of cognitive enhancement. One way of classifying cognitive enhancement techniques are whether they are conventional or unconventional [3]. Another way of classifying cognitive enhancement techniques is whether they are external/internal to the user and whether they are hardware/software based [21]. A diagnostic representation of cognitive enhancement classification is given in figure 1.6

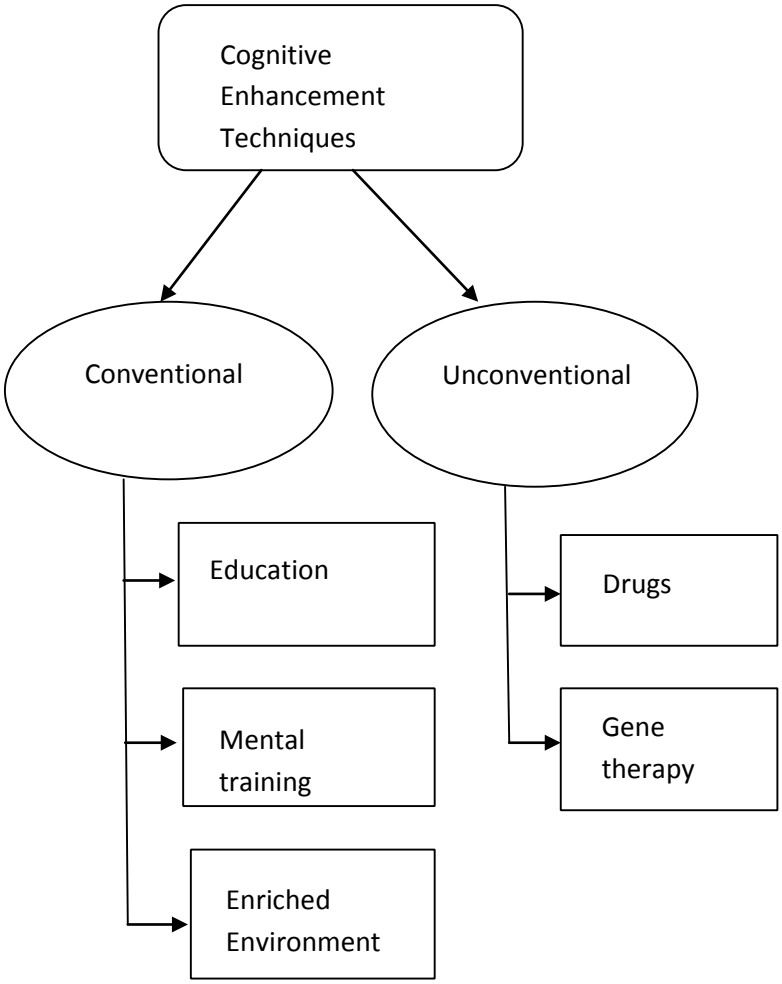


Figure 1.6: Classification of Cognitive Enhancement Techniques

1.4.1 Conventional

Education, mental training as well as use of external information processing devices come under "conventional" means of enhancing cognition [3].

1) Education

Whatever we learn in our school is "mental software" for managing various cognitive domains: mathematics, reading, writing and understanding language, problem solving in particular subject etc. This type of mental software will reduce one's mental load by clever encoding, organization, or processing [21]. From Wikipedia education is defined as a form

of learning in which through teaching, research or training group of people transfer skill, habits and knowledge from one generation to next. Education can be any experience that has effects on the way one thinks, feels or acts. Education is commonly separated into five stages starting from preschool, then primary school, followed by secondary school, then college, then university or apprenticeship [22]. Accordingly education by default enhances cognitive abilities. However for a particular task special efforts may be made to improve the speed or efficiency of performance. Abacus, which is a simple mechanical calculation device used to store numbers during mental calculations, increases the speed of calculations and these forms are example of cognitive enhancement. In this device, the beads are slid up or down on various rods to simplify the mathematical processes like subtraction, addition, division, multiplication, etc. Interestingly, with practice, the person is able to do the calculations without any physical abacus, by mentally picturing the beads. Many children trained on this technique are able to do calculations faster than those done with the help of electronic calculator. Learning this method thus can be classified as a cognitive enhancement technique. A basic abacus is shown in figure1.7

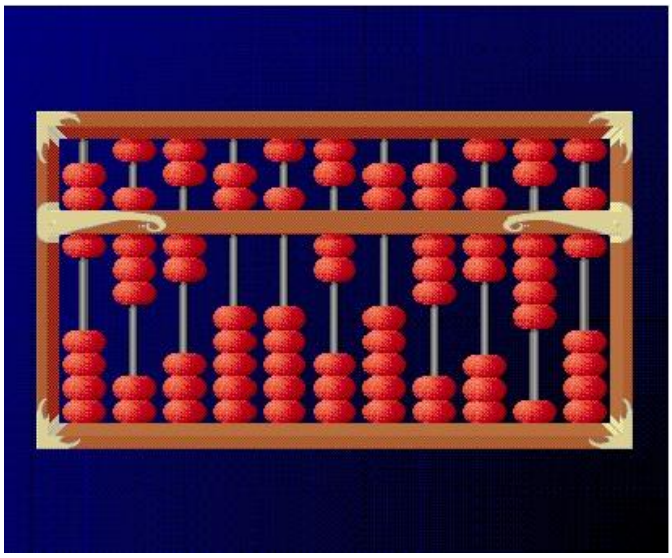


Figure 1.7: Basic Abacus

Another sub class of cognitive enhancement through education includes use of short cut techniques in mathematics. For example, taking square of any two digit number conventionally requires multiplication of the number with itself. In one of the shortcut method, we first make unit digit zero. After all, it is easy to multiply when unit digit is

zero. Here we multiply (the number + unit value) with (the number-unit value) and then add square of unit value. Let us see how it works by taking square of 53: (53+3)*(53-3) + (3*3) = (56*50) +9= (560*5) +9= 2800+9 =2809. Similarly for square of 64: (64+4)*(644)+(4*4) =(68*60)+16 =(680*6)+16 =4080+16 =4096. These strategies and short cut techniques improve the cognitive ability of number crunching. Interestingly these are popularly categorized as Vedic mathematics, though they don't find any mention in Indian Vedas.

All these types of methods have a narrow range of applicability but can be used for improving performance within a particular domain.

2) Enriched Environment

Enriched environment is another conventional technique by which we can enhance one's cognitive abilities. Enriched environment is the stimulus for brain by its social and physical surroundings [23].

There are various ways to provide enriched environment. Learning something new like – chess, poker, a new computer game, learning some musical instrument, learning new language etc is one simple way to provide enriched environment. Another way of enriching environment is travelling. Travelling will cut a person's daily routine and provide a new environment to him as well as to his neurons.

Various studies have demonstrated a positive effect on brain for those animals which are offered enriched environment. By comparing a single rat in normal cage with 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, thereby retrieving stress [24].

Stimulation-seeking children, who might be seeking out and creating enriched environment for themselves, score higher on Intelligence Quotient (IQ) test and do better at school than less stimulation seeking children [25]. 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 [26].Some of such interventions have both cognitive enhancement as well as therapeutic effects. For instance, an optimized intrauterine environment will not only help avoid specific pathology and deficits but is also likely to promote the growth of the developing nervous system in ways that enhance its core capacities [3].

No wonder, the expecting mothers in India are traditionally given extra importance on both physical as well as psychological level. Abhimanyu, a great archest and philosopher, is believed to learn the intricacies of archery and philosophy, even as a foetus in his mother's womb. Dr. T Mythily-chief music therapist, Apollo hospital, Chennai, reports that music therapy ensures natural and smooth delivery, and also increases the chance of high cognitive abilities, 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, which facilitates efficient and easy learning, and application of intelligent thinking, develops rapidly in foetus in the womb of mother by providing music stimulation. These babies are always ahead of their counterparts in all aspects of life whether acquiring skills and knowledge, this tendency seems to continue well into their lives.

3) Mental training

There are various forms of mental training by which cognitive enhancement can be done. Even general mental activity, "working the brain muscle" can improve performance [27] as well as long-term mental health [28], while relaxations techniques help regulate the activation of brain [29]. It has been suggested that the Flynn-effect [30], produces a general increase in raw intelligence test scores by 2.5 IQ (intelligence quotient) points per ten years in most western countries [3]. Flynn-effect is the sustained and long-sustained increase in general cognitive abilities across the population with passage of time. It can be explained on account of increased cognitive demands of abstract and visual thinking in modern

society and schooling, although there are certain factors such as improved nutrition and health status that may also play a major part [31].

Another form of mental training consists of learning strategies to memorize information (i.e. memory techniques). "The method of loci" is one such strategy. In this method subject will visualize the layout of shops on a street, any building or any geographical entity and in her imagination she will walk from room to room, depositing imaginary object that evokes natural association to the subject even though she is memorizing. During retrieval, subject will recall all the memorized information from her imaginary steps while walking to objects she placed [3]. As this method relies on memorizing and recollecting the content, it is used in tackling brain's spatial navigation system to remember objects or propositional contents. In basic term, it is a method of memory enhancement which uses visualization to organize and recall information.

There are various other methods for memory enhancements such as use of rhyming, recalling colorful or emotional scenes, recalling number series or letters. This kind of Memory techniques are used in everyday needs such as remembering passwords, door codes, shopping list, and by students who need to memorize name, dates and terms while preparing for exams [32-33].

Some other forms of mental training such as yoga, martial arts, meditation, video gaming are also used for cognitive enhancement [3].

Meditation is one of the techniques for improvement in cognitive abilities. From ancient period meditation is practiced by humanity across the globe in some form or other. It is helpful to reduce anxiety, improve psychological health, reduce stress, improve memory, attention etc. Mindfulness meditation helps in reducing anxiety and pan [34]. Mindfulness meditation improves short term memory, attention and decreases reaction time [35]. Another technique used for enhancing cognitive abilities is yoga , with alternate nostril breathing pranayama (one of the oldest yoga) mental stress reduces, physical strength and health improves [36].

Video gaming is yet another mental training technique to improve cognitive abilities. Gaming is good mental exercise. Persons playing fast paced games have better vision perception, attention and cognition. Video games are used in various fields like education, physical exercise and cognitive training [37]. Playing first person shooter game improves working memory [38].

1.4.2 Unconventional

Unconventional techniques of Cognitive enhancement include drugs, gene therapy, or neural implants; nearly all of them are considered as experimental at present time [21].

1) Drugs

The general perception of drugs used for enhancing cognitive abilities is that these are illegal and unhealthy. Contrary to this some drugs are legal and when taken in proper amount are very useful for cognitive enhancement.

Cognitive abilities like memory, attention, and concentration can be improved by drugs such as nootropics. Nootropics work by improving the brain's oxygen supply, by stimulating nerve growth, or by altering the availability of the brain's supply of neurochemicals (neurotransmitters, enzymes, and hormones). Nootropics formulations have been used in ayurvedic system since ages. Some examples for enhancing memory are almonds, ginger, tulsi, ambla, Indian tulip tree etc [39]. These being conventional may not be considered under this category. These will provide a long term effect. However, some of the unconventional drugs which are used to improve memory are Ritalin and Adderall which provide short term effects. These are commonly used by college students to improve grades and provide an edge over their classmates [40].These methods of cognitive enhancement are legally not approved as they form a type of cheating, just in the same manner as doping for sports persons is banned. Some drugs which are used for treating Alzheimer's disease and other cognitive deficits also improve cognition in healthy individuals. US Food and Drug Administration has already approved a number of these drugs, including donepezil (Aricept®), rivastigmine tartrate (Exelon®), galantamine HBr

(Reminyl®), and memantine (Namenda®). In addition, the new psychastimulant modafinil (provigil®) improves alertness, a key factor in cognitive performance [41].It is also being tested for use by military and has shown improvement in simulator performance by helicopter pilots [42].

Two most popular drugs which are for long being used for improving cognition are nicotine and caffeine [3]. In case of caffeine tiredness reduces [43-45], while with nicotine a complex interaction with memory and attention occurs [46-48]. Caffeine is being used traditionally as a stimulant for providing alertness. It is often consumed in extremely high dosages. For example starbucks is a very popular coffee due to the fact that in a very small serving say 16- ounce contains 550 milligrams of caffeine, a 5 times the amount in a regular cup of coffee.

Supplement like choline when given to rats in prenatal (during pregnancy) and perinatal (few days before and after birth) stage have reported to improve memory [49-50].
Choline is naturally available in foods like eggs, sunflower, broccoli, peanuts etc.

2) Gene therapy

Gene therapy or gene modification is a technique which inserts genes directly into cell. It is used to cure or prevent disease instead of using drugs or surgery. This is useful in enhancing cognitive abilities as well. In rats and mice it has been demonstrated that gene modification enhances memory. NR2A subunit of NMDA (N-Methyl-D-aspartic acid) is linked with low plasticity of brain (or neuroplasticity is the ability of brain to change based on new experience). While normal animal is maturing, synthesis of NR2B is replaced by NR2A; hence memory is low in adult animals. Genetically modified mice to produce more of the NR2B subunits. The NR2B ‘‘Doogie’’ mice showed improved memory performance, in terms of both acquisition and retention [51].

1.5 Another way to classify Cognition Enhancement Techniques

There are another ways of classifying cognitive enhancement techniques into internal and external. Both internal and external techniques are further classified into software and hardware techniques. This type of classification is represented in figure 1.8

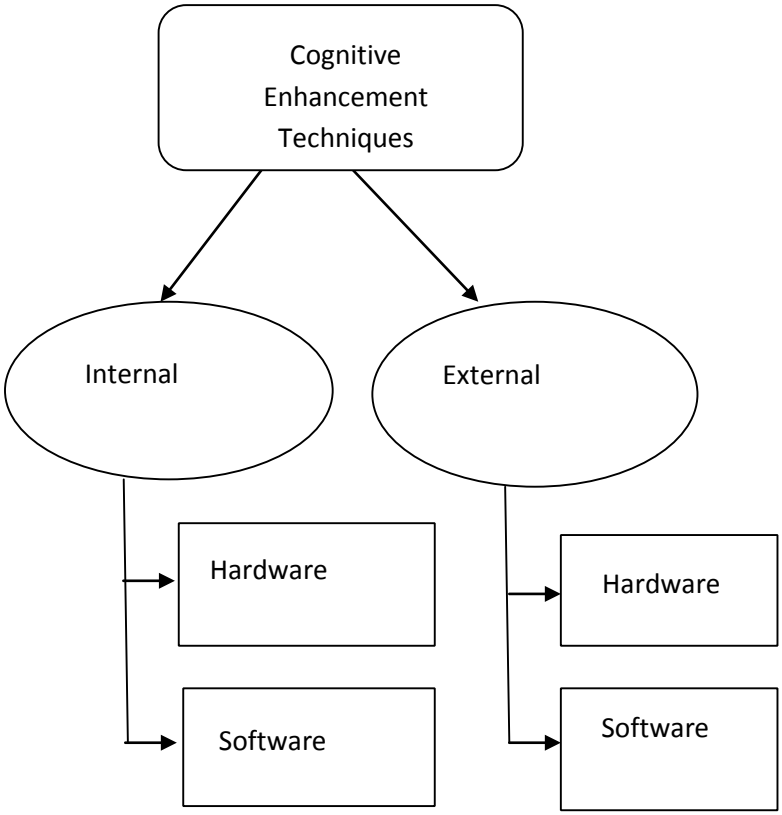


Figure 1.8: Classification of Cognitive Enhancement Techniques

1.5.1 Internal hardware

It is similar to unconventional means of enhancement. It deals with biological modifications such as genetic modifications (through hybridization or screening), surgery, tissue engineering, pharmaceutical or nutritional interventions and neural implants [21].

1.5.2 Internal software

The first cognitive enhancement strategy developed was internal software that helps us organize thoughts and memories. Internal software enhances cognition by learning improved cognitive strategies or making use of neuroplasticity [21]. The ability of brain to change with learning i.e. lifelong ability of brain to reorganize neural pathways based on one's new experience is known as neuroplasticity or the plasticity of brain.

Internal software deals with all types of mental training and education that basically comes under conventional means of cognitive enhancement.

1.5.3 External hardware

From long history external hardware has been used for improving cognitive abilities. Clay token was used as first external hardware for cognitive amplification. They were found across near east dating from 8000 BC up to the time of writing in 3000BC [52]. Originally they were just used for counting aids and recording of possession. As time changed their shapes also changed and we stared using clay tablets for writing purpose. It laid the groundwork for the permanent storage and transmission of information. Later we developed paper and ink. This is the most used and most powerful cognitive amplifier as it is most suitable means of storing information.

However computers are needed because paper is passive and is not used for processing. Wearable computers and Personal Digital Assistants (PDAs) are already intimate devices worn on the body, but there have been proposals for even lighter interfaces. Digital control of external devices through brain activity has been studied with some success for the last 40 years, although it remains a very low bandwidth form of signaling [53].

1.5.4 External software

Until recent practice all cognitive software's were internal. Today software Computers is not only used for storing information and performing calculations, they can also supplement our skills. For example symbolic math programs are able to amplify our mathematical skills by providing perfect storage and remember of formulas, the skill to do calculations with no risk of making slips and graphical visualization of the result. Similarly, decision support tools attempt to help making rational decision in uncertain situations (Walter 1997). When information is so large that human brain cannot handle it, like searching for relevant data in huge pile may take enormous time, by using data mining and information visualizing we can solve this problem. A very common example of such a

searching is Google. Other tools such as symbolic math program, expert systems, and search agents amplify specific skills and capacities [3].

CHAPTER 2
WORKING MEMORY AND ATTENTION: EFFECTS ON EEG

2.1 Attention

Attention is focusing on only one aspect of environment whether it is any thought, action, object while ignoring other things. It is basically of three type selective attention, sustained attention and divided attention. Several researchers have reported changes in various brain wave rhythms during attention.

Andrzej Wróbel focused on the beta activity to study visual attention. The researcher acknowledged that in the cat, cortico-geniculate feedback has a potentiation mechanism having beta frequency which activates thalamic cells and this may lower the threshold for visual information transmission. From this study it is observed that beta activity increases in visual attention task [54].

S.P. Kelly et al. examined the EEG alpha power in sustained attention task. It was found that in two of three subjects average power in the alpha band was connected to stimulus presentation. This pointed towards short-term attentional processes. From this study it is observed that alpha power decrease while engaged in an attention task [55].

Kridsakon Yaomanee et al. examine suitable location of brain for detecting EEG signals during attention tasks. Three experiments were constructed for this purpose. All 3 experiments made the examiners center on the specific task to stimulate attention. For alpha wave AF3 and F7 channels show results and for beta wave FC6 and F8 channels show results. It was also revealed that Alpha wave in the relaxation state was high than Alpha wave in the attention state and Beta wave in the attention state was high than Beta wave in the relaxation state [56].

2.2 Working memory

Memory is used to store and recall information. Memory is classified into two types: short term (or working memory), and long term memory. Working memory have limited storage

capacity, it can hold seven items not more than 20 to 30 seconds. Various researchers have reported changes in Brain wave rhythms during working memory task.

Allison Bell study the effect of brain wave rhythms (theta wave) **during** a working memory task .The study use a hypothesis- does eye closure increase theta wave amplitude and performance level during a working memory task. The EEG data analyses indicate no significant correlation among increased theta wave amplitude and eyes opened and eyes closed tasks [57].

Joshua Jacobs et al. studied the correlation between memory recovery and decision making with theta activity. During recovery, power of left-parietal theta oscillations increased in relation to how well a test item was remembered, and theta in central regions correlated with decision making. [58].

Ole Jensen and Claudia D. Tesche examined that frontal theta activity in humans increases in a working memory task. The research showed brain oscillations in the theta band are involved in tasks related to working memory. The activity in the theta band increased with the number of items retained in working memory. The results suggested that theta oscillations generated in frontal brain regions play a significant role in working memory tasks [59].

CHAPTER 3 MEDITATION FOR COGNITIVE ENHANCEMENT

3.1 Origin of word meditation and its history

In the Old Testament (Christian name of Hebrew bible), hāgâ means to sigh or murmur, and also, to meditate [60]. 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 [61]. Meditation is derived from meditatio, meaning to think, contemplate, devise, and ponder [62]. Meditation was introduced as a translation for eastern spiritual practices. Meditation is referred to as dhyāna in Buddhism and in Hinduism, it comes from Sanskrit root dhyai, meaning to meditate or contemplate. It is also referred to in Islamic Sufism, Christian hesychasm, Jewish kabbalah, and many other traditions.

The practice of mediation is of pre-historical origin. The history of meditation is closely bound up with the religious context with in which it was practiced [63]. Some of the earliest references to meditation are found in the Hindu Vedas during the Vedic period (Iron Age India) [63]. Around 6th to 5th centuries Before the Common Era (BCE), other forms of meditation developed are Buddhist in India and Taoist in China.

3.2 Types of meditation

Meditation is a state of thoughtless awareness. It basically means to drop everything which is in one's memory and to come to a state where only awareness (or consciousness) remains. For example if we take a lamp and remove all things placed near by it, lamp will still glow. Similarly, if we remove all thoughts, all imagination and all that happens from our consciousness, then only consciousness will remain and this form of pure consciousness is called meditation.

The word meditation is used to describe practices that self-regulate the body and mind, thereby affecting mental events, by engaging a specific attentional set [64]. It is broadly classified into two types: mindfulness and concentrative, depending upon how the attentional processes are directed. Most of meditation techniques lie somewhere inbetween the poles of these two general methods [65-66].

3.2.1 Mindfulness meditation

Mindfulness meditation is also referred to as Open Monitoring (OM). This type of meditation practices involve allowing any thoughts, feelings, or sensations to arise while maintaining a specific attentional stance: awareness of the phenomenal field as an attentive and non attached observer without judgment or analysis. Examples include Zen, Buddhist practice called Vipassana, and the western adaptation to mindfulness meditation [67]. Central aim of OM meditation is to remain only in the monitoring state (i.e. clear reflexive awareness). In OM meditation a person will meditate without explicitly focusing on any object, rather by being attentive moment to moment, to everything.

3.2.2 Concentrative meditation

This type of meditation techniques involve focusing on specific mental or sensory activity: a repeated sound, an imagined image, or specific body sensations such as breath. Therefore it is also referred to as Focused Attention (FA). Examples include forms of yogic meditation and the Buddhist sanatha meditation focus on the sensation of breath [64]. In FA meditation one has to constantly monitor the quality of attention. As attention will move away from focusing point, and we have to notice that, and then restore attention to the chosen object. For example, while focusing on any imagined image, suddenly attention diverges to pain in knee. At this stage person will release the distraction and has to restore attention back to focusing point. Broadly speaking

Transcendental Meditation (TM) is considered as concentrative meditation. While some researchers classify TM as a kind of FA, other maintains TM to be a separate class of meditation. Transcendental meditation practice involves a mantra. This practice is centered on repetition of mantras. However, unlike most mantra mediations, any possible meaning of the mantra is not part of TM practice. Rather, the individual is trained to appreciate the sound value of the mantra at more refined ‘levels’ [68].

3.3 Comparison between mindfulness and concentrative meditation

In concentrative meditation individual focuses on a particular object or thought. Everything else that might tend to attract attention, such as bodily sensations, environmental noise, or intrusive thoughts , are allowed to pass without clinging to them and bringing back attention to a specific object in order to develop an internal
"witnessing observer". In mindfulness meditation the individual is receptive to all the thoughts and sensations experienced without focusing attention on any particular concept or object; therefore attention is unrestricted and flexible. In total we can say that the
"effortful" selection and "grasping" of on object as primary focus in FA meditation is gradually replaced by the "effortless" sustaining of awareness without explicit selection of object in OM meditation. Both mindfulness and concentrative meditation styles are likely to overlap in their approach, as both progresses to a similar goal. For this reason many types of meditation may actually fit in both the categories as effort is made at some stage of meditation to maintain concentration while remaining mindfully alert.

3.4 Difference between transcendental and concentrative mediation

Transcendental meditation is broadly included in concentrative meditation. Unlike most of the mantra mediations (concentrative meditation) TM practice is a process of
"effortless transcending"- using the mantra as a vehicle to take attention from the ordinary thinking level to the least excited state of consciousness called pure consciousness[68-69]. Main difference between transcendental and concentrative meditation is that TM emphasizes effortlessly maintaining focus on an object, while in concentrative meditation an effort is required to maintain focus on an object.

3.5 Why meditation?

Mediation is helpful in various ways. Meditation is seen by number of researchers as potentially one of the most effective form of stress reduction [36]. It is also used in medical care. A US study for example, showed that a short course of behavior modification

strategies that include meditation led to significant fewer visits to physicians [70].Another study on insurance statistics showed that the use of medical care was significantly less for meditators as compare to non meditators [71].

3.6 Cognitive enhancement using mediation as intervention

Enhancement using meditation to any cognitive ability is done in three basic steps. Firstly, cognitive ability is assessed using either task oriented or physiological oriented cognitive assessment technique. In second step selected meditation is practiced for a predefined interval. In third step again cognitive abilities are assessed by using any one of techniques. After these three steps, results of pre and post cognitive assessments are compared to represent the final result, that is, whether enhancement occurred or not.

