

# Cognitive Enhancement using meditation as intervention

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## Abstract

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 meditation, odor, and video games etc.. The objective of this article is to review effect of meditation on brain functioning. EEG based improvements in cognitive abilities like attention and working memory using custom designed meditation is proposed.

## Key words

Meditation, Cognitive Enhancement, attention, working memory, other cognitive abilities

## 1. Meditation

### 1.1 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 [1]. 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* [2]. Meditation is derived from *meditatio*, meaning to think, contemplate, devise, and ponder [3]. 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 meditation is of pre-historical origin. The history of meditation is closely bound up with the religious context with in which it was practiced []. Some of the earliest references to meditation are found in the Hindu Vedas during the Vedic period (Iron Age India) [4]. Around 6<sup>th</sup> to 5<sup>th</sup> centuries Before the Common Era (BCE), other forms of meditation developed are Buddhist in India and Taoist in China.

### 1.2 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 [5]. It is broadly classified into two types: mindfulness and concentrative, depending upon how the attentional processes are directed. Most of meditation techniques lie somewhere in-between the poles of these two general methods [6-7].

#### 1.2.1 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 [8]. 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.

### **1.2.2 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 [5]. 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 meditations, 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' [9].

### **2. 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 an 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. Difference between transcendental and concentrative meditation**

Transcendental meditation is broadly included in concentrative meditation. Unlike most of the mantra meditations (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[9-10]. 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.

### **4. 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 [11]. It is also used in medical care. A US study for example, showed that a short course of behaviour modification strategies that include meditation led to significant fewer visits to physicians [12]. Another study on insurance statistics showed that the use of medical care was significantly less for meditators as compare to non meditators [13].

### **5. Cognitive abilities and their assessment**

All the brain base skills are cognitive abilities. There are various cognitive abilities like memory, attention, language, visual and spatial processing, logic and reasoning interpersonal skills, intrapersonal skills etc. [14]. Cognitive abilities are assessed to determine level of cognitive functioning of brain it is known as cognitive assessment. Cognitive assessment techniques are broadly divided into two ways: task oriented and physiological oriented. In task oriented assessment certain standard batteries like PEBL are used for assessing various cognitive abilities and in physiological assessment of cognitive abilities EEG, ECG, FMRI etc are used [15].

## **6. Interventions for cognitive enhancement**

Cognitive enhancement may be defined as amplification of cognitive abilities of brain. To bring this improvement some sort of intervention is necessary. Cognitive enhancement techniques are broadly classified as conventional and unconventional. Conventional techniques include education, mental training, enrich environment as well as use of external information processing devices. Unconventional techniques include drugs, gene therapy etc. [14].

## **7. Cognitive enhancement using meditation 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 of 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.

### **7.1 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 after practicing meditation.

#### **7.1.1 Mindfulness Meditation for Attention Enhancement**

**Randy J. simple** studied the effect of Benson technique, which is mindfulness meditation 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 is 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 mindfull 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. [16].

**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 group 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 [17]

**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 is 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 [18].

**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 [19].

### **7.1.2 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 [20].

**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; 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 [21].

## **7.2 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.

### **7.2.1 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 [22].

**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 reading-comprehension scores and working memory capacity while simultaneously reducing the distracting thoughts (mind wandering) [23].

**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 [24].

### **7.2.2 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 [25].

### **7.3 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.

#### **7.3.1 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 was considered as meditators group that performed meditation for 10 days; second group was considered as 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 [26].

**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 [27].

**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 their 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 [28].

### **7.3.2 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 non-meditators. 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 [29].

**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 delayed-start 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 post-tests that there was significant increases in Brain Integration Scale scores for Immediate-start 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 [30].

**V.K Sharma** et al. studied the effect of Sahaja yoga on cognitive functions like visuo-motor 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 [31].

### **Conclusion**

Meditation practices are prevalent since time immemorial. Apart from the spiritual benefits of meditation which take place at very suitable level, positive cognitive enhancements which can be quantified using scientific methods have also been reported worldwide. Meditation techniques like Sahaj yoga, Sudarshan Kriya, Zen meditation etc. result in enhancement of cognitive abilities like attention, working memory, visuo- spatial

attention etc.. It can be safely concluded the spending same time and effort to meditate will definitely improve the performance in life at gross materialistic level too. Not only meditation brings in the inner peace, it bring prosperity too. This article may be recommended to those scientific researchers who scoff at meditation as waste of time.

#### **Proposed work**

Effect of meditation on selected cognitive abilities like attention and working memory will be studied on healthy young engineering students. A custom designed meditation shall be used for fifteen days as a pilot study. Performance on attention and working memory task shall be monitored using Go/No-go task and D-Span tasks respectively. EEG shall be acquiring using MP150 Biopac system using standard 10-20 system. Alpha and beta band power shall be maintained in case of attention task, while theta and alpha band powers shall be maintained during working memory task.

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