3.6.1 Meditation to enhance attention

Attention is focusing on only one aspect of environment whether it is any thought, action, or object while ignoring other things. It is basically of three types: selective attention, sustained attention and divided attention. Lack of attention leads to various problems like person will move from one activity to another without completing any of them will have problem in studying and writing in presence of is any distraction in surrounding areas.
Several researchers have reported enhancement in attention often practicing meditation.

1) Mindfulness meditation for Attention Enhancement

Randye J. simple studied the effect of Benson technique, which is mindfulness mediation on 4 components of attention (sustained, vigilance, concentration, inhibition of distraction and execution). Three groups were taken: first group performed mindfulness meditation, second group was assigned a modified Progressive Muscle Relaxation (PMR) procedure, and third group was taken as control group. Benson technique was developed by Herbert Benson, M.D in Harvard Medical School. After 4 weeks of meditation that was practiced 20 minutes twice a day, it was seen that mediators group show significant improvement in

mindful attention than relaxation or the control group. The assessment of these cognitive abilities was made using Continuous Performance Test, Digit Symbol Substitution, Stroop Color and Word Test, Spielberger State-Trait Anxiety Inventory, and Profile of Mood States before and after intervention [72].

Fadel Zeidan et al. examined the effect of short term meditation that uses Shamatha skills, a mindfulness meditation for enhancing cognitive abilities. Subjects were divided into two groups. First group performed mindfulness meditation for 20 minutes daily, second was taken as control group in which students listened to audio book The Hobbit, authored by JRR Tolkien. Shamatha skill was performed for 4 days. In first and second session 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 learn in previous session was repeated, but with greater time spent in silence. After 4 days it was assessed that mindfulness training significantly improved sustained attention. These findings suggested that brief meditation training also give benefits that have been found with long-term meditation. The assessment of these cognitive abilities was made using Controlled Oral Word Association Test, Symbol Digit Modalities Test, forward/backward digit span, and computer adaptive n-back task before and after intervention [73].

Adam Moore et al. studied the effect of Buddhist meditation, a mindfulness meditation on cognitive flexibility; self reported mindfulness as well as other attentional functions.

Subjects were divided into two groups. First group was considered as meditators group, second group was considered as Meditation- naïve control group. Subjects in meditation group were Buddhist meditators taken from Buddhist centre who had completed 6- week beginners' course on meditation. It was found that cognitive flexibility and attention performance were positively correlated with meditation practice. Self reported mindfulness was higher in meditators than non-meditators. Further, meditators performed better in all measures of attention. This pattern of results indicates that mindfulness is intimately linked to improvement of attention functions and cognitive flexibility [74].

Agnes S. Chan et al. examined the effect of ancient Chinese mindfulness base meditation, Triarchic Body-pathway Relaxation Technique" (TBRT) on internalized attention and

positive emotions and compare it to music listening which were shown positive emotion. Nineteen college students were taken and each of them listened to both music audiotape and TBRT while EEG was recorded. Two EEG patterns 1) frontal midline theta activity associated with internalized attention 2) alpha asymmetry index associated with positive emotion were used. In both TBRT and music condition it was found that there is an increase in left-sided activation, a pattern associated with positive emotions. However, only TBRT exercise was shown to exhibit greater frontal midline theta power, a pattern associated with internalized attention [75].

2) Concentrative Meditation for Attention Enhancement

Shruti Baijal et al. investigated the brain oscillatory changes during Sahaj Samadhi meditation, a concentrative form of meditation. Brain oscillatory activity is associated with different cognitive processes. Subjects were divided into two groups. First group was considered as meditators, they were teachers of Sahaj Samadhi meditation at art of living and practicing meditation daily from 3 to 7 years, second group was considered as non-meditator control group. Sahaj Samadhi meditation is a part of Sudarshan Kriya yoga. It was found that theta power in frontal region is more in meditators as compare to control group. Given the association of theta and frontal regions with attention processing, meditation is considered an effective way training attentional brain networks which has shown benefit cognitive processing in humans [76].

Narayanan Srinivasan et al. uses Mismatch Negative (MMN) paradigm to investigate the effects of Sudarshan Kriya yoga meditation, a type of concentrative meditation. MMN is a component of ERP to an odd stimulus in a sequence of stimuli and is an indicator of pre-attentive processing. Subjects were divided into two groups. First group was considered as meditators group, they were teachers at art of living and have been practicing Sudarshan Kriya daily from 3 to 7 years, second group was considered as non meditators control group. Sudarshan Kriya is practiced in an ordered sequence with Mudra pranayama (5–7 min) followed by Sudarshan Kriya (10–12 min) and lastly by Sahaj Samadhi meditation (6–8 min). During recording, meditators followed the same order and correspondingly, non-meditators were asked to relax for duration that approximately matched with those of

meditators. MMN was recorded before and after each stages of meditation. It was found that concentrative meditation enhances perceptual and pre-attentive processing [77].

3.6.2 Meditation to enhance working memory

Memory is used to store and recall information. Memory is classified into two types: short term (or working memory), and long term memory. Working memory have limited storage capacity, it can hold seven items not more than 20 to 30 seconds. Lack of working memory lead to many problems like seeing again and again to the text while copying it etc.. Several researchers have reported enhancement in working memory after practicing meditation.

1) Mindfulness Meditation for Working Memory Enhancement

Marieke K. van Vugt et al. studied the effect of Sathipattana Sutra, a mindfulness meditation on working memory. Subjects were divided into two groups. First group performed mindfulness meditation 10-12 hours daily, and second group was taken as control group with age and education matched with meditators group. Participants performed delayed recognition task (for investigating working memory) before and after a month-long meditation practice. In the first 2 weeks, the participants focused mainly on their breath, and in the second 2 weeks, they opened up their attention and added practices that cultivated compassion and loving kindness. The EZ-diffusion mode (a mathematical model) suggested that mindfulness training leads to improved information quality and reduced response conservativeness, with no changes in non-decisional factors [78].

Michael D. Mrazek et al. examined the effect of Mindfulness Training (MT) on Graduate Record Examination (GRE) score and working memory. Subjects were divided into two groups. First group performed mindfulness exercise daily for 10 to 20 minutes for two weeks, and second group was taken as neutral group which do not perform anything. Mindfulness exercises required focused attention to some aspect of sensory experience (e.g., sensations of breathing, tastes of a piece of fruit, or sounds of an audio recording). Participants shared their experiences with the class and received personalized feedback

from the instructor. It was found that MT improved both GRE readingcomprehension scores and working memory capacity while simultaneously reducing the distracting thoughts (mind wandering) [79].

Amishi P. Jha et al. studied the impact of Mindfulness Training (MT) on working memory. Subjects were taken from military and were divided into two groups. First group performed meditation for 8 weeks, and second group was taken as control group. The MT course, referred to as mindfulness base mind fitness training, was created by former U.S army officer. The course matched many features of Mindfulness Base Stress Reduction (MBSR). The course involved 24 hr of class instruction over 8 weeks, with weekly 2-hr meetings (on average) and a full-day silent retreat. It was found that in the MT group, working memory decreased over time in those with low MT practice time, but increased in those with high practice time. In control group, it decreased but remained stable with time [80].

2) Concentrative meditation for Working Memory Enhancement

Sarina J. Grosswald et al. studied the effect of Transcendental Meditation technique to reduce stress and anxiety as a means of sinking symptoms of ADHD. Subject taken in this study were students ages 11-14, they practiced it twice daily in school. Results showed statistically significant reductions in stress, anxiety, and improvements in ADHD symptoms and executive function. Stress is known to reduce working memory. Since meditation helps in reducing stress, working memory enhancement is the natural consequence of practicing meditation [81].

3.6.3 Meditation to enhance other cognitive abilities

Apart from attention and working memory, meditation is also reported to have increased other Cognitive abilities like cognitive flexibility, autobiographical memory, visuo-spatial attention, immediate memory span etc. and to reduce stress, motor inhibition etc.

1) Mindfulness meditation for other Cognitive abilities Enhancement

Richard Chambers et al. examined the effect of mindfulness meditation on strength of mindfulness, ruminative tendencies, working memory, sustained attention and attention switching. Subjects were divided into two groups. First group is considered as meditators group that performed meditation for 10 days; 2) control group. It was found that meditators group as compare to control group shows significant improvement in strengthen of mindfulness, depressive symptoms, rumination, working memory and sustained attention [82].

Alexandre Heeren et al. studied the effect of Mindfulness-Base Cognitive Therapy (MBCT) on autobiographical memory, cognitive inhibition, motor inhibition, cognitive flexibility and motor flexibility. Subjects were divided into two groups. First group considered as mediators group performed MBCT for eight sessions, second group was considered as control group. Manual for MBCT was derived from Segal, Teasdale, and Williams, with little modifications. It was found that MBCT participants as compare to control group had improved specific and decrease general (i.e extended and categorical) autobiographical memory, improved cognitive flexibility and improved inhibit cognitive prepotent responses (cognitive inhibition). It was also found that MBCT is not associated with motor inhibition and motor flexibility. The assessment of these cognitive abilities was made using Autobiographical Memory Test, Hayling Task, Verbal fluency tasks, GoStop Paradigm, and Trail Making Test before and after intervention [83].

Maria Kozhevnikov et al. studied the effect of Deity Meditation (a Buddhist meditation), a mindfulness meditation on the cognitive ability: Visuo-spatial processing. Participants were divided into five groups. First group performed Deity yoga for 20 minutes daily, second group performed open presence for 20 minutes daily, third group was considered as meditators imagery control group; performed there preferred style of meditation which fulfilled some criteria's like having practiced their preferred style of meditation for at least 10 years, fourth group was considered as imagery control group and last group is taken as non-meditatory resting control group. Deity yoga consists of focused attention on an internal visual image. In open presence participant evenly distributes attention without directing it to any particular object. During intervention (meditation) both imagery group perform imagery task and resting group rested. This study indicates that Deity Yoga

practitioner's shows an improvement in performance on imagery tasks (visuo- spatial processing) compared with the other group. The assessment of cognitive ability was made using visual memory task and mental rotation task before and after intervention [84].

2) Concentrative meditation for other Cognitive abilities Enhancement

Ravi Prakash et al**.** investigated the effects of Vihangam Yoga meditation, a concentrative meditation on working memory (attention span), attention set shifting, ability to inhibit distracters, information processing speed and visuo-spatial attention. Participates taken in this study was above 55 years and were divided into two groups. First group was taken as meditators group, having practiced the meditation technique for at least past ten years, with daily practice of one hour the same for at least the past one year, second group was taken as non-meditators group. It was found that meditators had improved working memory (attention span), attention set shifting, ability to inhibit distracters, information processing speed and visuo-spatial attention as compare to nonmeditators. The assessment of these cognitive abilities was made using Digit Span Test, Digit Symbol Substitution Test, Stroop Color–Word Test,Trail making Test, Letter Cancellation Task, and Rule Shift Card Test [85].

Fred Travis et al. examined the effects of Transcendental meditation on Brain Integration scale (Frontal EEG coherence of alpha, beta and gamma; Alpha/Beta power ratios; and preparatory brain response), sleepiness, Heart Rate, and Respiratory Sinus Arrhythmia. They were divided into two groups of immediate-start and delayed-start. In immediate-start, subjects start doing meditation immediately after pre-test and delayedstart subjects start doing meditation 10 weeks before final week of spring term. Pre-test data was recorded in beginning of spring term and post-test was recorded one week before end of spring term. EEG was recorded at pre-test and post-test during 1) 1-min eyes closed, 2) 1-min eyes open, 3) 1-min eyes open paced breathing at 10 Breath Per Minute (bpm) to calculate respiratory sinus arrhythmia, 4) 12-min of computer tasks (three different tasks), and 5) a 10-min eyes-closed session. It was observed from posttests that there was significant increases in Brain Integration Scale scores for Immediatestart students but decreased in delayed-start students; significant reduction in sleepiness in Immediate-start

students with no change in Delayed-start students; and no changes in habituation rates in Immediate-start students, but significant increases in Delayed-start students [86].

V.K Sharma et al. studied the effect of Sahaja yoga on cognitive functions like visuomotor speed, attention, working memory, immediate verbal memory span and vigilance on patients suffering from depression. Subjects were divided into two groups. First group performed Sahaj yoga for 30 minutes three times per week in addition to conventional anti-depression treatment; second group received conventional anti-depression treatment. After 8 weeks both groups show significant improvement in visuo-motor speed, attention, manipulation of information in verbal working memory and vigilance but this improvement was more marked in group one than in second. The result demonstrated that Sahaj yoga practice in addition to conventional treatment led to additional improvement. The assessment of these cognitive abilities was made using Neuro-Cognitive Test Battery before and after Sahaj yoga [87].

CHAPTER 4 PROBLEM DEFINITION

As of now, researchers have studied cognitive abilities in relation with numerous sorts of meditations like Sahaja Yoga Meditation, Transcendental Meditation, etc. However, very less work has been carried out on healthy engineering students in this regard. It has been notified that attention and working memory of an individual increase after undergoing through proper meditative training. Studies on EEG signals acquired from different parts of brain reveal that alpha power decreases and beta power increases in case of attention, and in case of working memory, theta and alpha powers increase.

The present research on healthy engineering students shall therefore focus on

1) To verify the changes in EEG rhythms during tasks involving attention and working memory

2) To explore the effects of a custom designed meditation on cognitive enhancement of attention and working memory

CHAPTER 5 PROPOSED METHOD

Any Cognitive enhancement technique involves application of suitable intervention. Pre and post cognitive assessment is made to confirm the cognitive enhancement achieved, if any. The protocol proposed for this research involves the following

5.1 Selection of participants

The entire participant shall be engineering students from undergraduate or postgraduate level**.** None of the participant shall have any psychological or neurological illness history. The subjects shall be informed about the purposes, methods, and protocol of the experiment before starting experiment. All the participants shall voluntarily participate in the study. All experiments shall be conducted in the Laboratory of Thapar University.

5.2 Preparation of participants for EEG

Participants shall sit on a comfortable armchair in the front of monitor. They shall be explained about complete procedure, that is, hardware (EEG system), data acquisition, and all the tests to be carried out, as a result of which subject shall become familiar with the experiment. The scalp of subject shall be prepared by light abrasion to remove dead cells.

5.3 Baseline data acquisition

For attentional task baseline data shall be collected from the participants with their eyes closed, as the visuo-spatial attention reduces with closing eyes. For working memory task data shall be collected from participants with eyes open as baseline. Details of data acquisition are given in section 6.1.

5.4 EEG data shall be acquired while performing cognitive tasks for pre assessment

Go/No-go task shall be used for assessing attention and for assessing working memory D-span task shall be used. Details of both tasks are given in section 6.2.

5.6 Statistical Analysis of data

Analysis of data shall be done using one tail paired type t-test and correlational studies shall also be made. Details of both are given in section 6.3.

5.7 Meditation as Intervention

For enhancing cognitive abilities (attention and working memory) meditation shall be used as intervention. Meditation used shall be custom designed meditation comprising of both concentrative and mindfulness meditations. It is of half hour duration meditation and subjects shall perform it daily for 15 days.

5.8 EEG data shall be acquire while performing cognitive tasks for post assessment

Post assessment shall be done to find the improvements after intervention. In post assessment EEG data acquired while performing Go/No-go task for attention and D-span for working memory.

CHAPTER 6 IMPLEMENTING THE PROPOSED METHOD

6.1 Data Acquisition

For data acquisition EEG signals are used. Electroencephalography (EEG) refers to the recording of brain's spontaneous electrical activity. Brain's electrical activity is maintained by billions of neurons.Neurons have the amazing ability to gather and transmit electrochemical signals - think of them like the gates and wires in a computer. To maintain resting potential or to propagate action potential (i.e. electrical potential) neurons constantly exchange ions with the extracellular milieu.When several ions are pushed out of several neurons at the same time, they will push their neighbors because ions of similar charges repel each other, who will further push their neighbors, and so on, in a wave. Metal parts of the electrodes place on the scalp 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 [88]. The electric potential generated by an individual neuron is far too minute to be pulled out up by EEG [89]. EEG activity therefore always reflects the summation of the synchronous activity of thousands or millions of neurons that have similar spatial orientation.

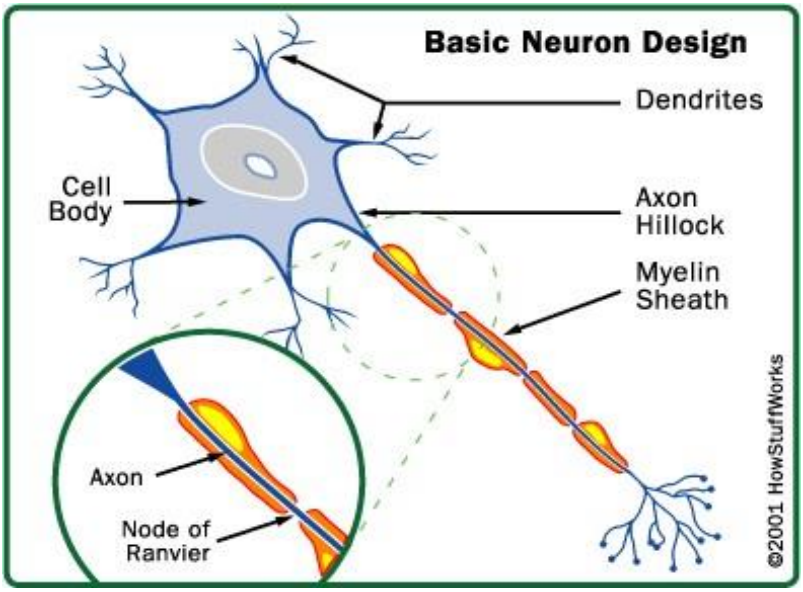


Figure 6.1 Basic Neuron Design

EEG is defined by 4 frequency bands: delta (0.5-4 Hz), theta (4-8 Hz), alpha (8-13 Hz), beta (13-30 Hz) and gamma (30-100 Hz) as shown in figure 6.1 [90].

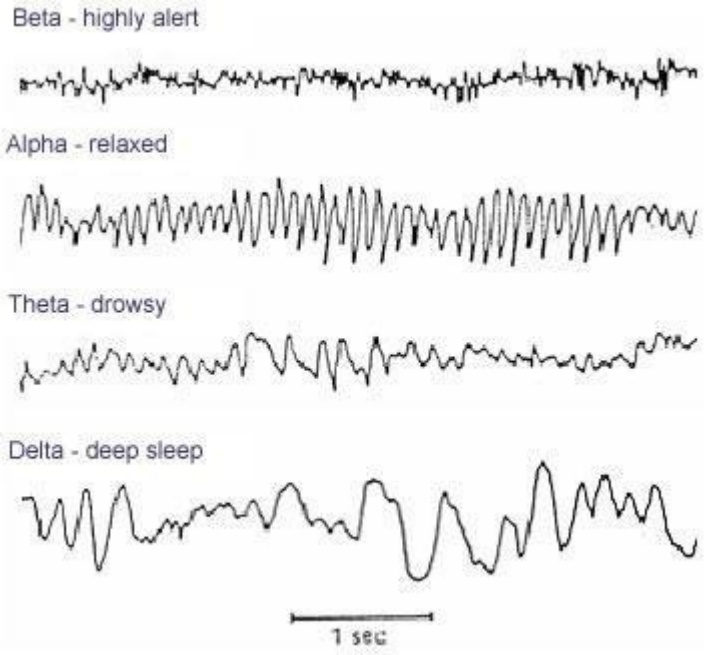


Figure 6.2 Brain Rhythms

For recording the EEG signal, small metal discs usually made of tin, stainless steel, silver or gold or covered with a silver chloride coating, are placed on the scalp in special positions. The placement of electrodes is done as per "International 10-20" system. The position of electrodes is shown in figure 6.3. Two reference points are used for positioning of electrodes i.e. nasion and inion. Nasion is the delve at the top of the nose, level with the eyes; and inion is the bony lump at the base of the skull on the midline at the back of the head. The entire distance between these two reference points are divided into six segments at a distance 10%-20%-20%-20%-20%-10% as shown in figure 6.2
[16].

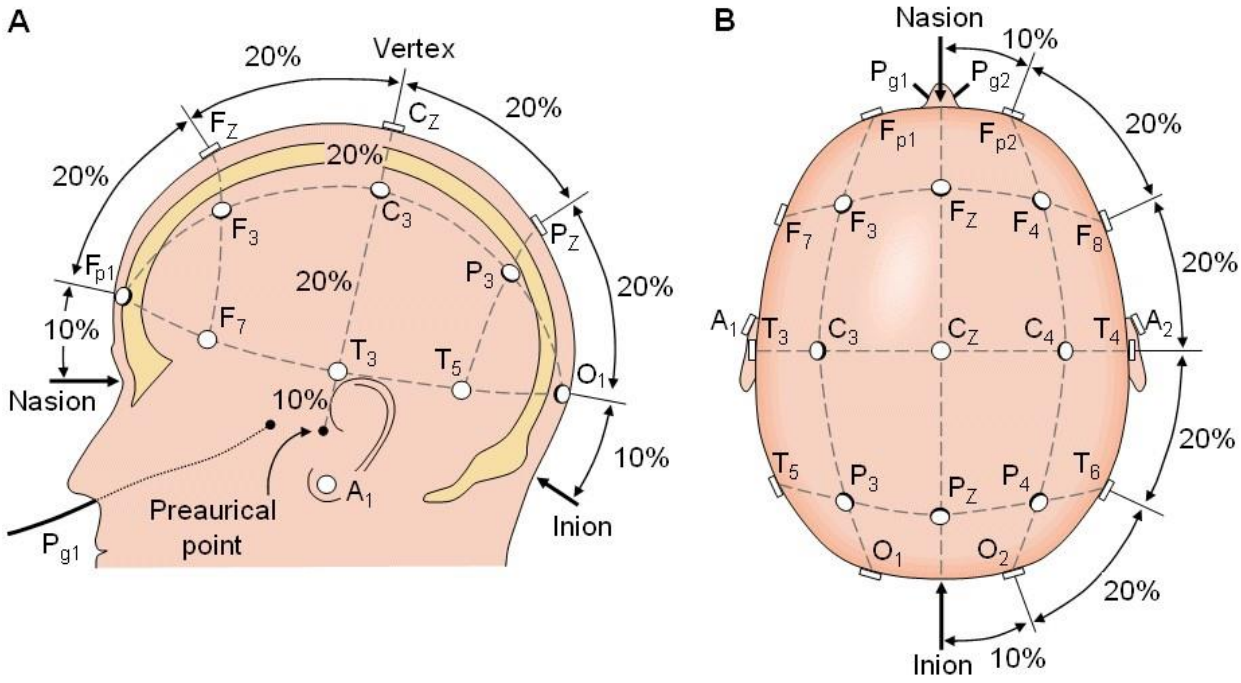


Figure 6.3: 10-20 system of EEG electrode placement

6.1.1 Data acquisition hardware

EEG data was acquired using MP150 BioPac system. The MP System (MP150 or MP36R) is a complete data acquisition system that includes both hardware and software for the acquisition and analysis of life science data. The MP System (MP150 or MP36R) is used for data acquisition, analysis, storage, and retrieval. The MP System is a computer-based data acquisition system that performs many of the same functions as a chart recorder or other data viewing device, but is better to such devices in many ways like it transcends the physical restrictions frequently encountered (such as paper width or speed). The MP data acquisition unit (MP150 or MP100) is the heart of the MP System. The MP unit generates digital signals that can be processed with the computer by converting the incoming signals into digital signals.

Figure 6.4: MP150 BioPac system

The MP150 high-speed data attainment system utilizes the newest Ethernet technology. The MP150 is acquiescent with any Ethernet (UDP) ready PC running Macintosh or Windows. This next age group product takes full benefit of cutting edge technology. Access numerous MP150 devices located on a local area network and record data to any computer linked to the same Local Area Network (LAN) Record numerous channels with changeable sampling rates to maximize storage efficiency. Recording is done at a speed up to 400 KHz (aggregate).

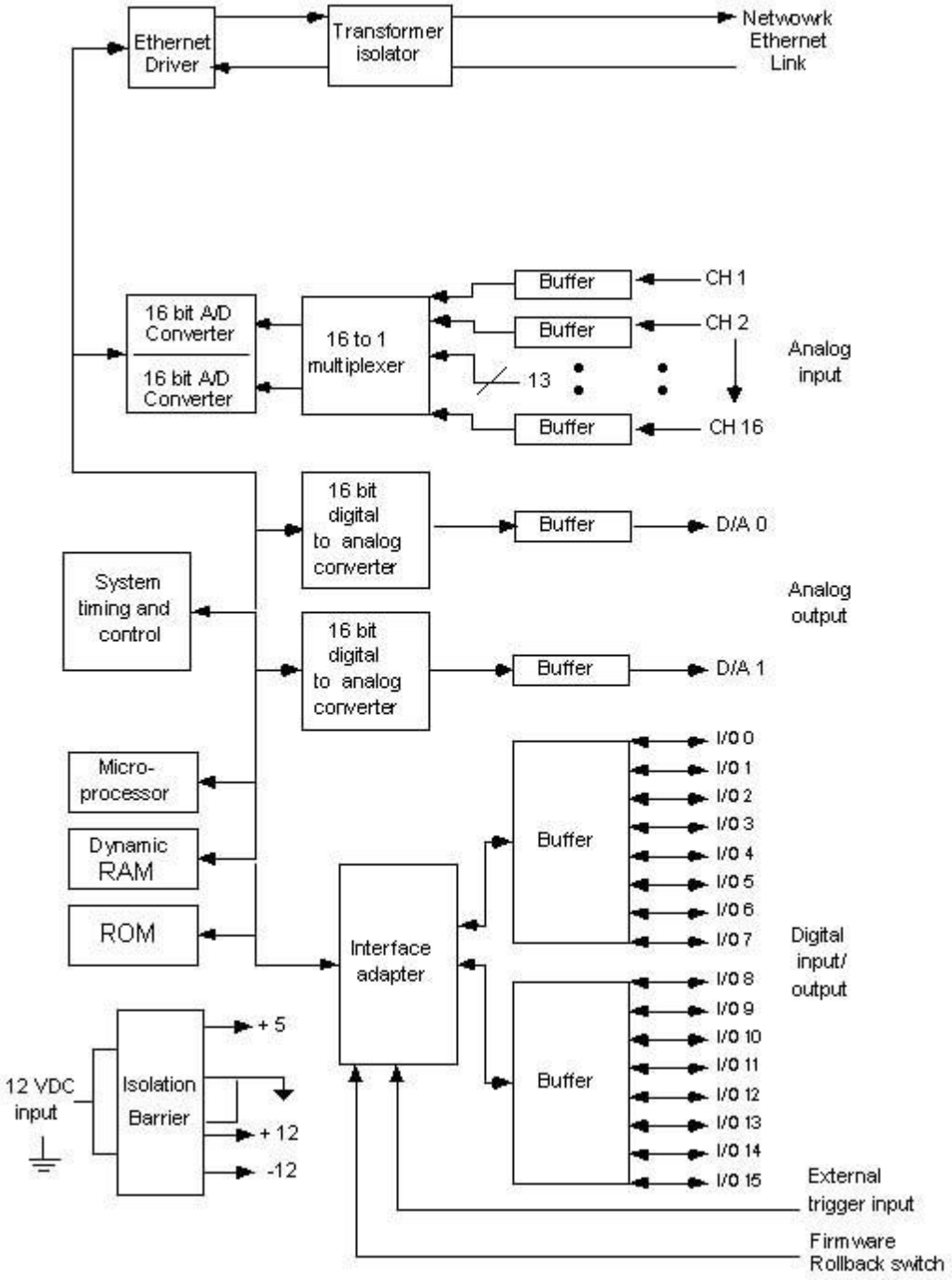


Figure6.5: MP150 Block Diagram

To control the data acquisition and communication with the computer the MP150 has an internal microprocessor. There are two analog output channels, 16 digital channels that can be used for either output or input, 16 analog input channels and an external trigger input. The digital lines can be programmed as either outputs or inputs and purpose in 8 channel

blocks. Block 1 (I/O lines 0 through 7) can be programmed as either all inputs or all outputs, independently of block 2 (I/O lines 8 through 15) [91].

EEG data was recorded using 11 electrodes (10 channels) placed in accordance with complete international 10-20 system with linked ear lobe reference electrode. Data was recorded at a sampling rate of 1000 sample per second and sampling rate of 500 Hz of each channel. Out of these eleven electrodes one is ground electrode. Conductivity of electrodes with scalp is made using gel. Impedance of each electrode is compared with reference to ground of cap and is set up approximately below 10 KΩ. Electrodes from which data is recorded are darkened in figure 6.5.

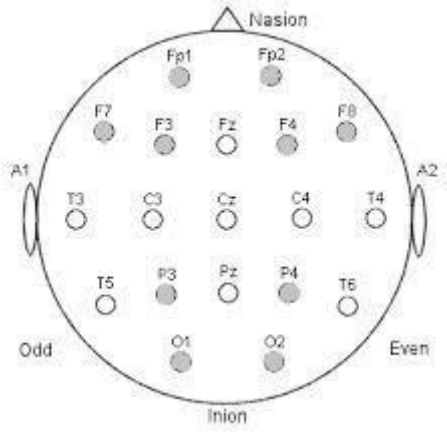


Figure 6.6: Marked electrodes for recording

6.1.2 Signal conditioning and feature extraction

AcqKnowledge software is used for feature extraction. AcqKnowledge software not only makes data collection easier, but also performs analyses quickly and easily that are impossible on a chart recorder. Easily edit data, cut and paste sections of data, perform arithmetic and statistic transformation, and copy data to other applications (such as a drawing program or spreadsheet) for reports and publication. The MP System (MP150 or MP36R data acquisition unit) with AcqKnowledge 4 is compatible with Windows 7 or Vista OS or Mac OS X 10.4-10.6. AcqKnowledge uses the familiar point-and-click

interface common to all Windows and Macintosh applications [91]. Complex tasks such as digital filtering or fast Fourier transformations are now as easy as choosing a menu item or clicking the mouse. There is inbuilt notch filter in MP150 which is used for signal conditioning. For feature extraction power spectral density is computed using AcqKnowledge software using hamming window. Step wise description of calculating Power Spectral Density (PSD) shown in figures (6.7- 6.9)

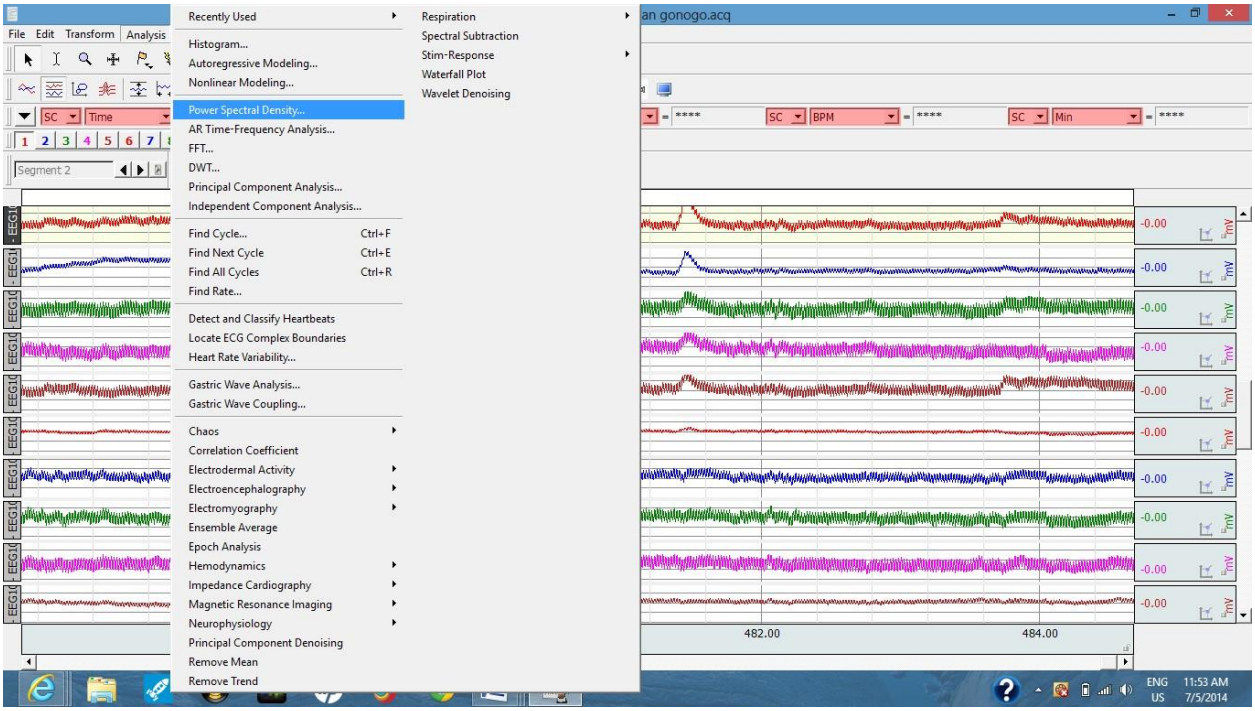
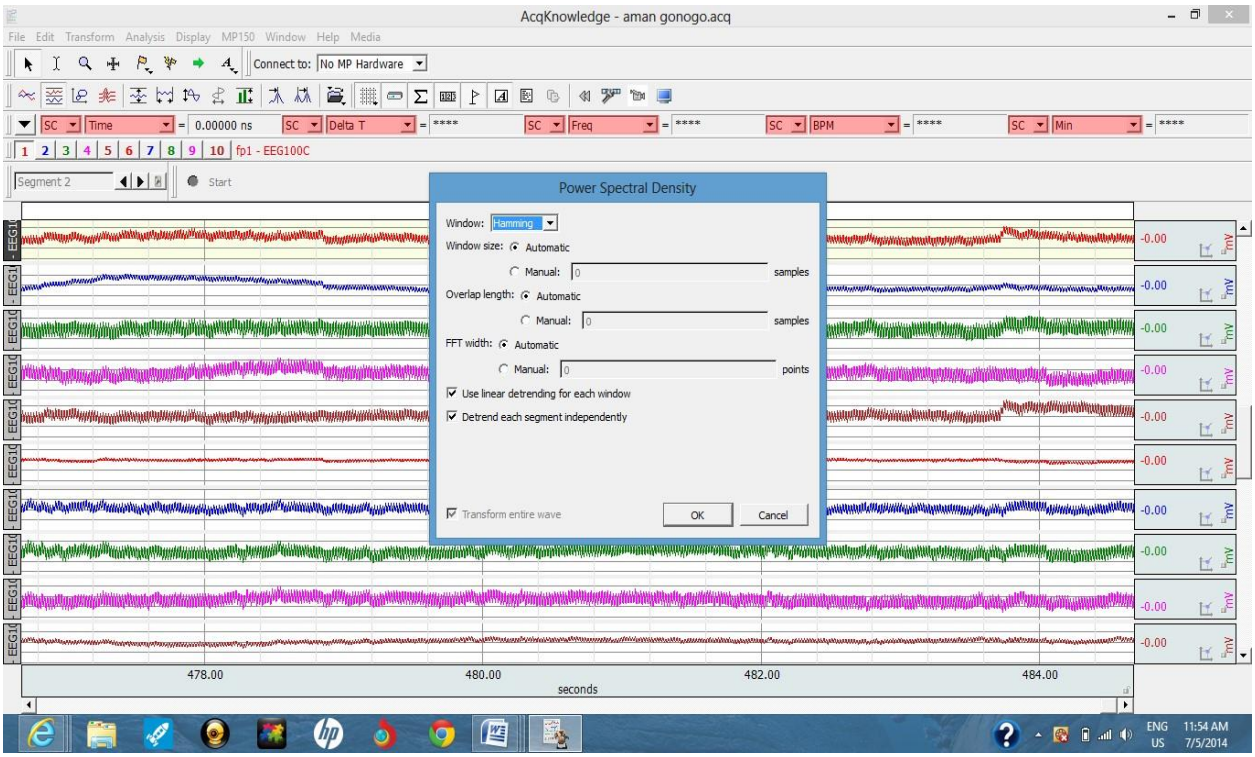


Figure 6.7: Applying PSD on data

Figure 6.7 represent how with the help of AcqKnowledge software we can compute power spectral density from the acquired EEG data.



Figur6.8: Using Hamming window for PSD calculation

Figure 6.8 represent the methodlogy of computing PSD using Hamming window with the help of AcqKnowledge software.

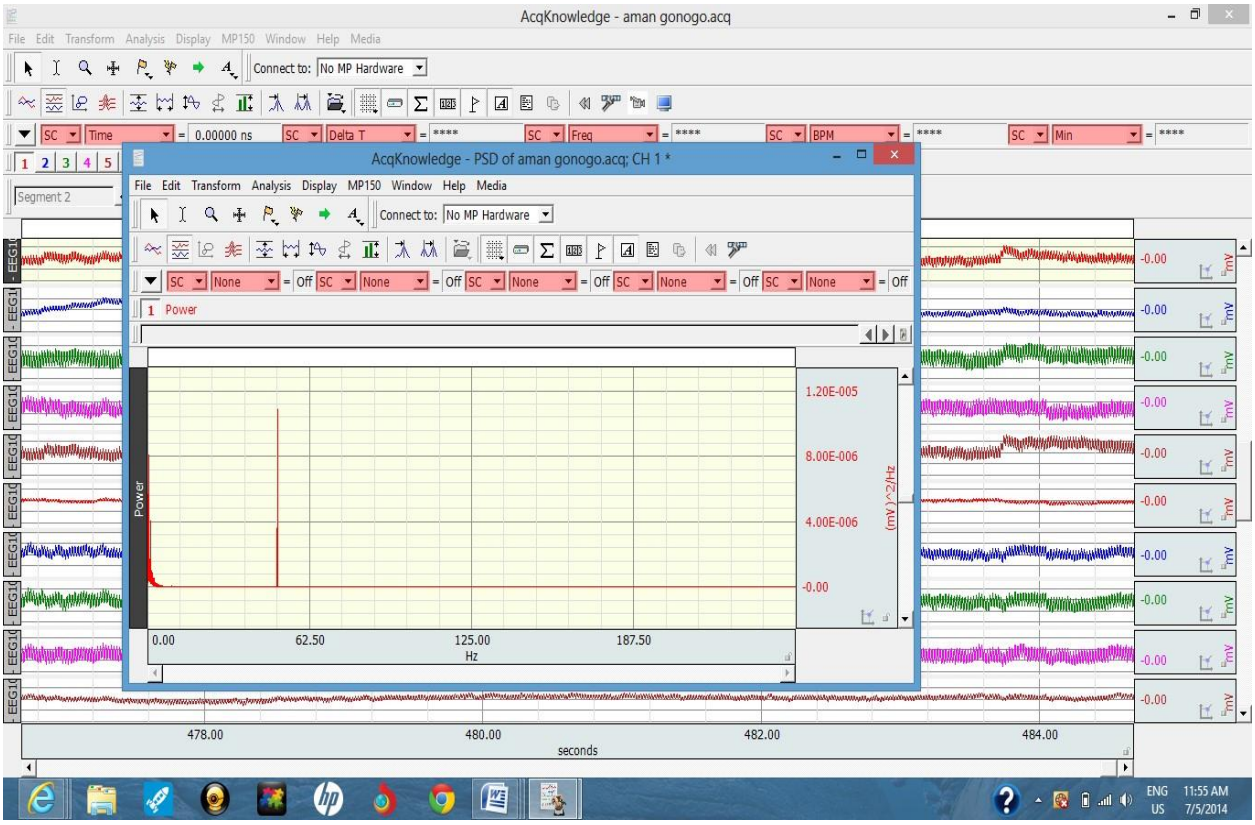
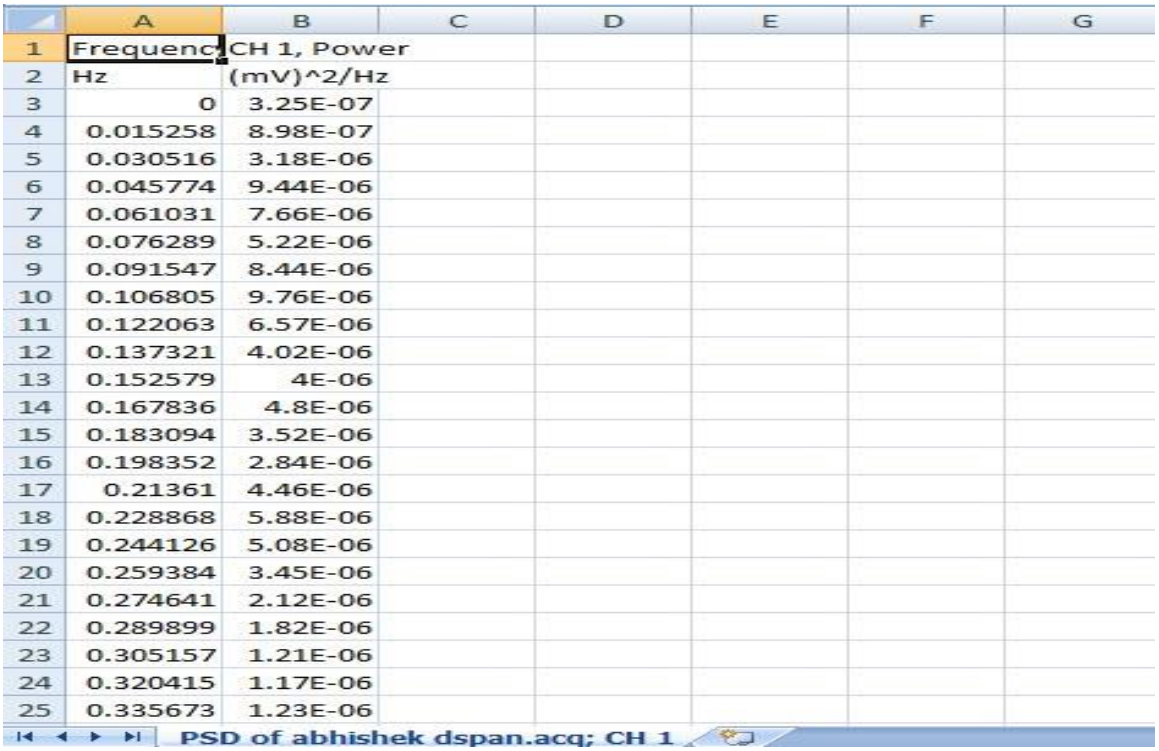


Figure 6.9: Calculated Graph of PSD

Figure 6.9 represent how with the help of AcqKnowledge software the final graph of calculated PSD from the acquired data is computed.



	A	B	C	D	E	F	G
1	Frequenc	CH 1, Power					
2	Hz	(mV)^2/Hz					
3	0	3.25E-07					
4	0.015258	8.98E-07					
5	0.030516	3.18E-06					
6	0.045774	9.44E-06					
7	0.061031	7.66E-06					
8	0.076289	5.22E-06					
9	0.091547	8.44E-06					
10	0.106805	9.76E-06					
11	0.122063	6.57E-06					
12	0.137321	4.02E-06					
13	0.152579	4E-06					
14	0.167836	4.8E-06					
15	0.183094	3.52E-06					
16	0.198352	2.84E-06					
17	0.21361	4.46E-06					
18	0.228868	5.88E-06					
19	0.244126	5.08E-06					
20	0.259384	3.45E-06					
21	0.274641	2.12E-06					
22	0.289899	1.82E-06					
23	0.305157	1.21E-06					
24	0.320415	1.17E-06					
25	0.335673	1.23E-06					

PSD of abhishek dspan.acq; CH 1

Figure 6.10 Excel sheet of PSD

Figure 6.10 represent the excel sheet of the calculated PSD from the acquired data. After that power of Alpha (8-13Hz) and Beta (13-30Hz) bands is extracted for attention and for working memory power of theta (4- 8 Hz) and alpha is extracted. Power is calculated from power spectral density using following formula.

$$power = \frac{\sum \frac{mv^2}{Hz}}{no\ of\ samples} \times frequency\ range$$

6.2 Tasks for assessment

For assessing attention and working memory standard cognitive assesment battery that is Psychology Experiment Building Language (PEBL) is used. In PEBL we can run as well as design computer-based experiments as it is a free cross-platform [92]. Following tasks are used

6.2.1 Go/no-go test

This test is used for assessing attention. In this test, subject will see a sequence of “P”s and “R”s on the screen. Whenever subject see a “P”, react by pressing right shift key on the key board and don’t react when see an “R”.

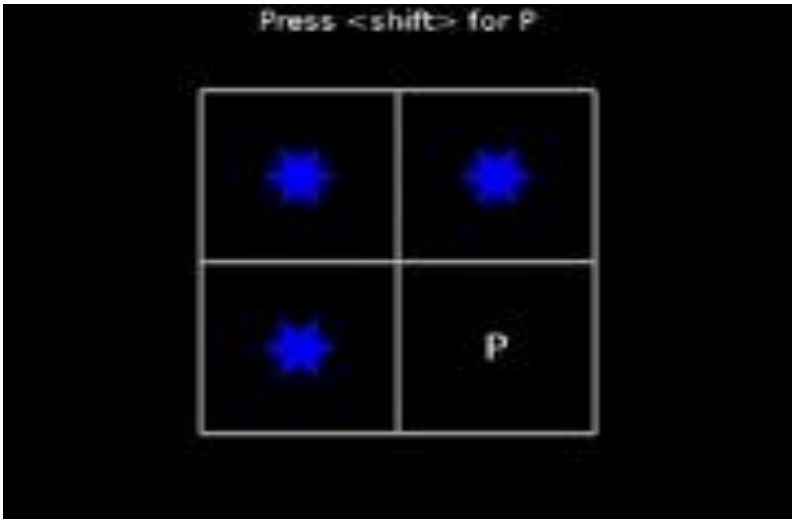


Figure 6.11: go/no-go test

6.2.2 D-span test

Digital Span (D-span) test is used for assessing working memory. In Digit Span, subject sees a sequence of digits existing in a box at the top of the screen and her task will be to keep in mind these numbers in sequence. After a brief period of time, the numbers will disappear and the subject will act in response by entering the digits.

Figure 6.12: d-span test

6.3 Data analysis

Statstically data is analyse using t-Test and correl.

6.3.1 t-Test

The t-Test is used to test the null hypothesis that the means of two populations are equal. For testing statistical significance of data either one tailed or two-tail test are computed. Depending on whether one trend is considered in extreme or both trends are considered equally likely one tail or two tail tests are considered respectively. t-Test can be type one, type two or type three depends on whether data is paired, homoscedastic or unequal respectively. It returns the value of probability associated with the t-Test i.e. “p” value.

6.3.2 Correlational studies

Returns the correlation coefficient of the array1 and array2 cell ranges. Use the correlation coefficient to find out the connection between two properties. For example, you can study the connection between a location's average temperature and the use of air conditioners**.**

The correlation coefficient equation is**:**

$$Correl(X,Y) = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \sum (y-\bar{y})^2}}$$

where

$\bar{x}$ and $\bar{y}$

are the samples mean AVERAGE of array1 and AVERAGE of array2.

CHAPTER 7 RESULTS AND DISCUSSIONS

7.1 Changes in brain wave rhythms

In this study, results for attention and working memory are computed for both task oriented and physiological assessment. For physiological assessment EEG is taken and power of alpha (8-13 Hz) and beta (13-30 Hz) bands are computed for attention; and power of theta (4-8 Hz) and alpha (8-13 Hz) bands for working memory. In task oriented assessment computer based tasks like Go/No-go and D-span tests for attention and working memory respectively were performed and correlation between the task performance and physiological assessment derived.

7.1.1 Physiological assessment

1) Attention task

For attention task in particular channels alpha decreases and beta increases. Alpha in AF3 (fp1, f3) and F7 decreases and beta increases in F8 and AF4 (FP2, F4) [53].

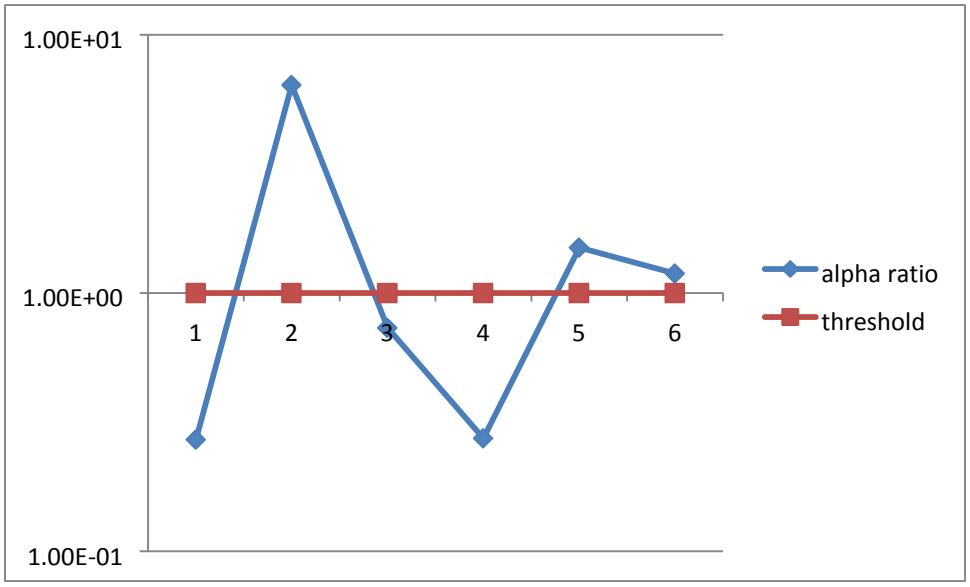


Figure 7.1:Fp1 alpha (8-13 HZ) ratio during attentional task

From figure 7.1 it is inferred that in alpha band of FP1 no conclusion is drawn as expected, it may be due to some experimental errors. Results are also verified statistically using T-

test. For Fp1 t-Test value is p=0.426346. Therefore nothing can be concluded from this pilot study.

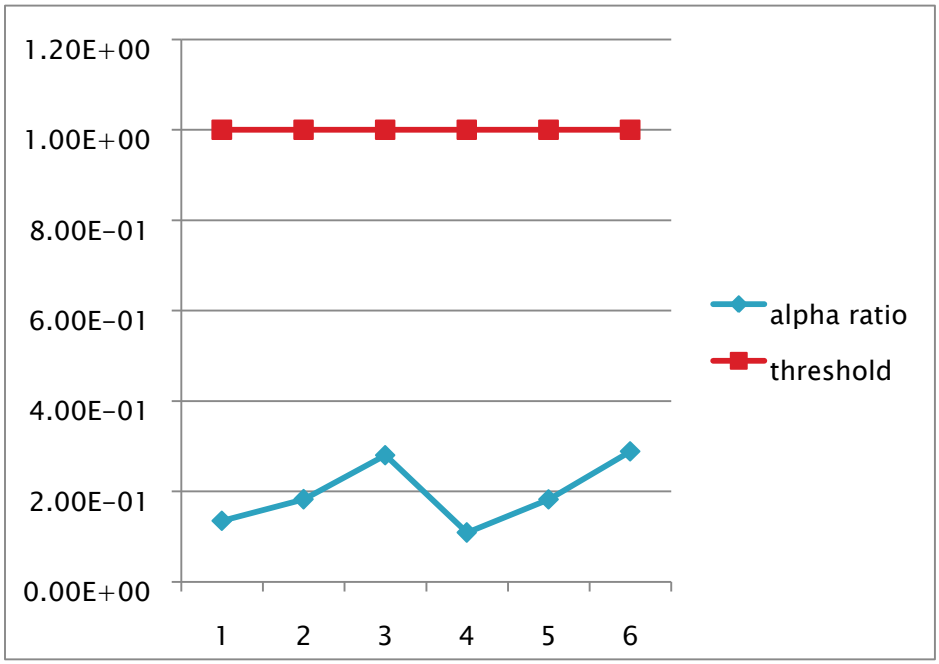


Figure 7.2: F3 alpha (8-13 Hz) ratio attentional task

From figure 7.2 it is inferred that alpha band of F3 decreases in attentional task as expected. Results are also verified statistically using T-test. For F3 T-test value is p=0.002014. Therefore it is concluded from this pilot study that F3 decreases in attentional test, which is evident from the figure. Moreover the p value is less than 0.05. Though the numbers of subjects are less still the results are proven to be statistically significant

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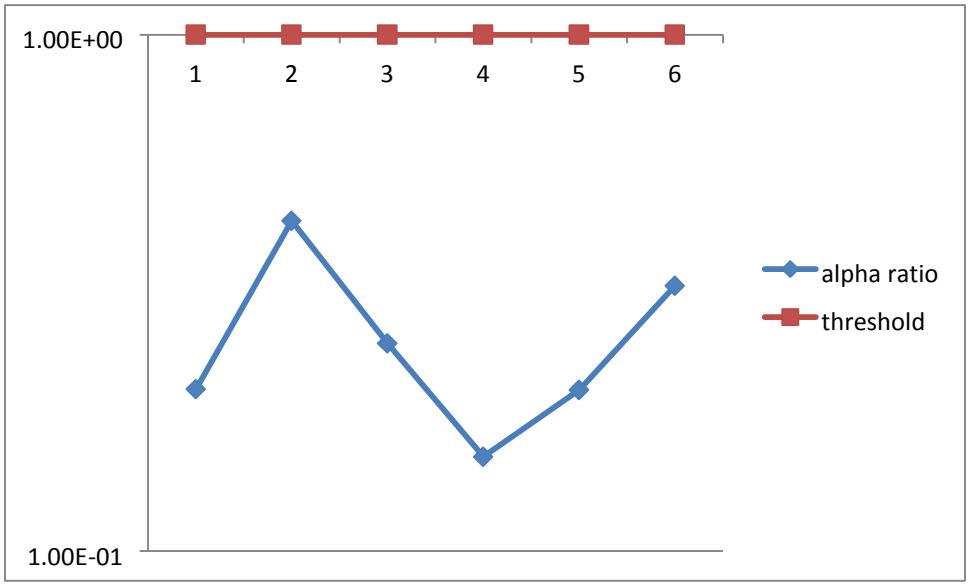

Figure 7.3: F7 alpha (8-13 Hz) ratio attentional task

From figure 7.3 it is inferred that alpha band of F7 decreases in attentional task as expected. Results are also verified statistically using t-Test. For F7 t-Test value is p= 0.000423. Therefore it is concluded from this pilot study that F7 decreases in attentional test, which is evident from the figure. Moreover the p value is less than 0.05. Though the numbers of subjects are less still the results are proven to be statistically significant.

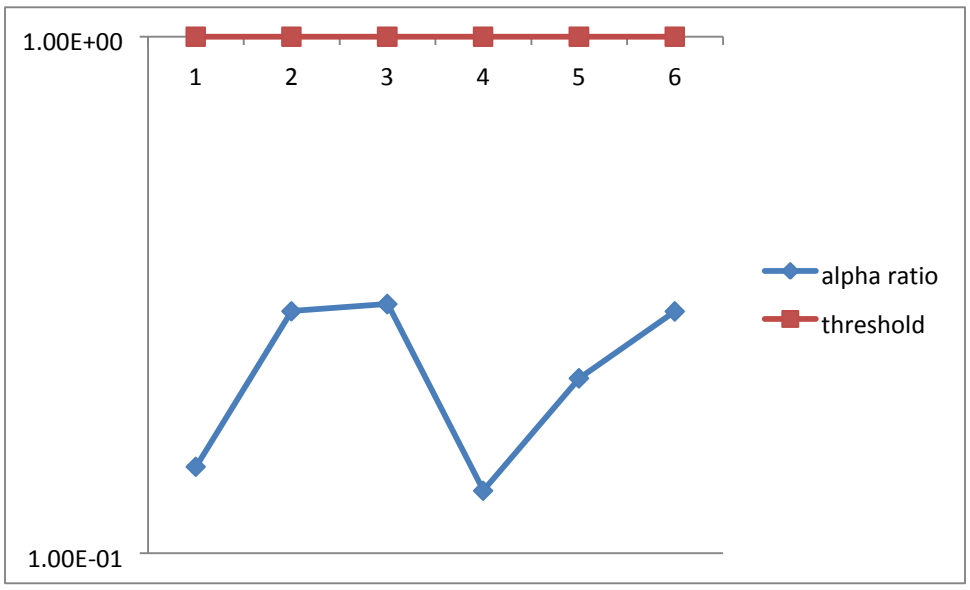

Figure 7.4: F4 alpha (8-13 Hz) attentional task

From figure 7.4 it is inferred that alpha band of F4 decreases in attentional task, it is a new finding**.** Results are also verified statistically using t-Test. For F4 t-Test value is p = 0.002123. Therefore it is concluded from this pilot study that F4 decreases in attentional test, which is evident from the figure. Moreover the p value is less than 0.05.Though the numbers of subjects are less still the results are proven to be statistically significant.

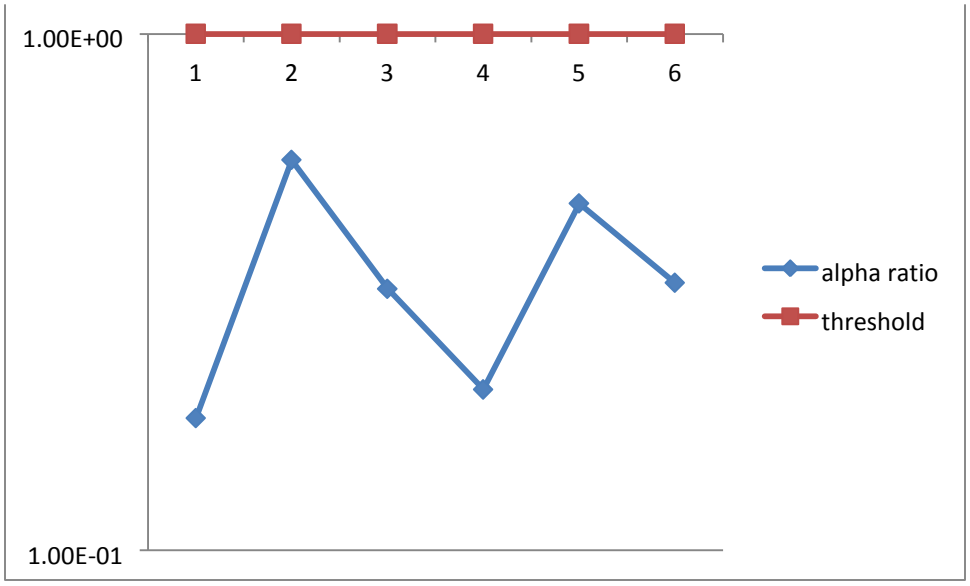

Figure 7.5: F8 alpha (8-13 Hz) ratio attentional task

From figure 7.5 it is inferred that alpha band of F8 decreases in attentional task, it is a new finding. Results are also verified statistically using t-Test. For F8 t-Test value is p = 0.001405. Therefore it is concluded from this pilot study that F8 decreases in attentional test, which is evident from the figure. Moreover the p value is less than 0.05. Though the numbers of subjects are less still the results are proven to be statistically significant.

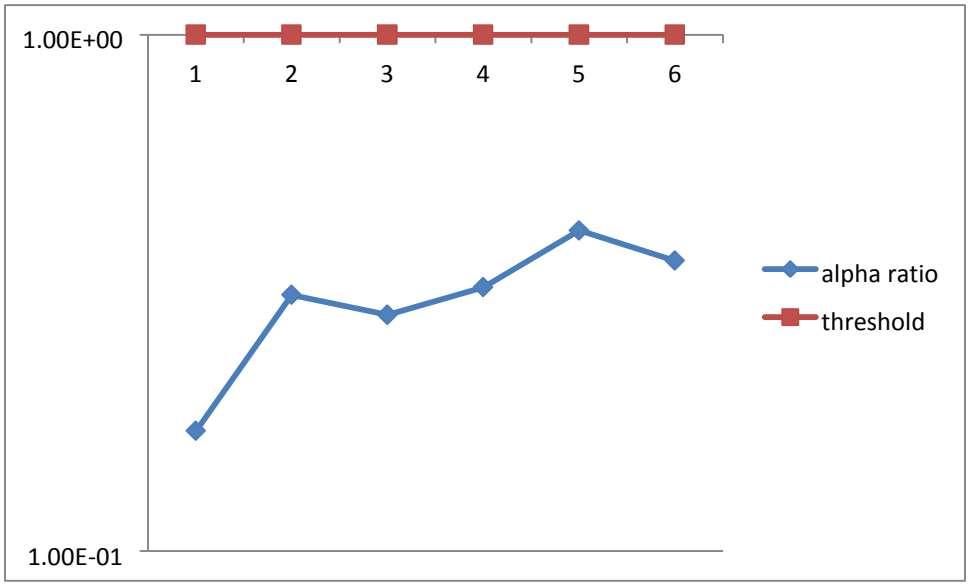

Figure 7.6: Fp2 alpha (8-13 Hz) ratio attentional task

From figure 7.6 it is inferred that alpha band of FP2 decreases in attentional task, it is a new finding**.** Results are also verified statistically using t-Test. For Fp2 t-Test value is p = 0.001744. Therefore it is concluded from this pilot study that Fp2 decreases in attentional test, which is evident from the figure. Moreover the p value is less than 0.05. Though the numbers of subjects are less still the results are proven to be statistically significant.

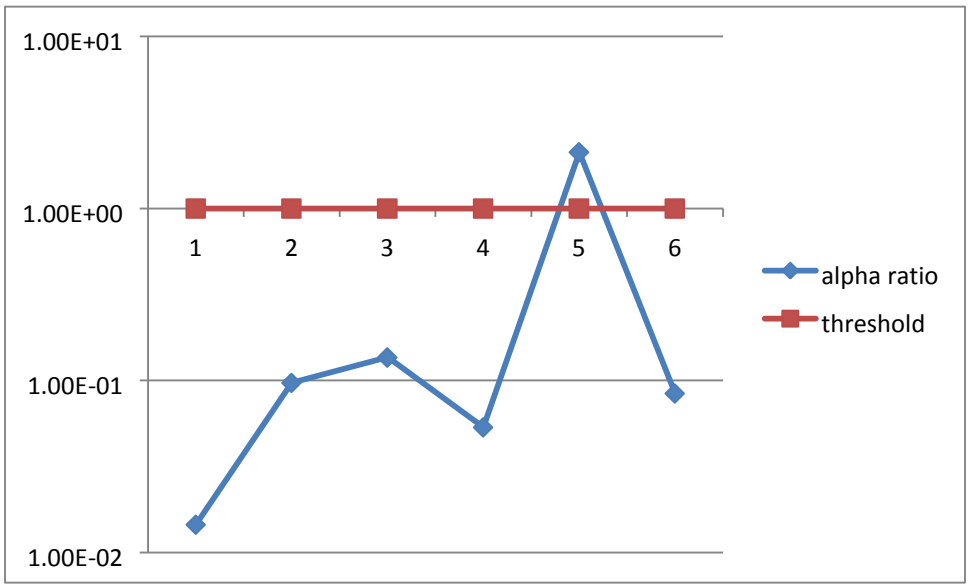

Figure 7.7: O1 alpha (8-13 Hz) ratio attentional task

From figure 7.7 it is concluded that alpha band in O1 also decreases in attentional task and it is a new finding. Results are also verified statistically using t-Test. For O1 t-Test value is p = 0.005068. Therefore it is concluded from this pilot study that O1 decreases in attentional test, which is evident from the figure. Moreover the p value is less than 0.05. Though the numbers of subjects are less still the results are proven to be statistically significant.

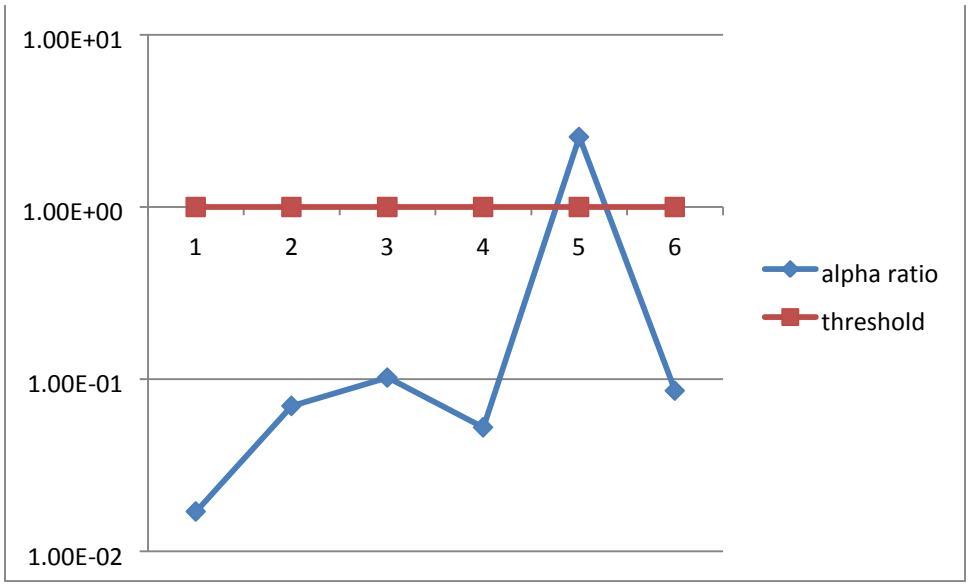

Figure 7.8: O2 alpha (8-13 Hz) ratio attentional task

From figure 7.8 it is inferred that alpha band in O2 decreases in attentional task and it is a new finding**.** Results are also verified statistically using t-Test. For O2 t-Test value is p = 0.008075.Therefore it is conclude from this pilot study that O2 decreases in attentional test, which is evident from the figure. Moreover the p value is less than 0.05. Though the numbers of subjects are less still the results are proven to be statistically significant.

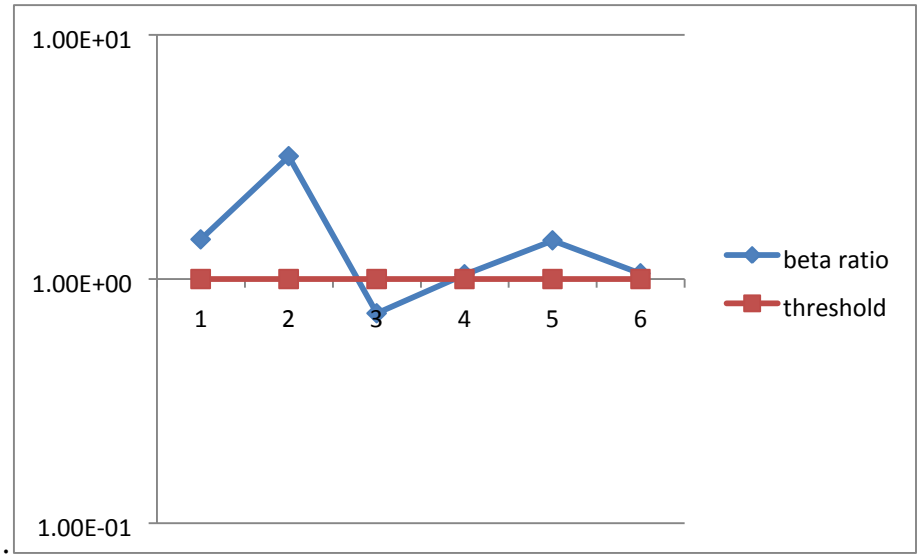

Figure 7.9: F8 Beta (13-30 Hz) ratio attentional task

From figure 7.9 it is inferred that Beta band in F8 does not represent good results (i.e. increase) as expected but acceptable in attentional task. Results are also verified statistically using t-Test. For F8 t-Test value is p = 0.146132.Therefore it is concluded from this pilot study that F8 increases in attentional test, which is evident from the figure.

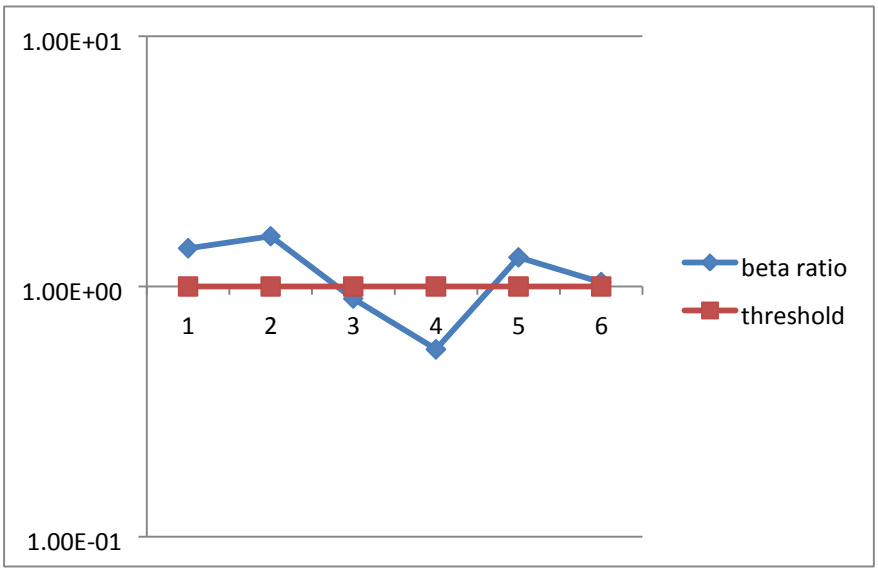

Figure 7.10: F4 Beta (13-30 Hz) ratio attentional task

From figure 7.10 it is inferred that in beta band in F4 no conclusion is drawn as expected, it may be due to some experimental errors. Results are also verified statistically using tTest.

For F4 t-Test value is p = 0.245644. Therefore nothing can be concluded from this pilot study as p value is not less than 0.05.

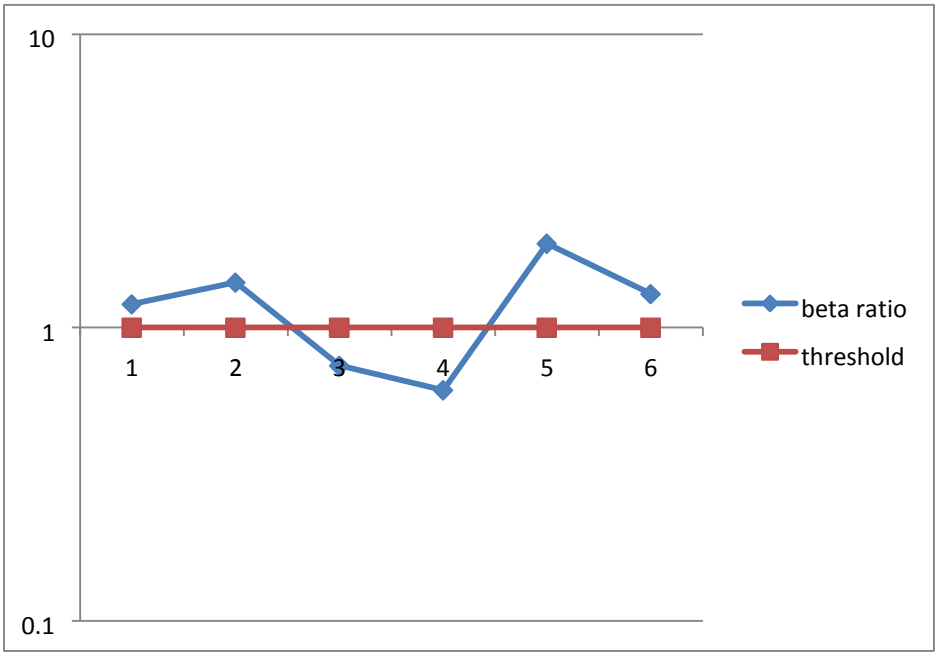

Figure 7.11 Fp2 Beta (13-30 Hz) ratio attentional tasks

From figure 7.11 it is inferred that beta band of Fp2 does not represent good results as expected (i.e. increase) but acceptable in attentional task**.** Results are also verified statistically using t-Test. For Fp2 t-Test value is p = 0.144092. Therefore it is concluded from this pilot study that Fp2 increases in attentional test, which is evident from the figure.

2) Working memory

For working memory in particular channels theta and alpha increases. Theta increase in frontal region (fz,f3,f4,fp1,fp2,f7 and f8) and alpha increase in posterior (Pz,Cz,O1,O2) and bilateral central areas (Fc5, T4, Fc8, T8)[93].

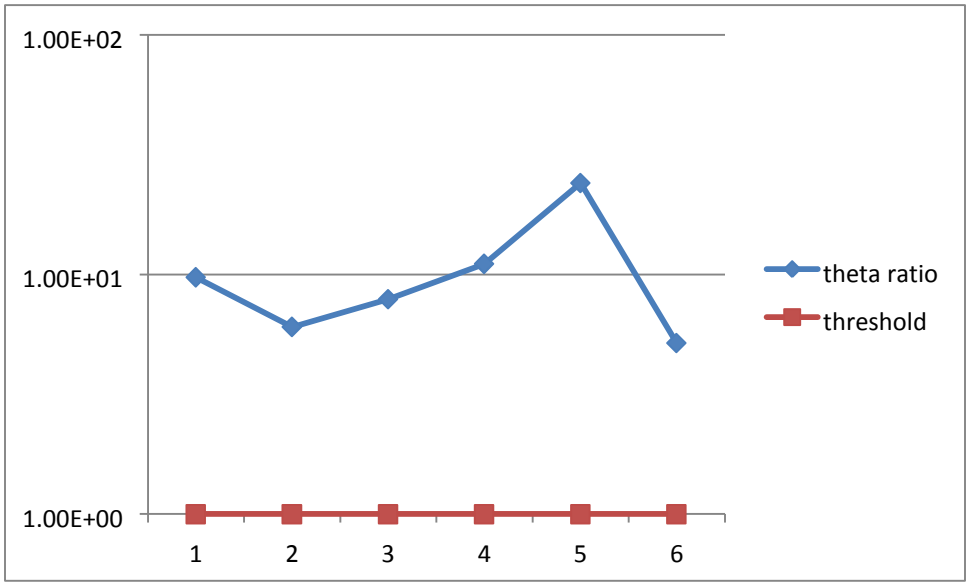

Figure7.12: Fp1 Theta (4-8 Hz) ratio working memory task

From figure 7.12 it is inferred that theta band of Fp1 increases in working memory as expected. Results are also verified statistically using t-Test. For Fp1 t-Test value is p =0.007632 Therefore it is concluded from this pilot study that Fp1 increases in working memory test, which is evident from the figure. Moreover the p value is less than 0.05. Though the numbers of subjects are less still the results are proven to be statistically significant.

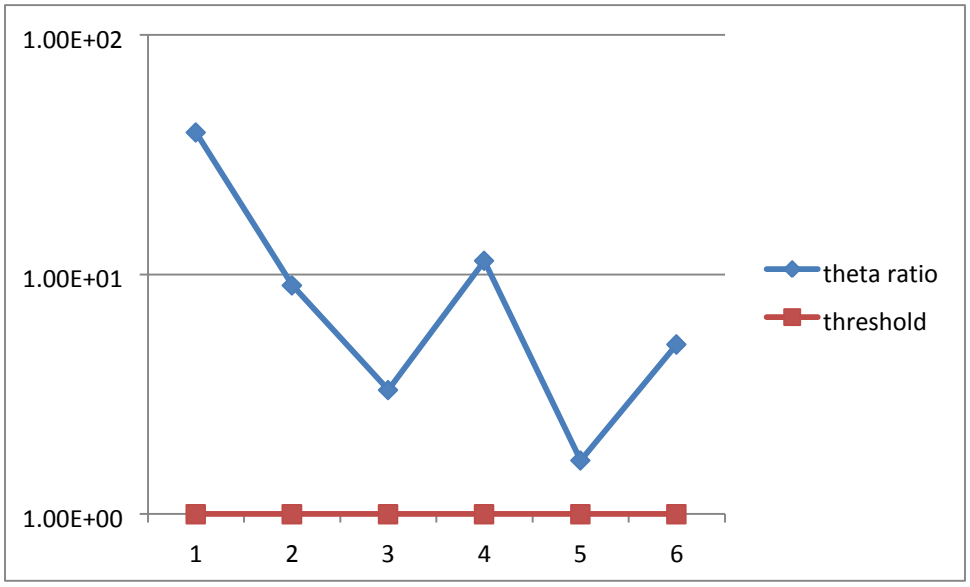

Figure 7.13: Fp2 Theta (4-8 Hz) ratio working memory task

From figure 7.13 it is inferred that theta band of Fp2 increases in working memory as expected. Results are also verified statistically using t-Test. For Fp2 t-Test value is p = 0.014948. Therefore it is concluded from this pilot study that Fp2 increases in working memory test, which is evident from the figure. Moreover the p value is less than 0.05. Though the numbers of subjects are less still the results are proven to be statistically significant.

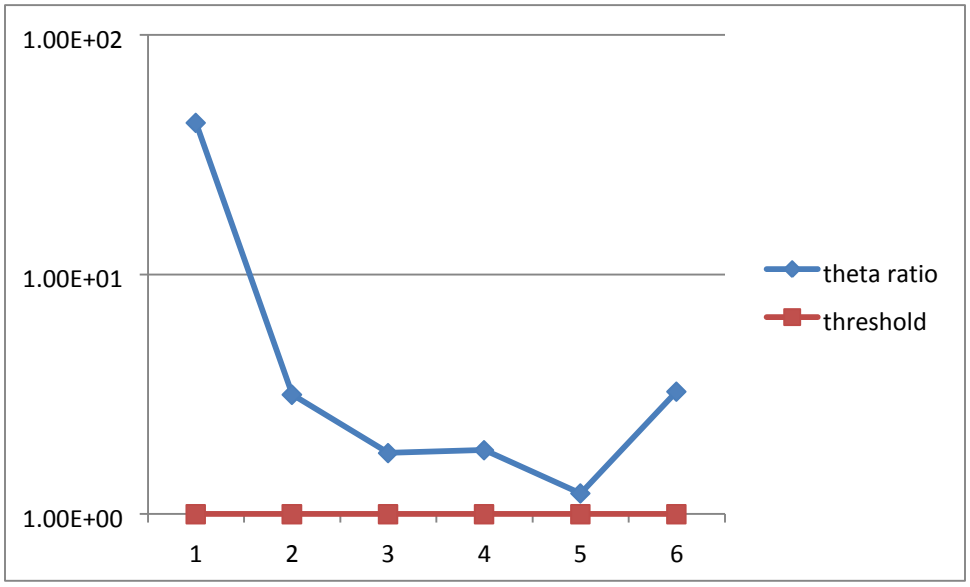

Figure7.14: F3 Theta (4-8 Hz) ratio working memory task

From figure 7.14 it is inferred that theta band of F3 increases in working memory as expected. Results are also verified statistically using t-Test. For F3 t-Test value is p = 0.014948. Therefore it is concluded from this pilot study that Fp2 increases in working memory test, which is evident from the figure. Moreover the p value is less than 0.05. Though the numbers of subjects are less still the results are proven to be statistically significant.

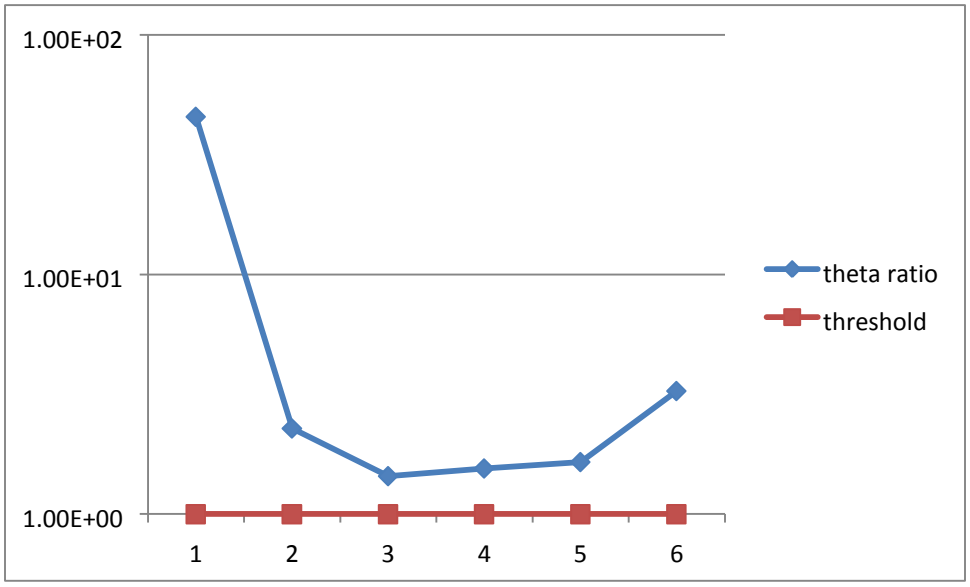

Figure 7.15: F4 Theta (4-8 Hz) working memory task

From figure 7.15 it is inferred that theta band of F4 increases in working memory as expected. Results are also verified statistically using t-Test. For F4 t-Test value is p = 0.080354. Therefore it is concluded from this pilot study that F4 increases in working memory test, which is evident from the figure. Moreover the p value is approximately equal to 0.05. Though the numbers of subjects are less still the results are proven to be statistically significant.

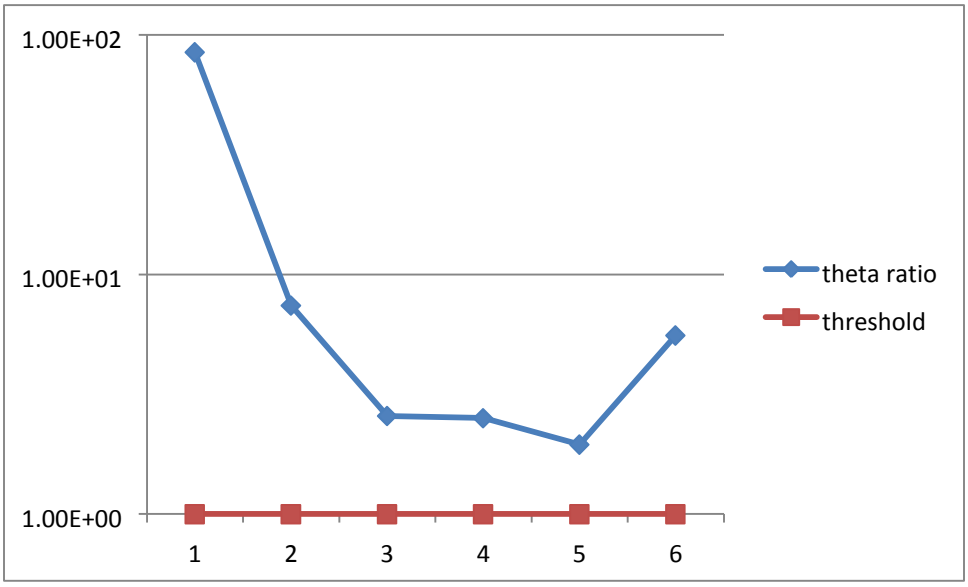

Figure 7.16: F7 Theta (4-8 Hz) ratio working memory task

From figure 7.16 it is inferred that theta band of F7 increases in working memory as expected. Results are also verified statistically using t-Test. For F7 t-Test value is p = 0.066967. Therefore it is concluded from this pilot study that F7 increases in working memory test, which is evident from the figure. Moreover the p value is approximately equal to 0.05.Though the numbers of subjects are less still the results are proven to be statistically significant.

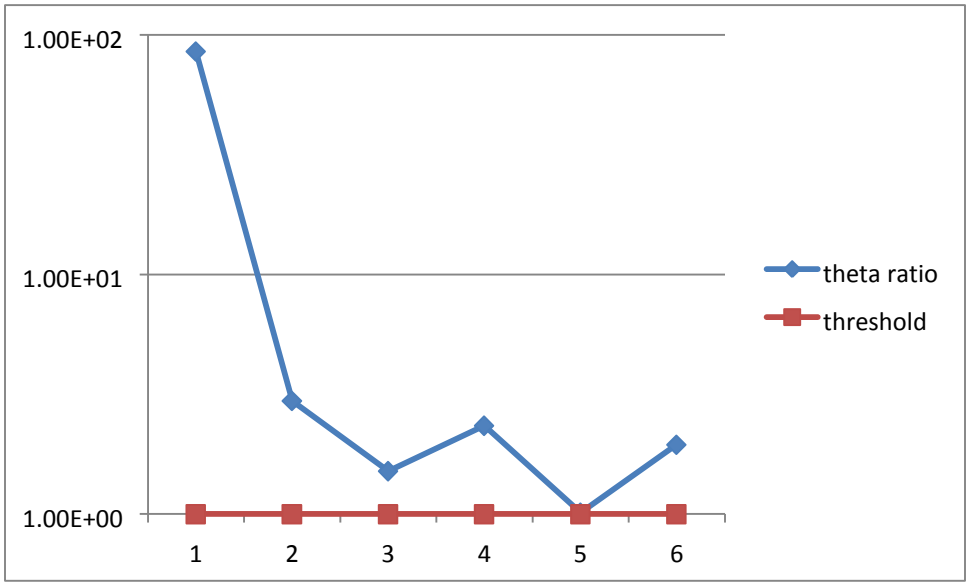

Figure 6.17: F8 Theta (4-8 Hz) ratio working memory task

From figure 6.17 it is inferred that theta band of F8 does not represent good results as expected (i.e. increase) but acceptable in working memory task**.** Results are also verified statistically using t-Test. For F7 t-Test value is p = 0.109599. Therefore it is concluded from this pilot study that F7 increases in attentional test, which is evident from the figure.

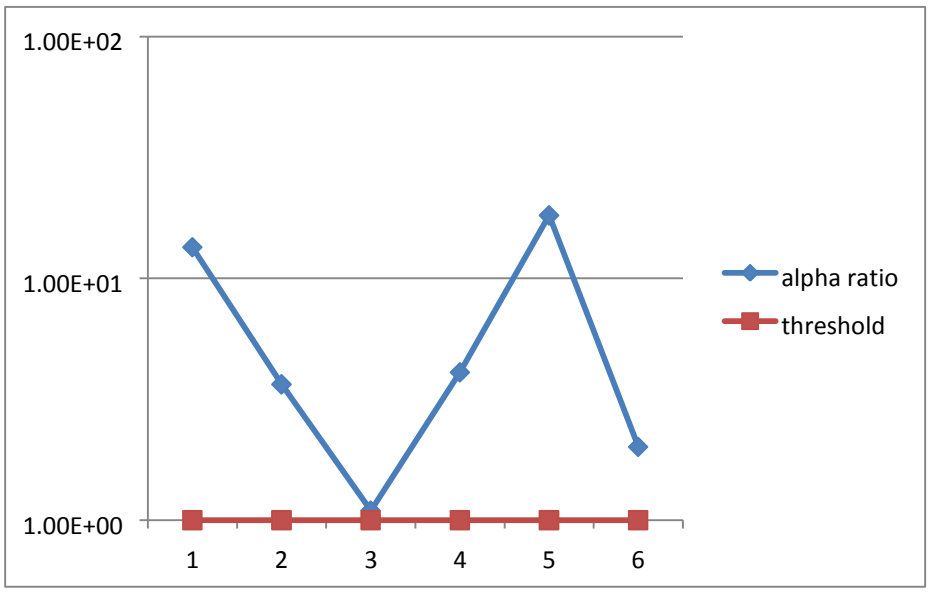

Figure 7.18: Fp1 alpha (8-13 Hz) ratio working memory task

From figure 7.18 it is inferred that alpha band of Fp1 increases in working memory as expected. Results are also verified statistically using t-Test. For Fp1 t-Test value is p

=0.043337. Therefore it is concluded from this pilot study that Fp1 increases in working memory test, which is evident from the figure. Though the numbers of subjects are less still the results are proven to be statistically significant.

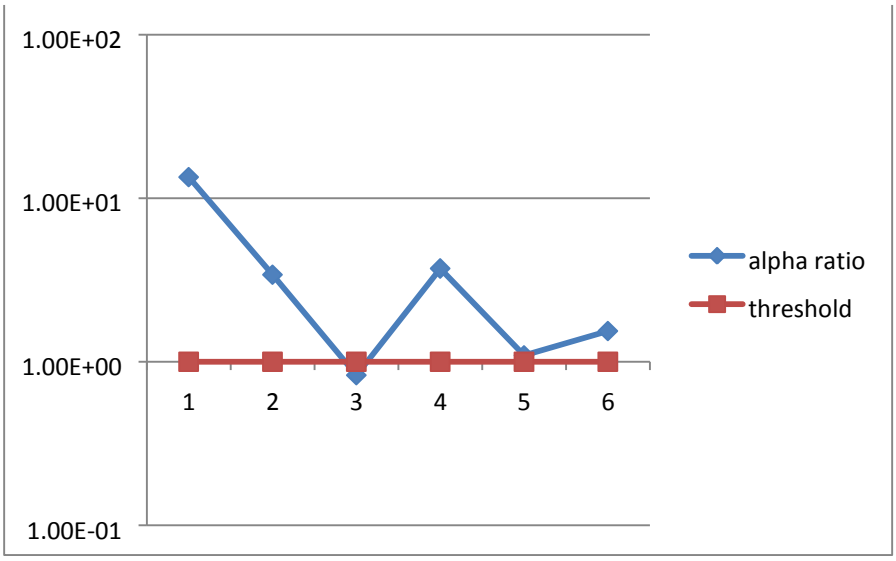

Figure 7.19: Fp2 alpha (8-13 Hz) ratio working memory task

From figure 7.19 it is inferred that alpha band of Fp2 increases in working memory as expected. Results are also verified statistically using t-Test. For Fp2 t-Test value is p =0.046564. Therefore it is concluded from this pilot study that Fp2 increases in working memory test, which is evident from the figure. Moreover the p value is less than 0.05. Though the numbers of subjects are less still the results are proven to be statistically significant.

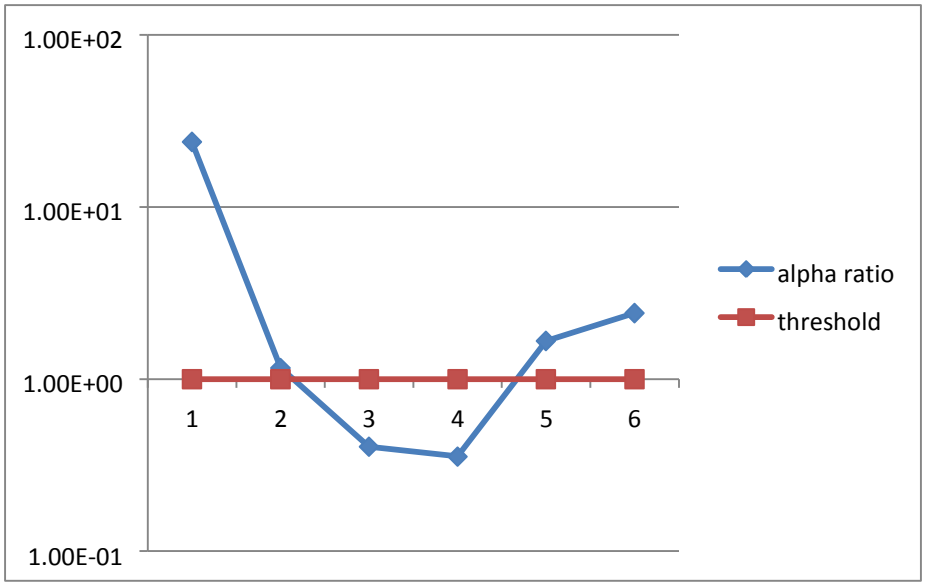

Figure 7.20: O1 alpha (8-13 Hz) ratio working memory task

From figure 7.20 it is inferred that in alpha band of O1 no conclusion is drawn as expected, it may be due to some experimental errors. Results are also verified statistically using t-Test. For O1 t-Test value is p=0.303206. Therefore nothing can be concluded from this pilot study as p value is not less than 0.05.

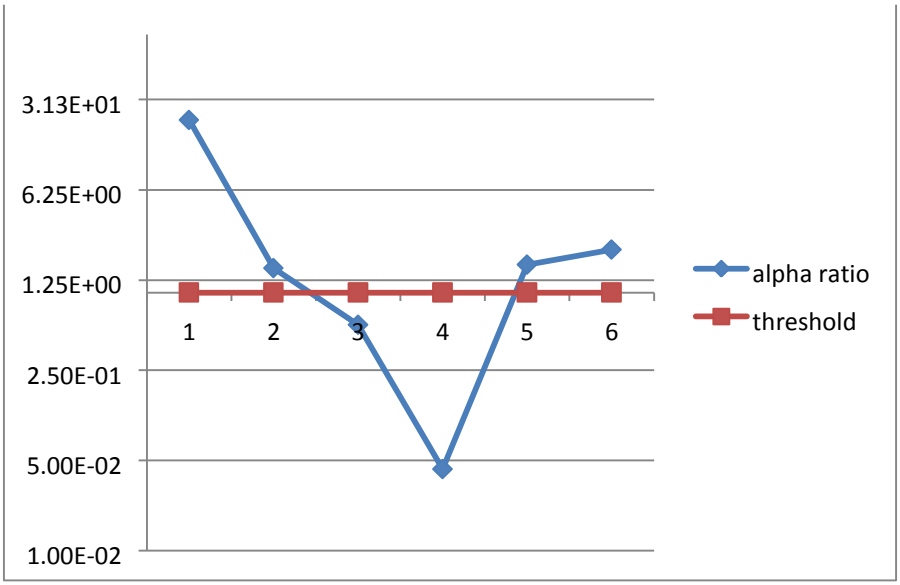

Figure 7.21: O2 alpha (8-13 Hz) ratio working memory task

From figure 7.21 it is inferred that in alpha band of O2 no conclusion is drawn as expected, it may be due to some experimental errors. Results are also verified statistically using t-Test. For O2 t-Test value is p= 0.395126. Therefore nothing can be concluded from this pilot study as p value is not less than 0.05.

7.1.2 Correlational study of subject's performance in PEBL and EEG frequency band power

To verify correlation between the performance of the subjects on PEBL task and select EEG parameters in different frequency bands, same of the encouraging results obtained are being reported here. This being a pilot study with a small number of subjects may be taken a confidence building measure to improve the extent of research.

a) Correlation between attentional task Go/No-go and alpha (8-13 Hz) band power of Fp1

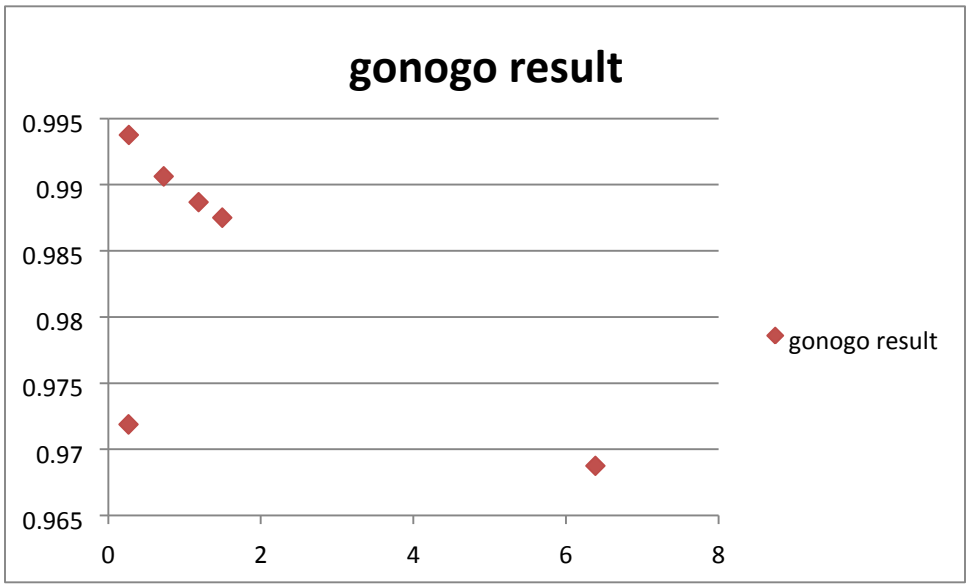

Figure 7.22:Fp1 alpha (8-13 Hz) band power and Go/No-go correlation

The correlation obtained for entire population is -0.63182.
For best five subjects, the graph is shown in following figure

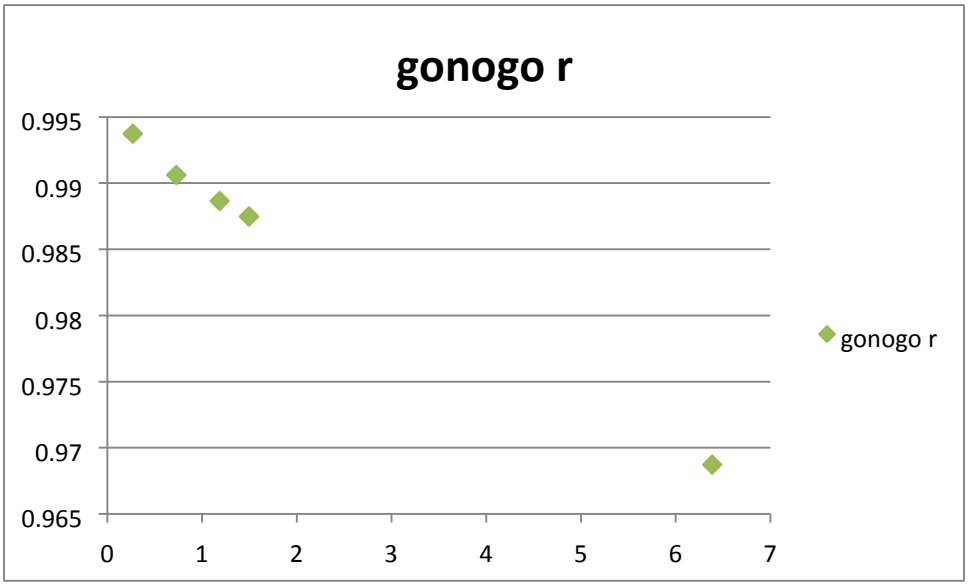

Figure 7.23: Fp1 alpha (8-13 Hz) band power and Go/No-go correlation best five

The correlation obtained for entire population is -0.99806

b) Correlation between attentional task Go/No-go and alpha (8-13 Hz) band power of F7

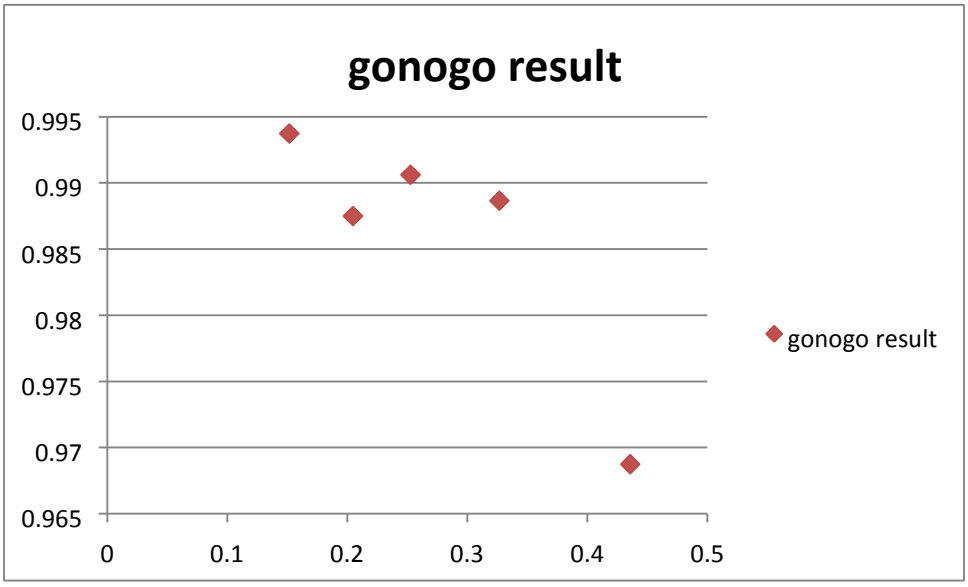

Figure 7.24: F7 alpha (8-13 Hz) band power and Go/No-go correlation

The correlation obtained for entire population is -0.55458

For best five subjects, the graph is shown in following figure

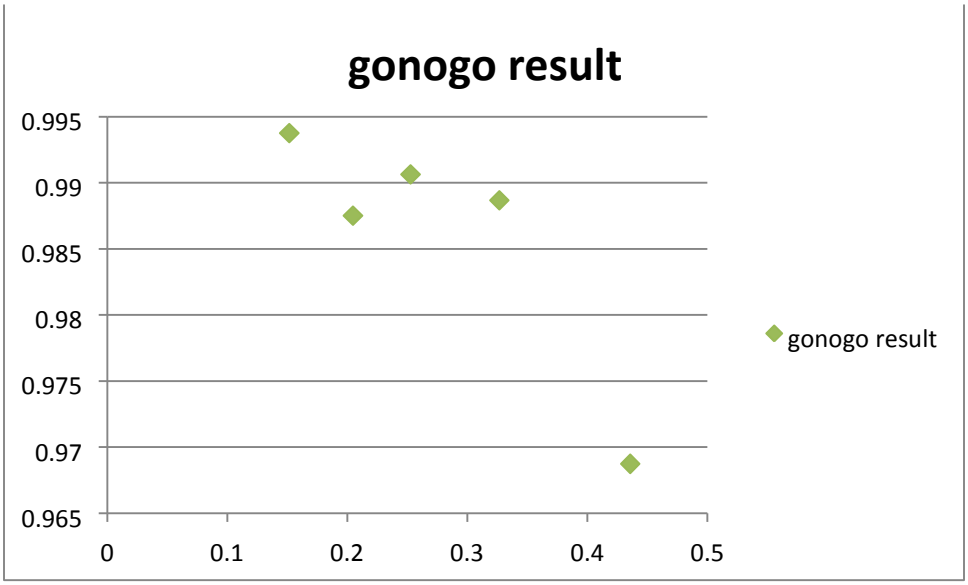

Figure 7.25: F7 alpha (8-13 Hz) band power and Go/No-go correlation best five

The correlation obtained for entire population is -0.86966

c) Correlation between attentional task Go/No-go and alpha (8-13 Hz) band power of F8

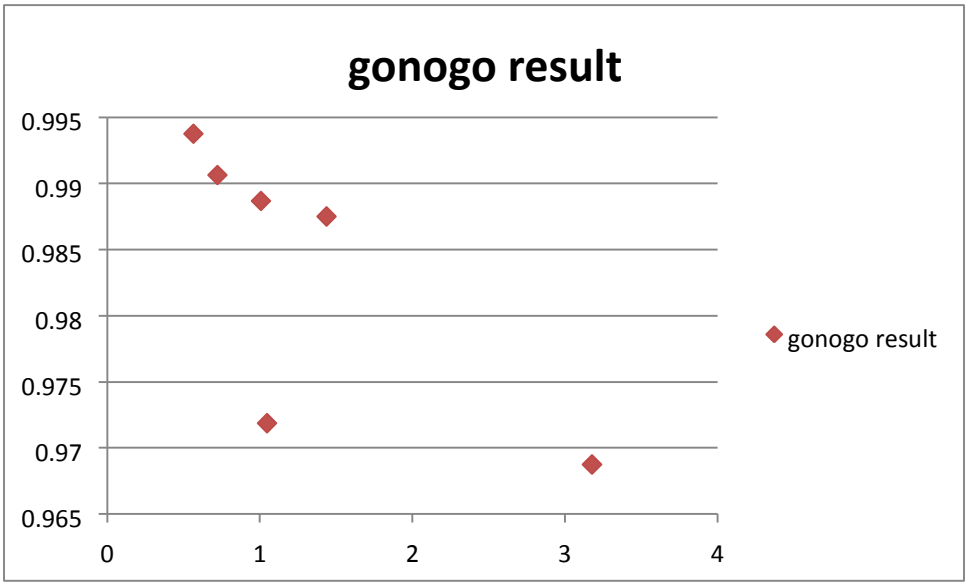

Figure 7.26: F8 alpha (8-13 Hz) band power and Go/No-go correlation

The correlation obtained for entire population is -0.74519

For best five subjects, the graph is shown in following figure

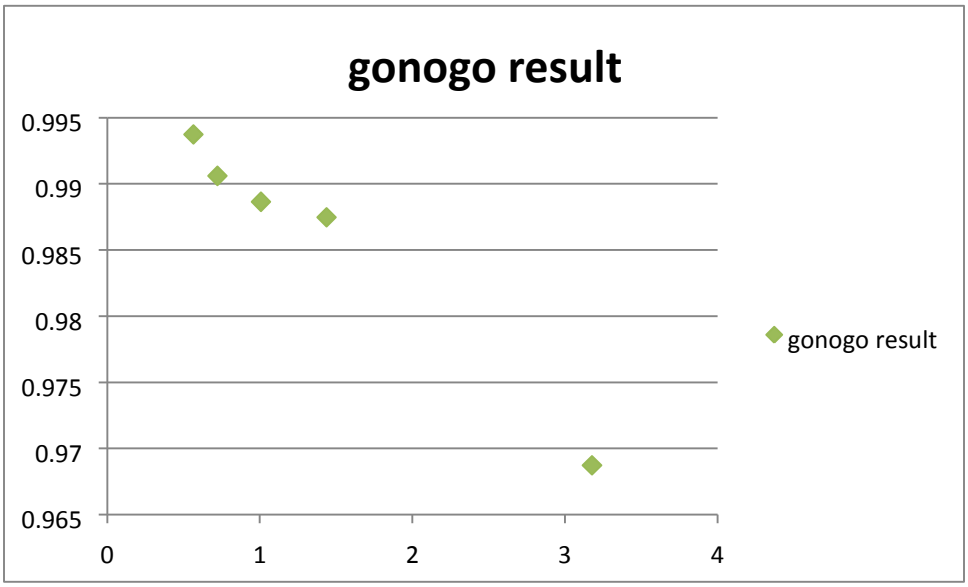

Figure 7.27: F8 alpha (8-13 Hz) band power and Go/No-go correlation best five

The correlation obtained for entire population is -0.99064

d) Correlation between attentional task Go/No-go and beta (13-30 Hz) band power of F8

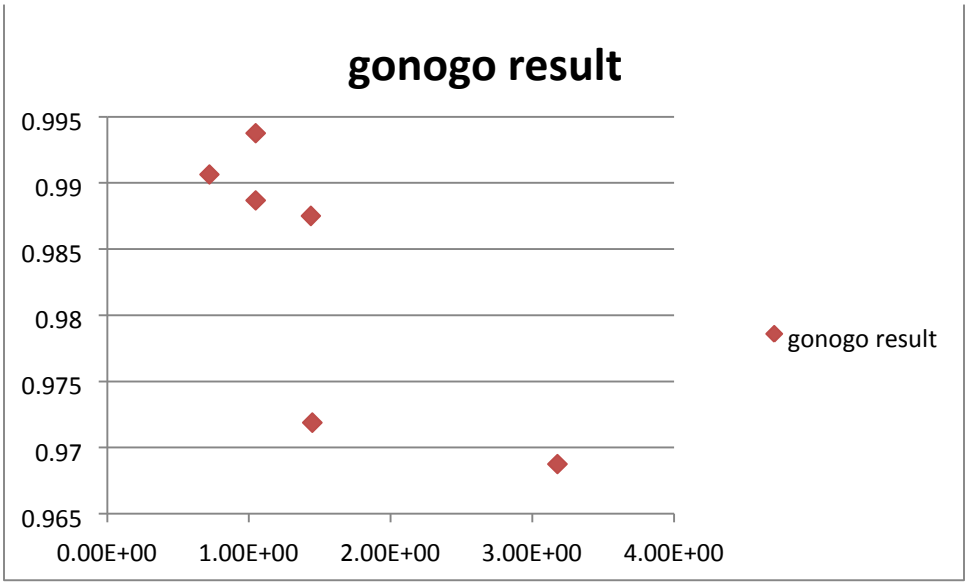

Figure 7.28: F8 beta (13-30 Hz) band power and Go/No-go correlation

The correlation obtained for entire population is -0.80275

For best five subjects, the graph is shown in following figure

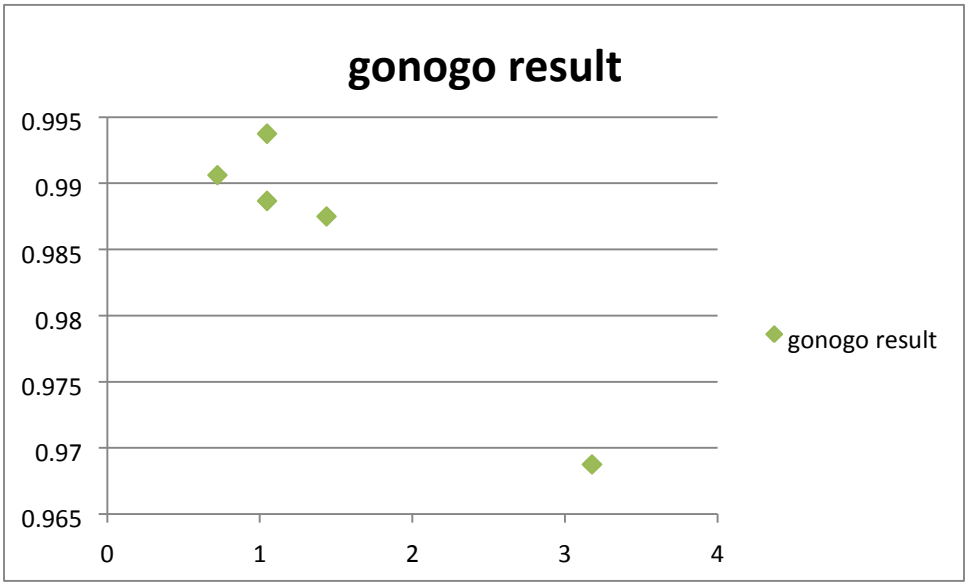

Figure 7.29: F8 beta (13-30 Hz) band power and Go/No-go correlation best five

The correlation obtained for entire population is -0.96835

e) Correlation between attentional task Go/No-go and beta (13-30 Hz) band power of f4

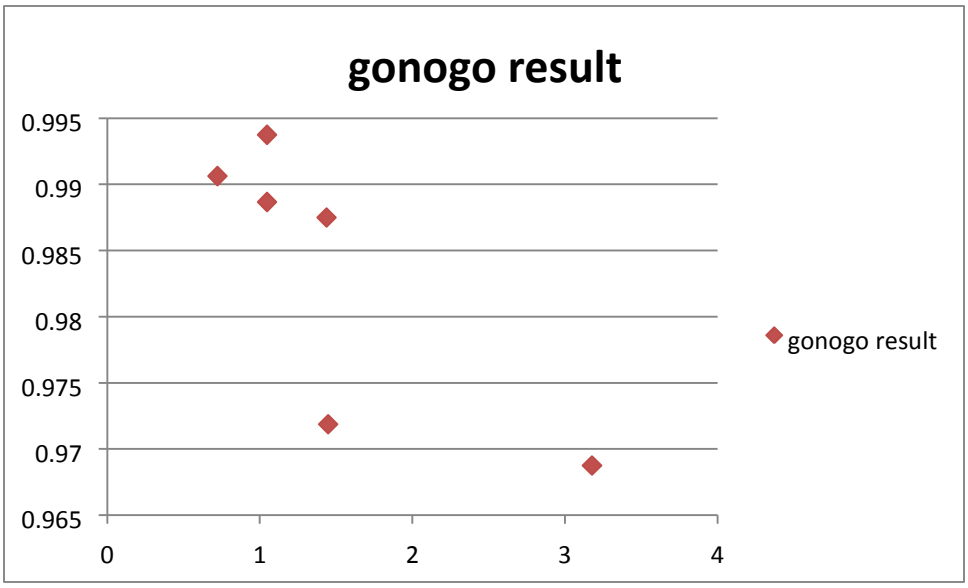

Figure 7.30: F4 beta (13-30 Hz) band power and Go/No-go correlation

The correlation obtained for entire population is -0.80275

For best five subjects, the graph is shown in following figure

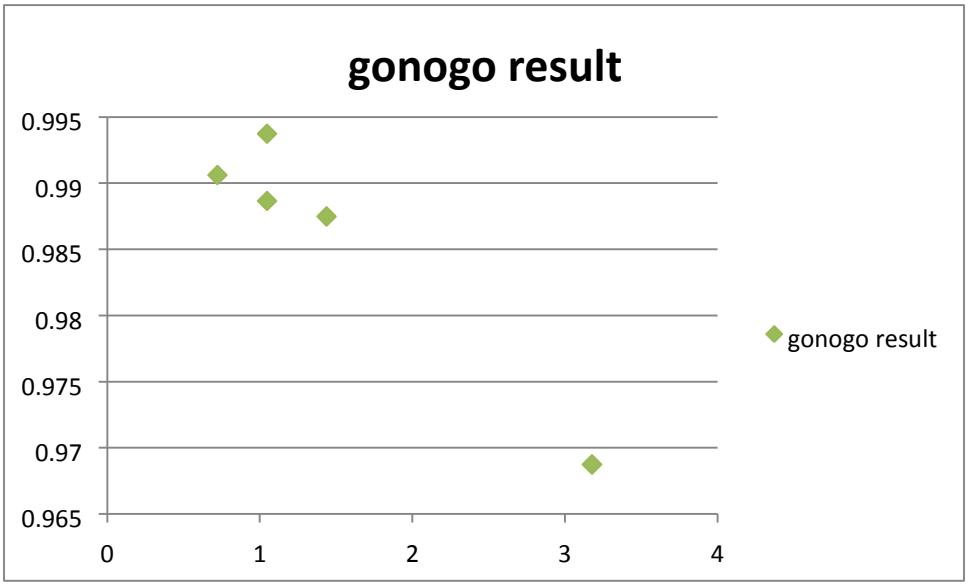

Figure 7.31: F4 beta (13-30 Hz) band power and Go/No-go correlation best five

The correlation obtained for entire population is -0.96835

f) Correlation between working memory task D-span and theta (4-8 Hz) band power of f3

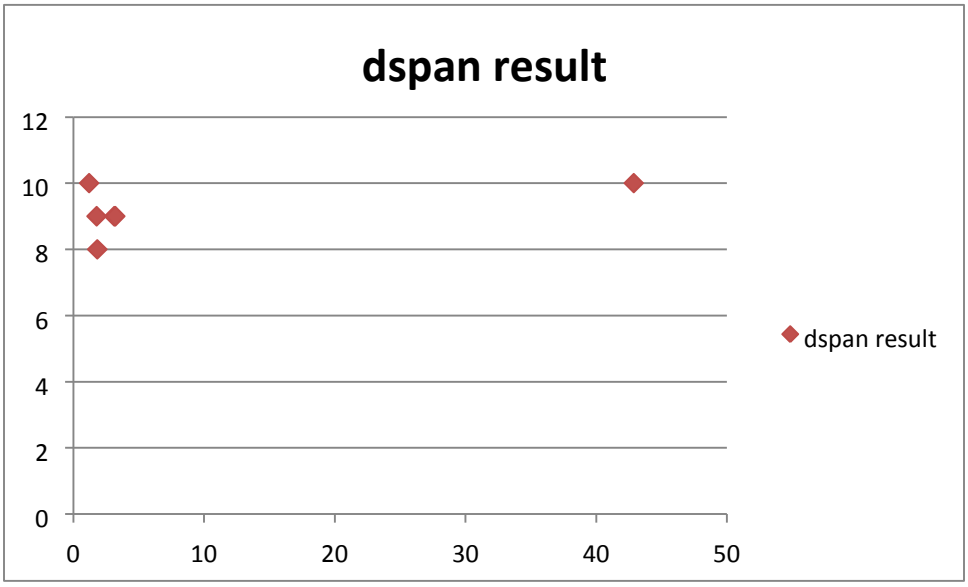

Figure 7.32: F3 theta (4-8 Hz) band power and D-span correlation

The correlation obtained for entire population is 0.53162

For best five subjects, the graph is shown in following figure

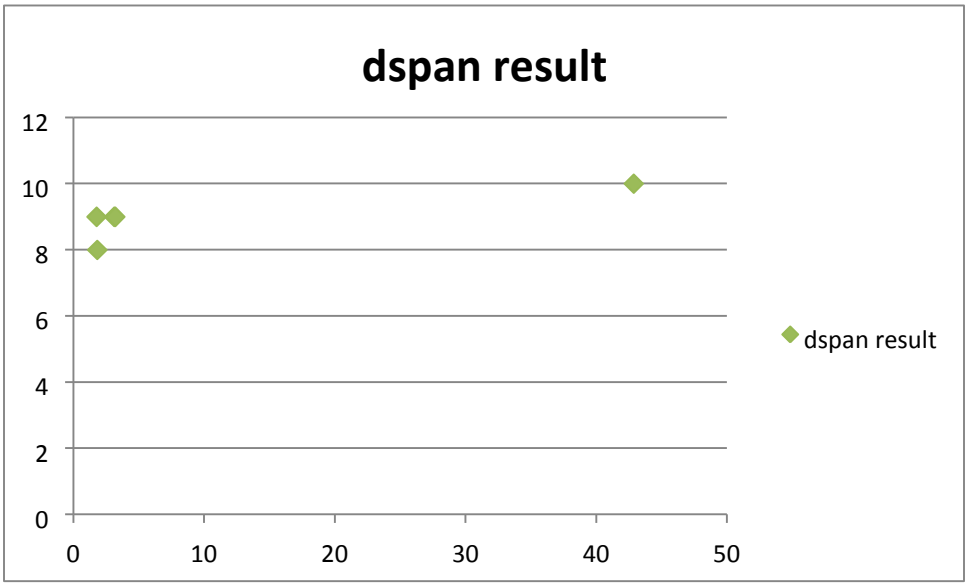

Figure 7.33: F3 theta (4-8 Hz) band power and D-span correlation best five

The correlation obtained for entire population is 0.802909

g) Correlation between working memory task D-span and theta (4-8 Hz) band power of f4

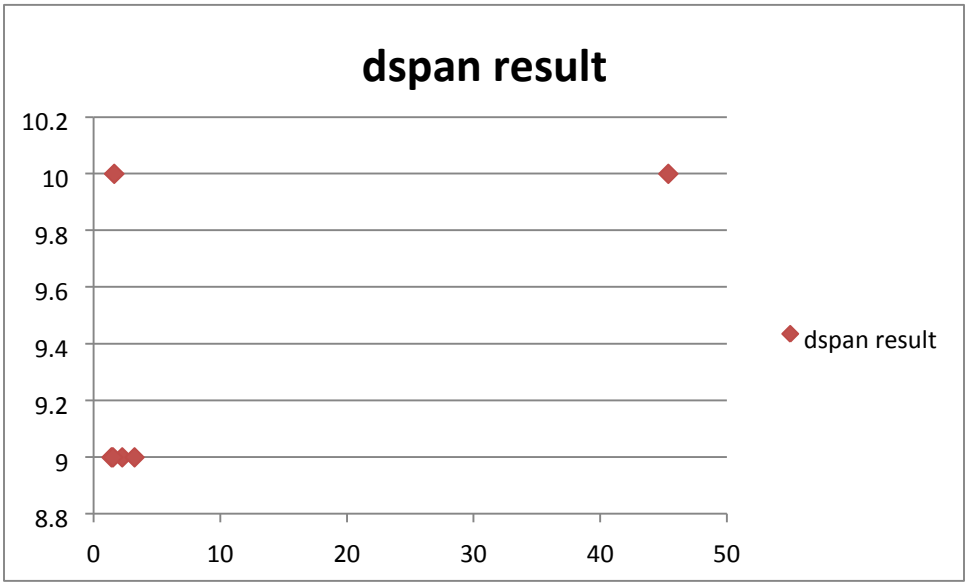

Figure 7.34: F4 theta (4-8 Hz) band power and D-span correlation

The correlation obtained for entire population is 0.623554

For best five subjects, the graph is shown in following figure

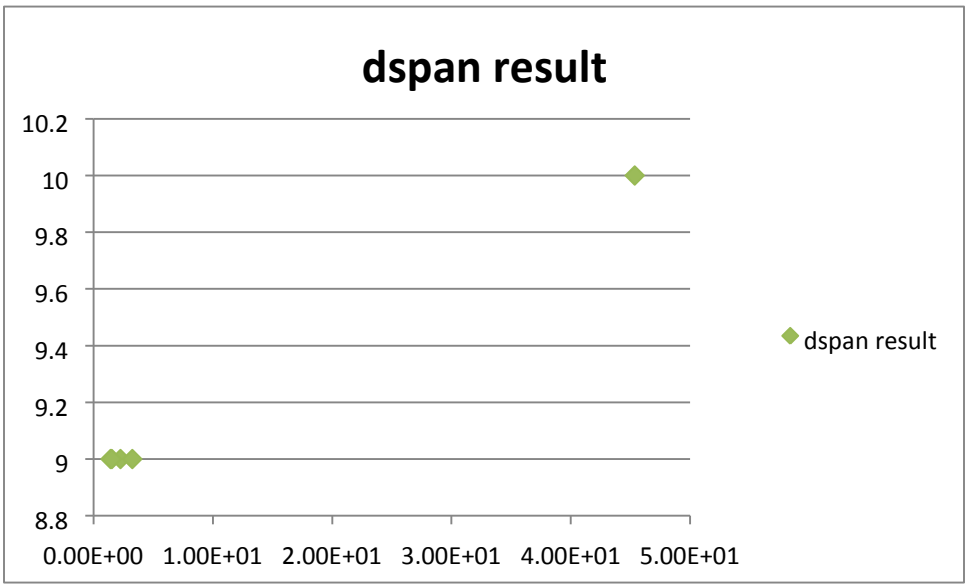

Figure 7.35: F4 theta (4-8 Hz) band power and D-span correlation best five

The correlation obtained for entire population is 0.999296

h) Correlation between working memory task D-span and theta (4-8 Hz) band power of f7

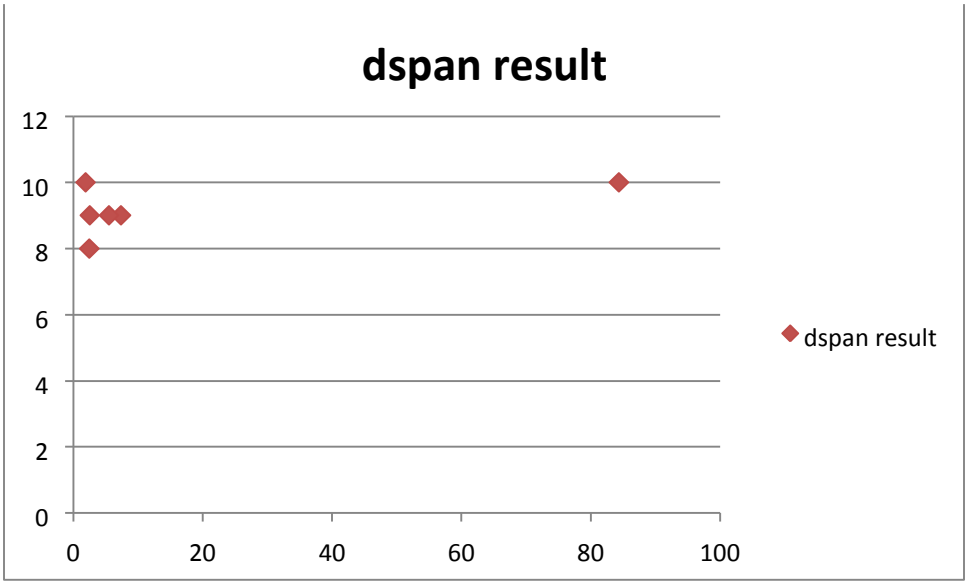

Figure 7.36: F7 theta (4-8 Hz) band power and D-span correlation

The correlation obtained for entire population is 0.536676

For best five subjects, the graph is shown in following figure

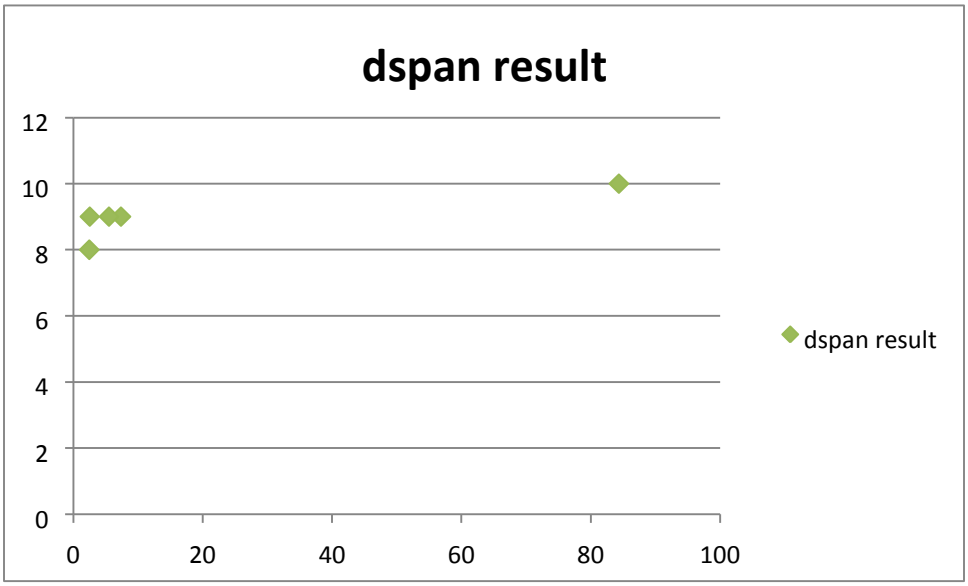

Figure 7.37: F7 theta (4-8 Hz) band power and D-span correlation best five

The correlation obtained for entire population is 0.808998

i) Correlation between working memory task D-span and theta (4-8 Hz) band power of f8

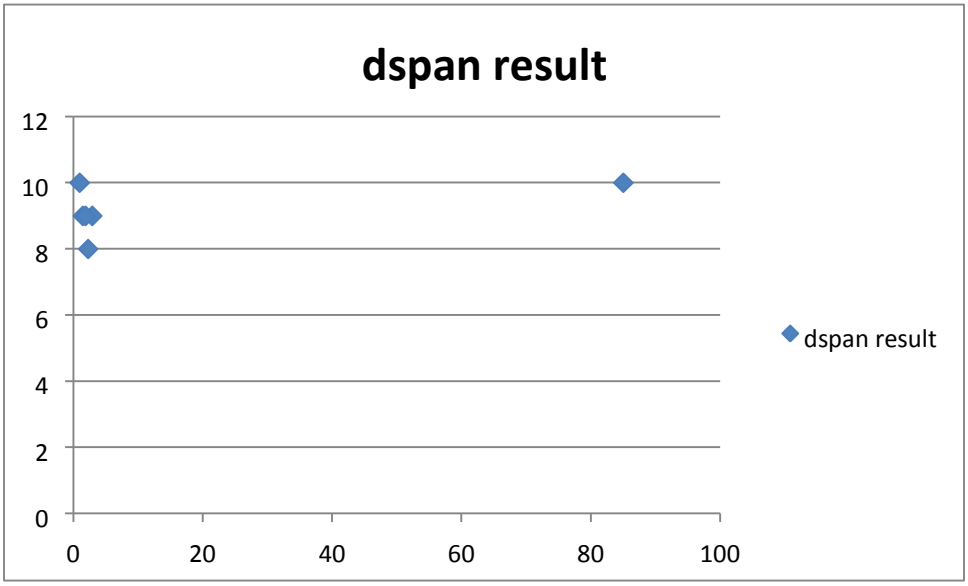

Figure 7.38: F8 theta (4-8 Hz) band power and D-span correlation

The correlation obtained for entire population is 0.531812

For best five subjects, the graph is shown in following figure

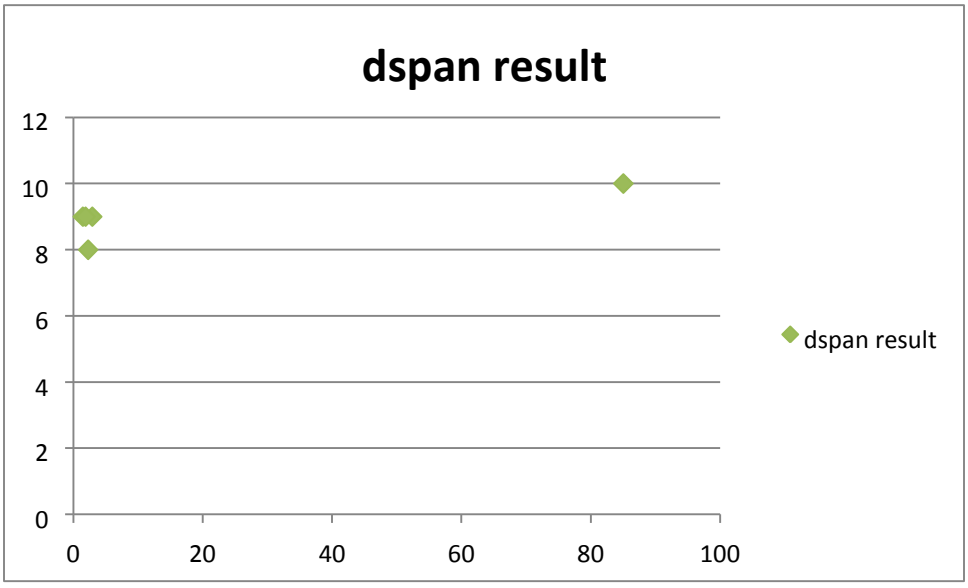

Figure 7.39: F8 theta (4-8 Hz) band power and D-span correlation best five

The correlation obtained for entire population is 0.789058

j) Correlation between working memory task D-span and alpha (8-13Hz) band power of fp1

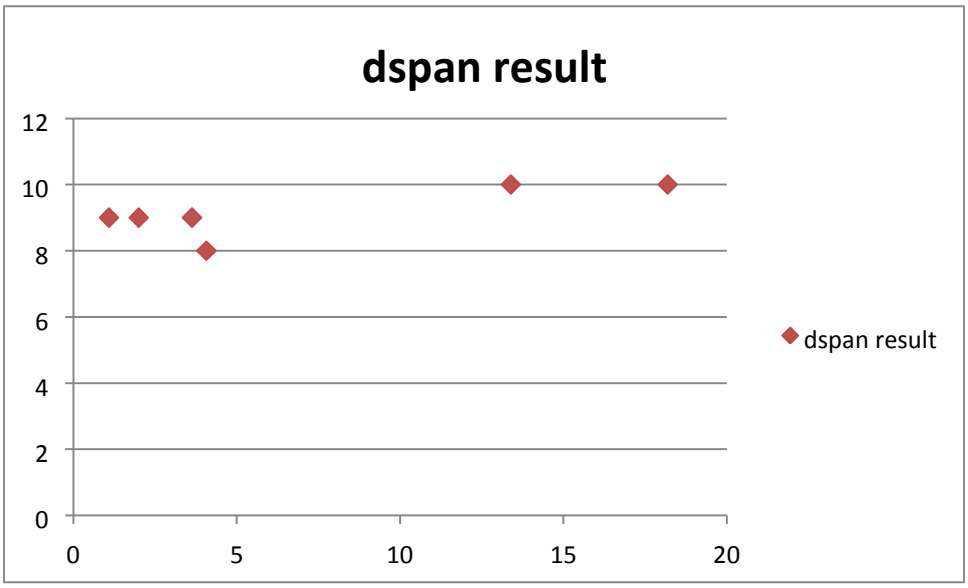

Figure 7.40: Fp1 alpha (8-13Hz) band power and D-span correlation

The correlation obtained for entire population is 0.774701

For best five subjects, the graph is shown in following figure

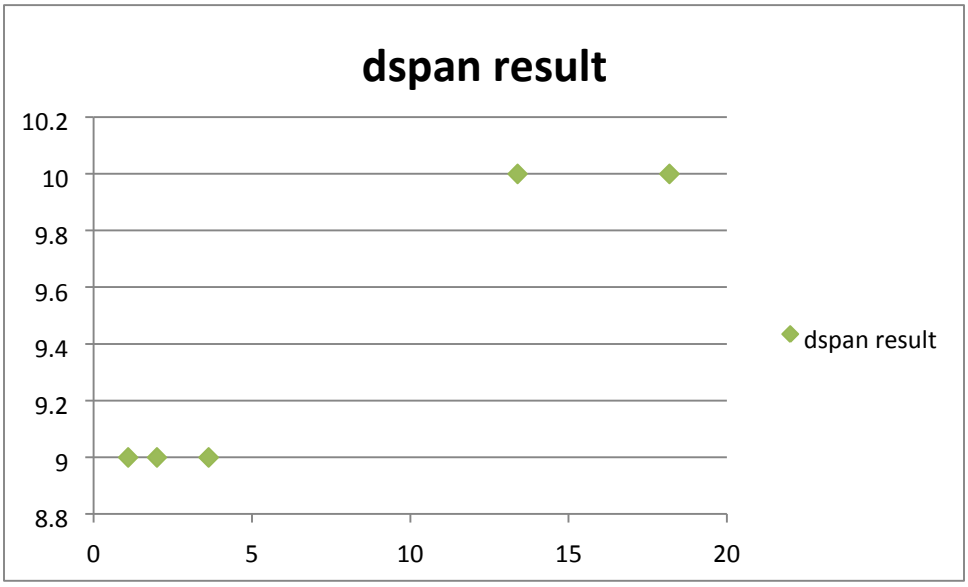

Figure 7.41: Fp1 alpha (8-13Hz) band power and D-span correlation best five

The correlation obtained for entire population is 0.967949

k) Correlation between working memory task D-span and alpha (8-13Hz) band power of O1

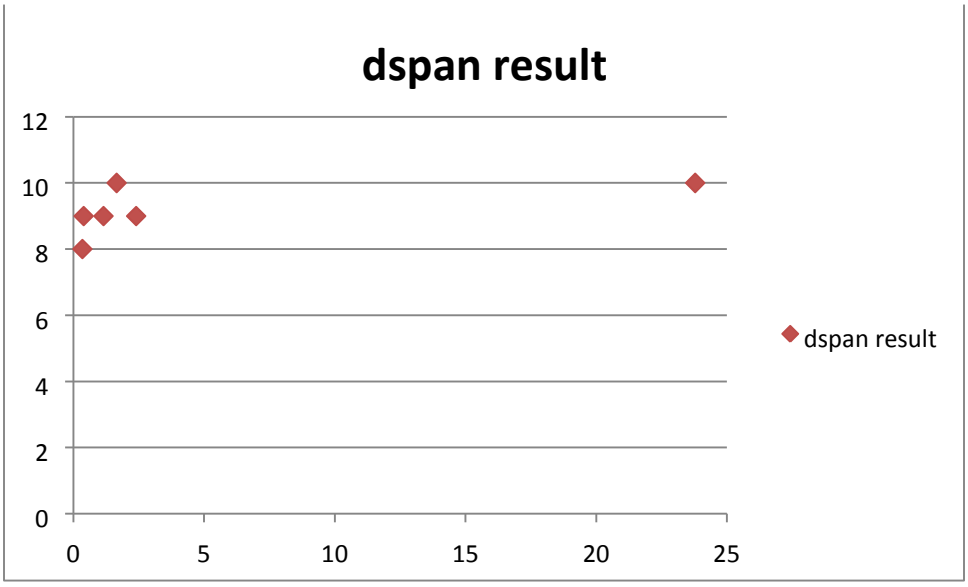

Figure 7.42: O1 alpha (8-13Hz) band power and D-span correlation

The correlation obtained for entire population is 0.578137

For best five subjects, the graph is shown in following figure

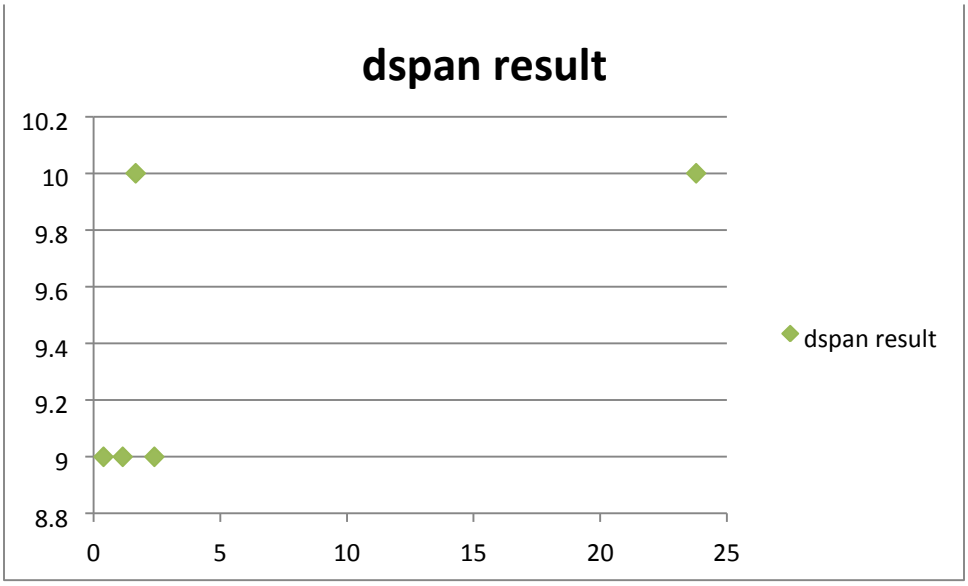

Figure 7.43: O1 alpha (8-13Hz) band power and D-span correlation best five

The correlation obtained for entire population is 0.622509

l) Correlation between working memory task D-span and alpha (8-13Hz) band power of O2

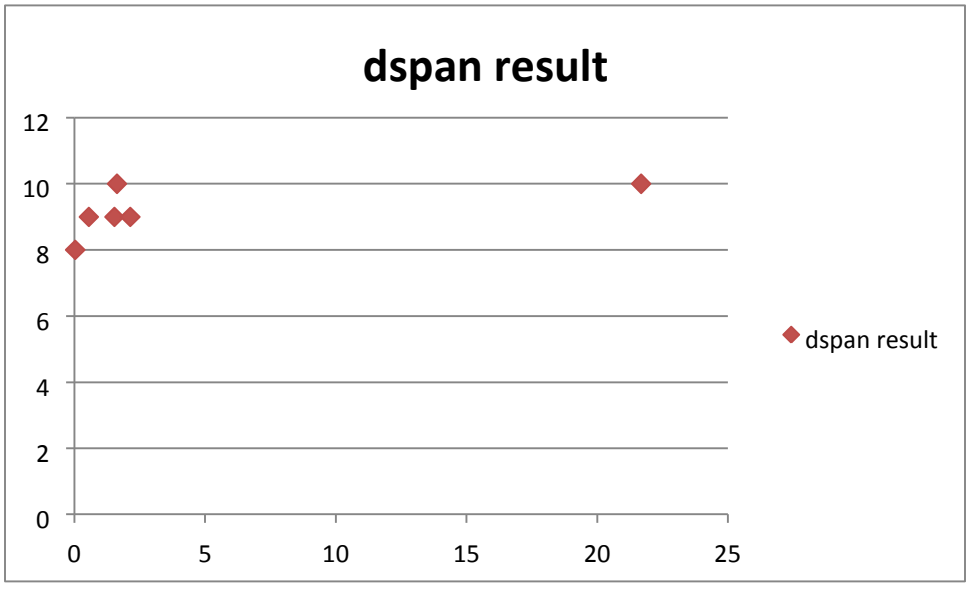

Figure 7.44: O2 alpha (8-13Hz) band power and D-span correlation

The correlation obtained for entire population is 0.590512

For best five subjects, the graph is shown in following figure

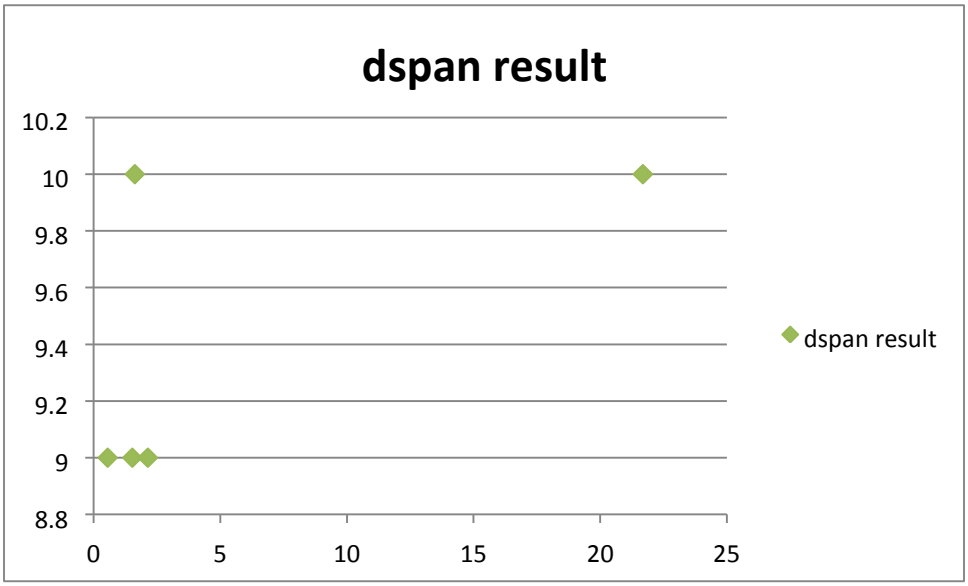

Figure 7.45: O2 alpha (8-13Hz) band power and D-span correlation best five

The correlation obtained for entire population is 0.61954

7.2 Cognitive Enhancement using Meditation an Intervention

In this study results for attention and working memory are computed for both task oriented and physiologically assessment. For physiologically assessment EEG is taken and power of alpha (8-13 Hz) and beta (13-30 Hz) bands are computed for attention; and power of theta (4-8 Hz) and alpha (8-13 Hz) bands for working memory. In task oriented assessment computer based tasks like Go/No-go and D-span tests for attention and working memory respectively were performed.

7.2.1 Physiologically assessment

1) Attention task

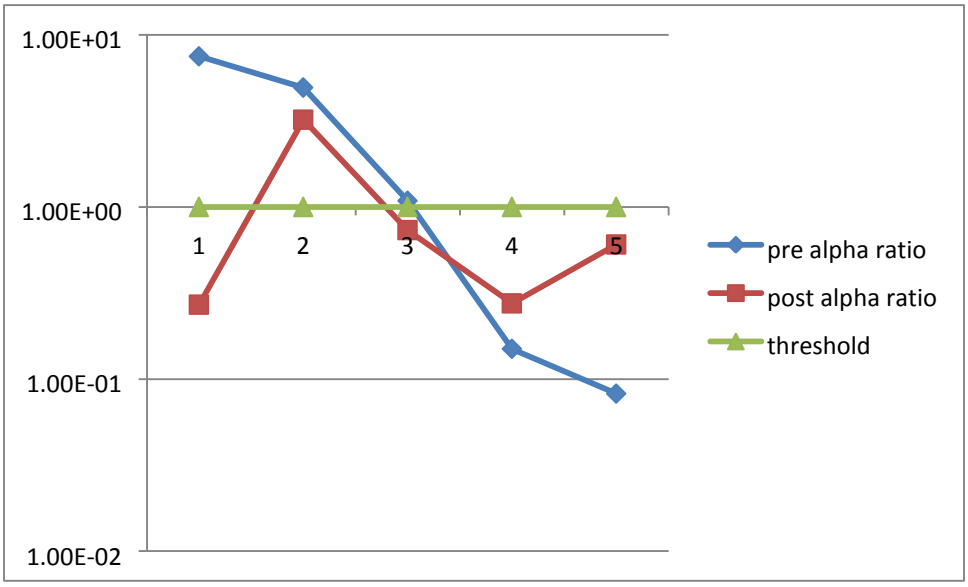

Figure 7.46:Fp1 alpha (8-13Hz) ratio attention task

From figure 7.46 it is inferred that alpha band of Fp1 does not represent so good results (i.e. decreasing) as expected but still acceptable in pre-post comparison for attentional task. Results are also verified statistically using t-Test. For Fp1 t-Test value is p =0.145779.Therefore it is concluded from this pilot study that Fp1 decreases in attentional test, which is evident from the figure.

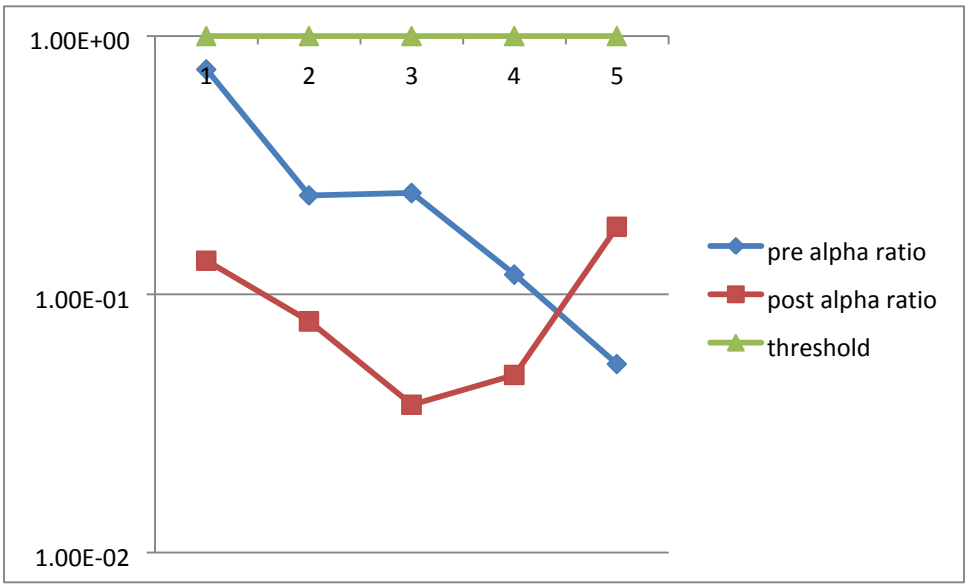

Figure 7.47:F3 alpha (8-13Hz) ratio attention task

From figure 7.47 it is inferred that alpha band of Fp2 does not represent so good results (i.e. decreasing) as expected but acceptable in pre-post comparison for attentional task. Results are also verified statistically using t-Test. For Fp2 t-Test value is p =0.100729.Therefore it is concluded from this pilot study that Fp2 decreases in attentional test, which is evident from the figure.

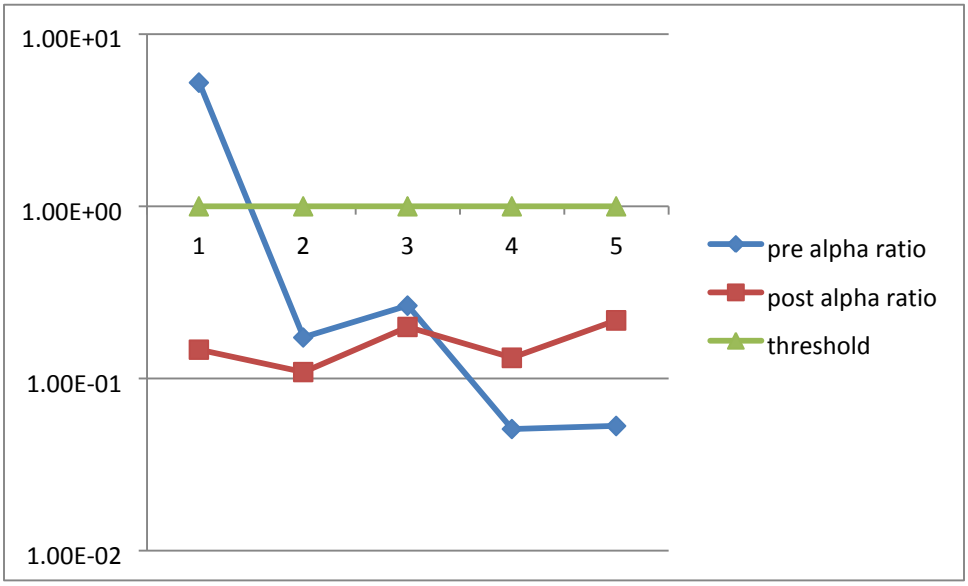

Figure 7.48:F4 alpha (8-13Hz) ratio attention task

From figure 7.48 it is inferred that alpha band of F4 does not represent so good results (i.e. decreasing) as expected but acceptable in pre-post comparison for attentional task. Results are also verified statistically using t-Test. For Fp2 t-Test value is p =0.193303.Therefore it is concluded from this pilot study that F4 decreases in attentional test, which is evident from the figure.

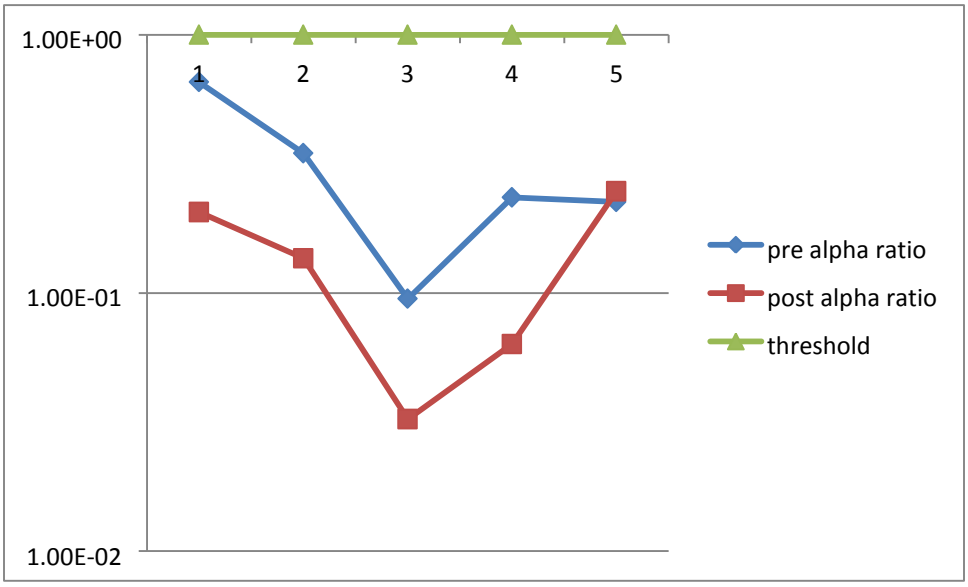

Figure 7.49:F7 alpha (8-13Hz) ratio attention task

From figure 7.49 it is inferred that alpha band of F7 decreasing as expected in pre-post comparison for attentional task. Results are also verified statistically using t-Test. For F7 t-Test value is p =0.047535.Therefore it is concluded from this pilot study that F7 decreases in attentional test, which is evident from the figure. Moreover the p value is 0.047535 which is less than 0.05. Though the numbers of subjects are less still the results are proven to be statistically significant.

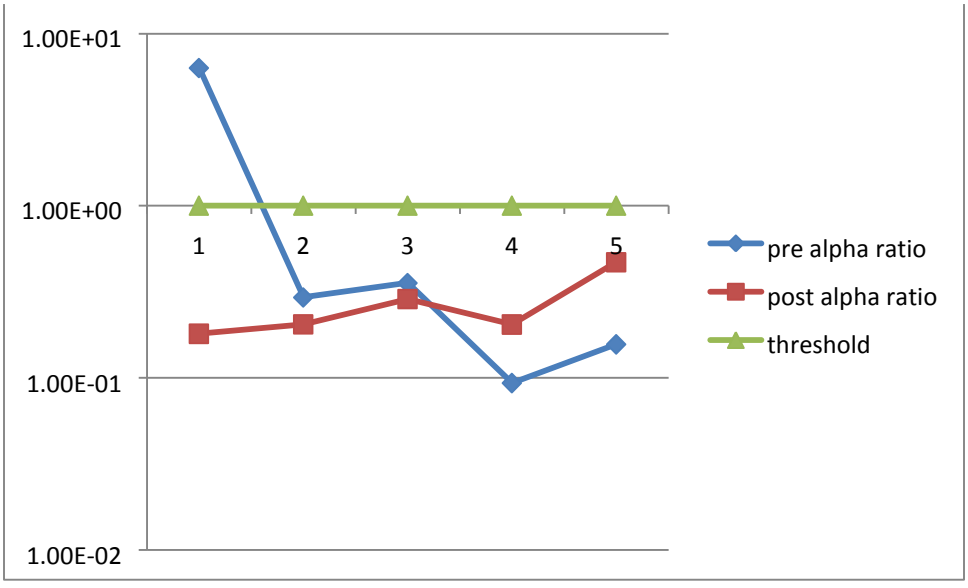

Figure 7.50:F8 alpha (8-13Hz) ratio attention task

From figure 7.50 it is inferred that alpha band of F8 does not represent so good results (i.e. decreasing) as expected but acceptable in pre-post comparison for attentional task. Results are also verified statistically using t-Test. For F8 t-Test value is p =0.199178.Therefore it is concluded from this pilot study that F8 decreases in attentional test, which is evident from the figure.

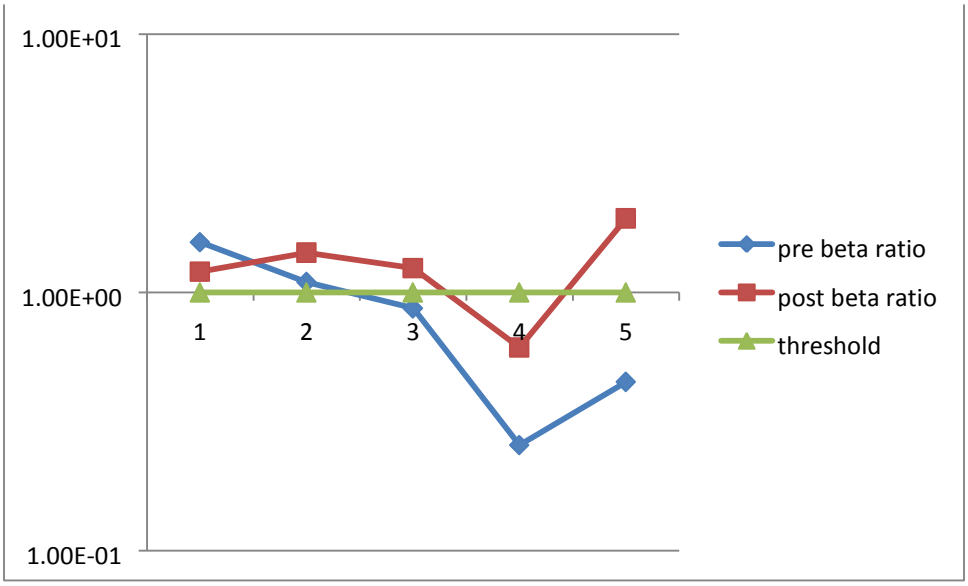

Figure 7.51:Fp2 beta (13-30Hz) ratio attention task

From figure 7.51 it is inferred that beta band of Fp2 does not represent so good results (i.e. increasing) as expected but acceptable in pre-post comparison for attentional task. Results are also verified statistically using t-Test. For Fp2 t-Test value is p =0.107442.Therefore it is concluded from this pilot study that Fp2 increases in attentional test, which is evident from the figure.

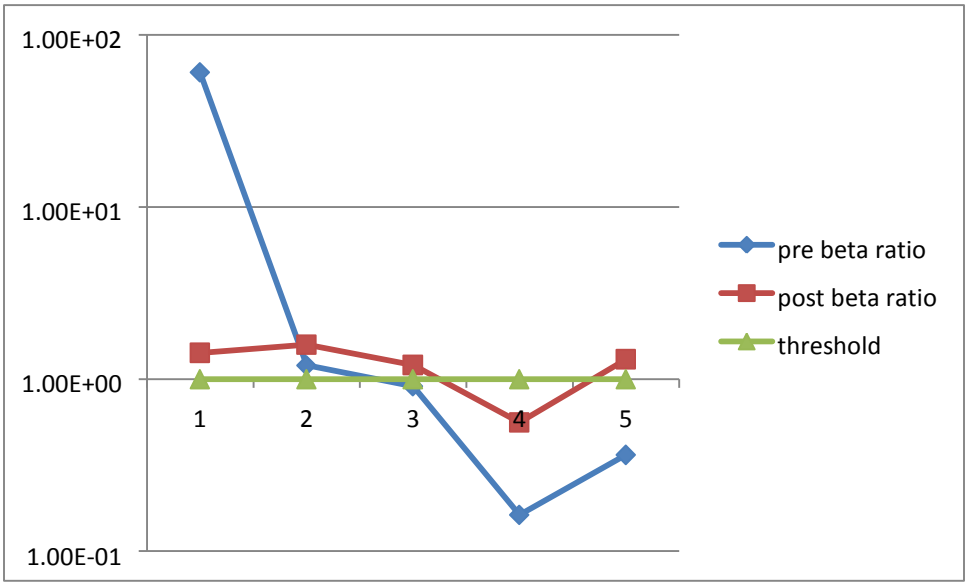

Figure 7.52:F4 beta (13-30Hz) ratio attention task

From figure 7.52 it is inferred that beta band of F4 does not represent so good results (i.e. increasing) as expected but acceptable in pre-post comparison for attentional task. Results are also verified statistically using t-Test. For F4 t-Test value is p =0.196304.Therefore it is concluded from this pilot study that F4 increases in attentional test, which is evident from the figure.

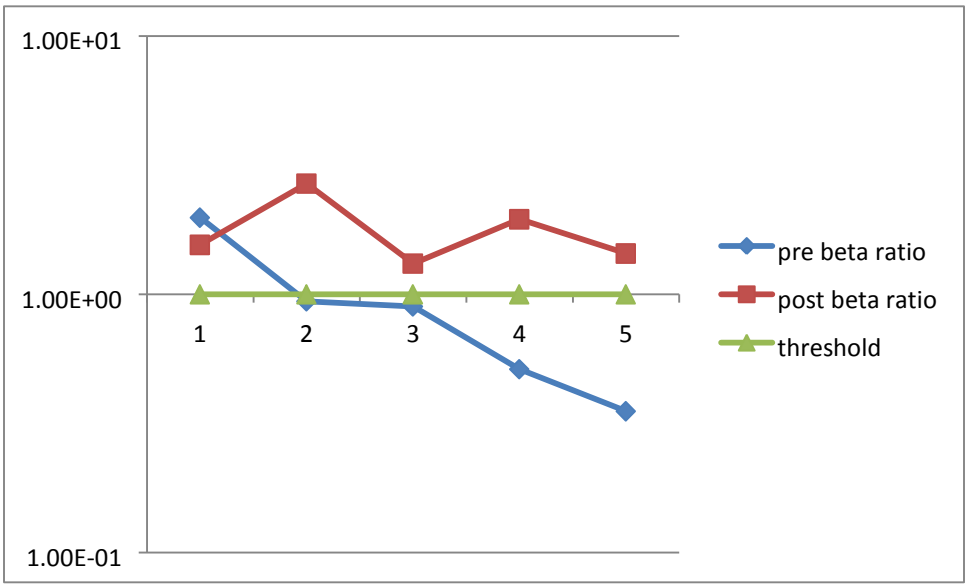

Figure 7.53:F8 beta (13-30Hz) ratio attention task

From figure 7.53 it is inferred that beta band of F8 increases as expected in pre-post comparison for attentional task. Results are also verified statistically using t-Test. For F8 t-Test value is p =0.046671.Therefore it is concluded from this pilot study that F8 increases in attentional test, which is evident from the figure. Moreover the p value is 0.046671which is less than 0.05. Though the numbers of subjects are less still the results are proven to be statistically significant.

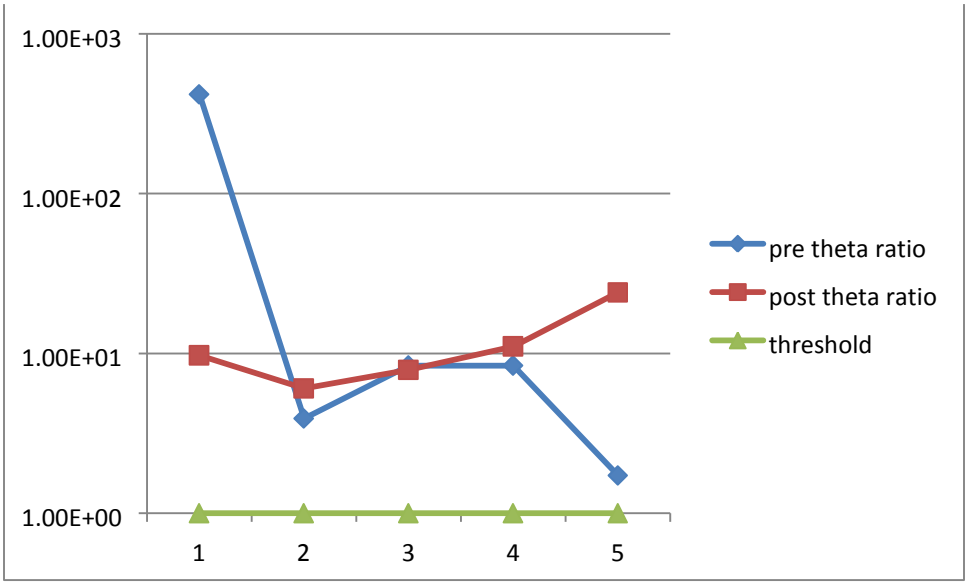

Figure 7.54:Fp1theta (4-8Hz) ratio working memory task

From figure 7.54 it is inferred that theta band of Fp1 does not increase as expected in prepost comparison for working memory task. Results are also verified statistically using tTest. For Fp1 t-Test value is p =0.205149.No conclusion is drawn from this result as value of p is very large then 0.05.

2) Working Memory

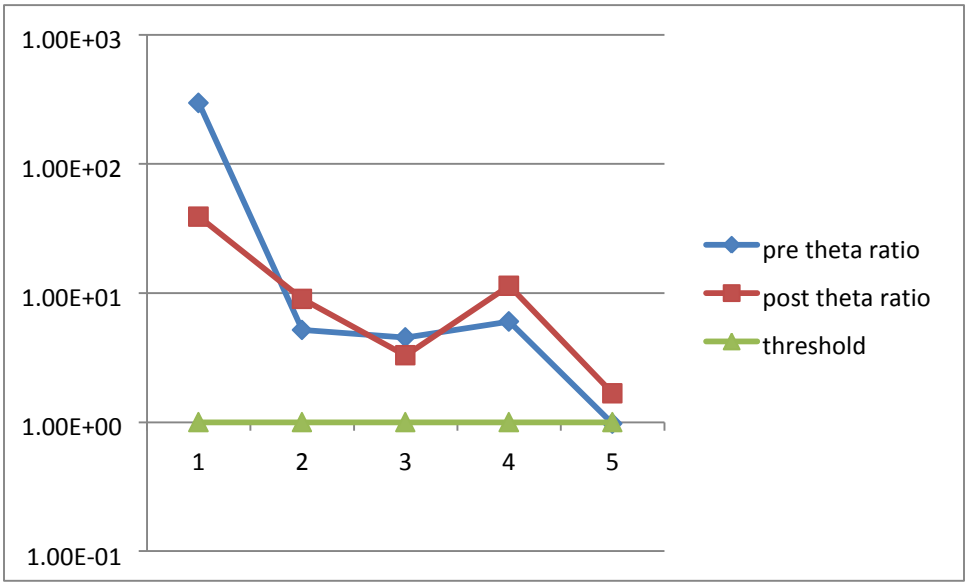

Figure 7.55:Fp2 theta (4-8Hz) ratio working memory task

From figure 7.55 it is inferred that theta band of Fp2 does not represent so good results (i.e. increasing) as expected but acceptable in pre-post comparison for working memory task. Results are also verified statistically using t-Test. For Fp2 t-Test value is p =0.196146.Therefore it is concluded from this pilot study that Fp2 increases in working memory test, which is evident from the figure.

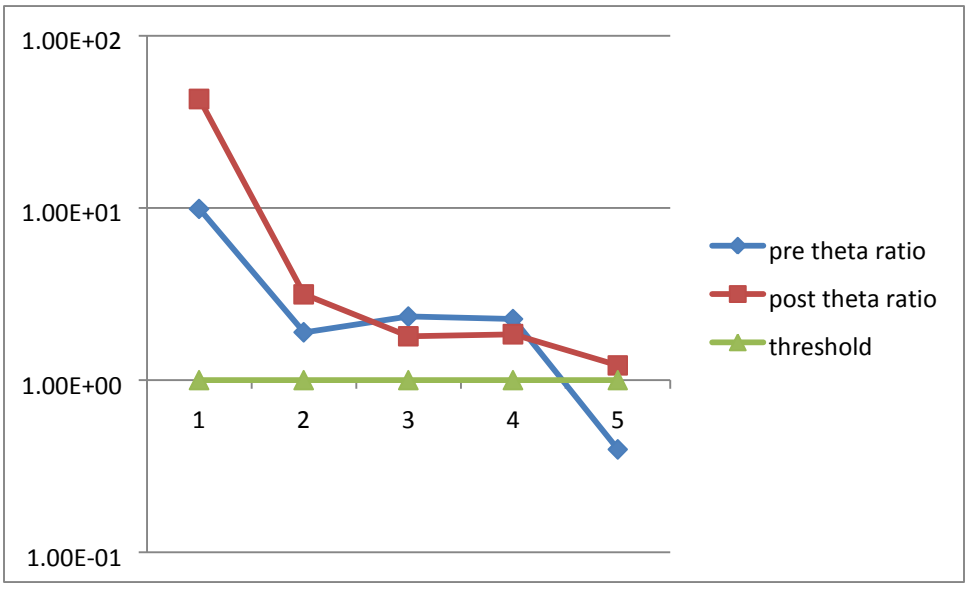

Figure 7.56:F3 theta (4-8Hz) ratio working memory task

From figure 7.56 it is inferred that theta band of F3 does not represent so good results (i.e. increasing) as expected but acceptable in pre-post comparison for working memory task. Results are also verified statistically using t-Test. For F3 t-Test value is p=0.178304.Therefore it is concluded from this pilot study that F3 increases in working memory test, which is evident from the figure

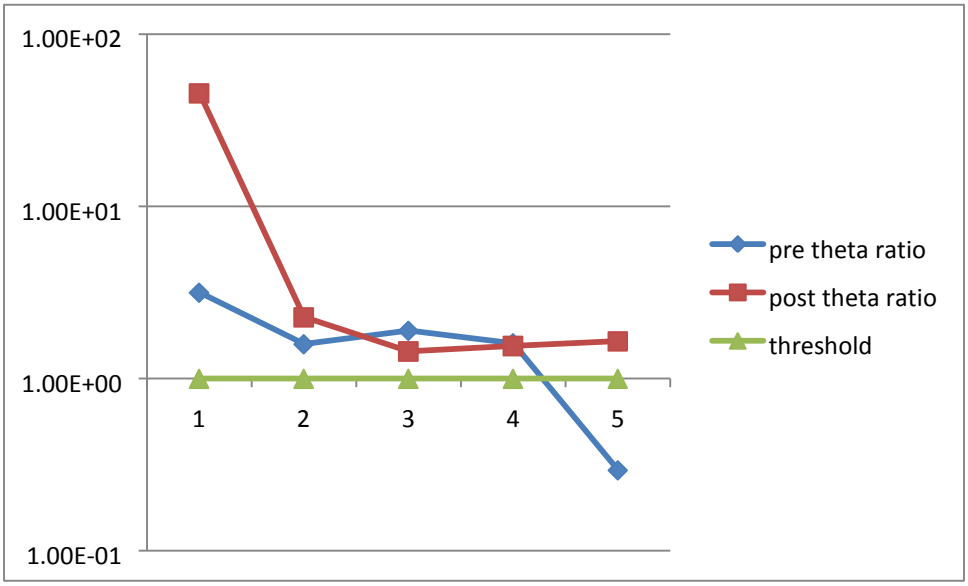

Figure 7.57:F4 theta (4-8Hz) ratio working memory task

From figure 7.57 it is inferred that theta band of F4 does not represent so good results (i.e. increasing) as expected but acceptable in pre-post comparison for working memory task. Results are also verified statistically using t-Test. For F4 t-Test value is p=0.177515Therefore it is concluded from this pilot study that F4 increases in working memory test, which is evident from the figure.

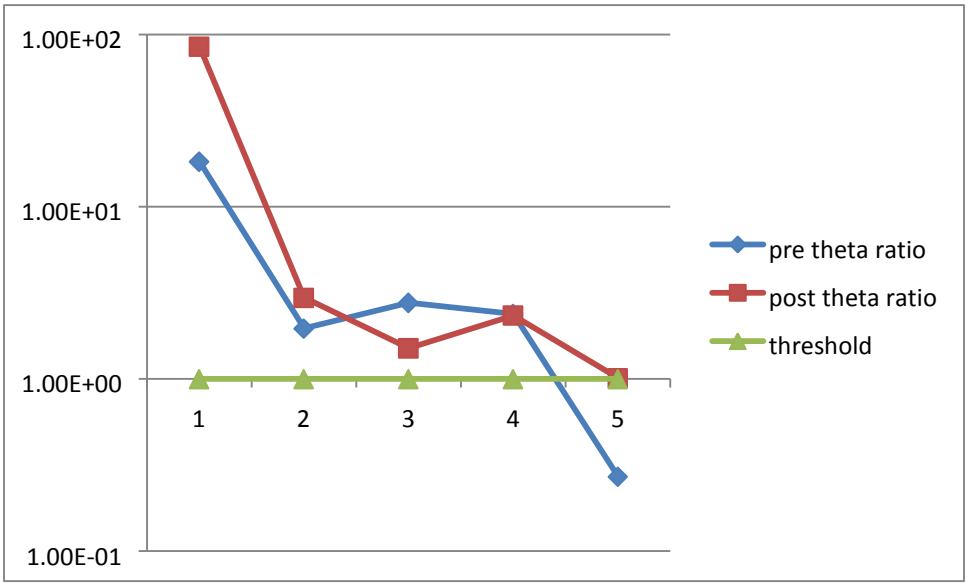

Figure 7.58:F8 theta (4-8Hz) ratio working memory task

From figure 7.58 it is inferred that theta band of F8 does not represent so good results (i.e. increasing) as expected but acceptable in pre-post comparison for working memory task. Results are also verified statistically using t-Test. For F8 t-Test value is p=0.1853. Therefore it is concluded from this pilot study that F8 increases in working memory test, which is evident from the figure.

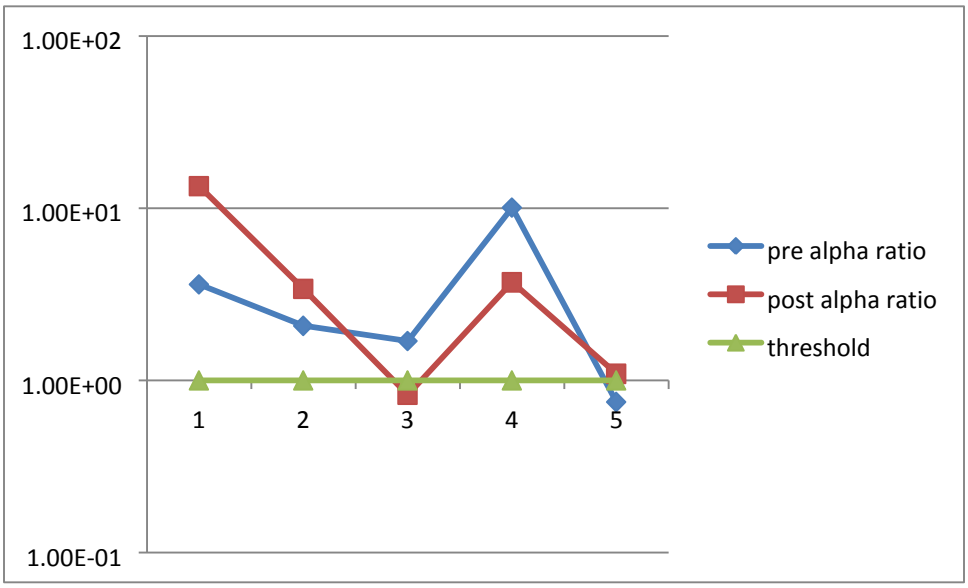

Figure 7.59:Fp2 alpha (8-13Hz) ratio working memory task

From figure 7.59 it is inferred that alpha band of Fp2 does not increase as expected in pre-post comparison for working memory task. Results are also verified statistically using t-Test. For Fp2 t-Test value is p =0.379956.No conclusion is drawn from this result as value of p is very large then 0.05.

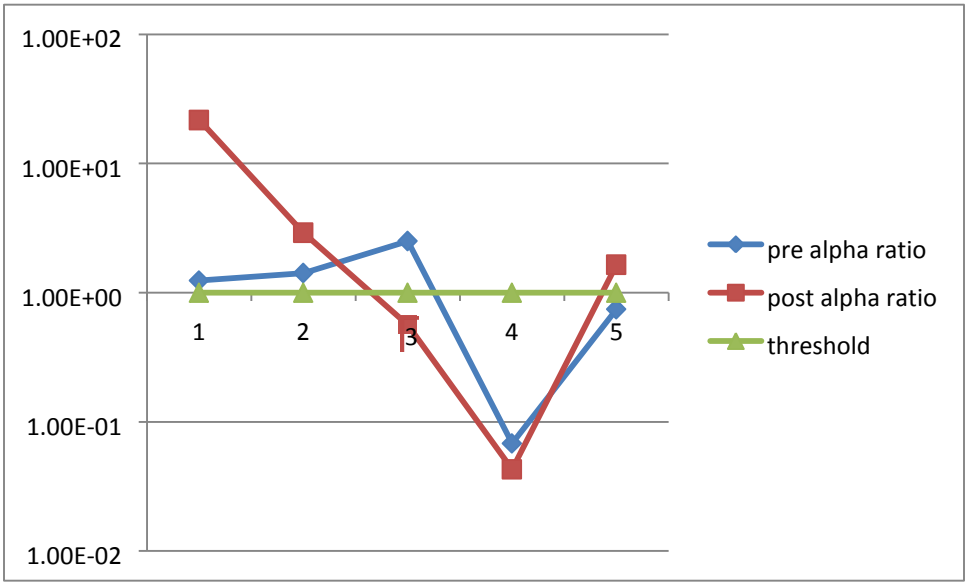

Figure 7.60:O2 alpha (8-13Hz) ratio working memory task

From figure 7.16 it is inferred that alpha band of O2 does not represent so good results (i.e. increasing) as expected but acceptable in pre-post comparison for working memory task. Results are also verified statistically using t-Test. For O2 t-Test value is p= 0.183655. Therefore it is concluded from this pilot study that O2 increases in working memory test, which is evident from the figure.

7.2.2 Task oriented assessment

As observed from the data, the error for post intervention gets reduced during attention test (go-no-go) as compared to the pre intervention session. That is, the error during post session of go-no-go comes out to be 0.0175 and that of pre session is 0.018261. Also, it is inferred that memory span increases during post intervention test for working memory (D-span) as compared to the pre intervention session. The value of memory span is calculated to be 9.2 during post session and in that of pre session it comes out to be 8.6.

CHAPTER 8 CONCLUSION AND FUTURE SCOPE

8.1 Conclusion

Cognitive abilities of an individual can be assessed by two methods, task oriented assessment and physiological assessment. Physiological signals of EEG stand verified as reported by other researchers, namely, alpha power decreases and beta power increases of the EEG signal while the subject is indulged in a task involving attention. Also, alpha power and theta power increase while the subject does a working memory task. There exists a correlation between changes in physiological signals of EEG and performance scores obtained during the task. Most importantly, cognitive assessment made before and after mediation for two weeks indicates an enhancement in both the cognitive abilities, i.e., attention and working memory. It can safely be concluded that spending some time and effort to meditate definitely improves the performance in life at gross materialistic level

too, apart from giving the spiritual benefits. Meditation thus brings not only the inner peace, but it brings prosperity too.

8.2 Future Scope

It is suggested to increase the number of subjects in future in this research. Also, there should be one control group which does not involve in any sort of intervention so that the results can be compared. The study may involve the effect of meditation on other cognitive abilities like motor speed, reaction time, fatigue, etc.

CHAPTER9
CHECK FOR ORIGINALITY

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http://www.paperrater.com/plagiarism_checker

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