

**PSYCHOPHYSIOLOGICAL EFFECTS OF TWO MEDITATIVE STATES  
DESCRIBED IN YOGA TEXTS**

*Thesis submitted by*  
**RAGHAVENDRA BHAT**

*Towards the partial fulfillment of*  
**DOCTOR OF PHILOSOPHY (YOGA)**  
**DECEMBER 2012**



**SWAMI VIVEKANANDA YOGA ANUSANDHANA SAMSTHANA**  
(Declared as Deemed University under Section 3 of the UGC Act, 1956)  
**BANGALORE - 560 019**  
**INDIA**

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By

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## **D E C L A R A T I O N**

I, hereby declare that this study was conducted by me at Swami Vivekananda Yoga Anusandhana Samsthana (S-VYASA), Bengaluru, under the guidance of Dr. Shirley Telles, Hon. Prof, S-VYASA University Bengaluru and Dr. H. R. Nagendra, Vice-chancellor, S-VYASA University Bengaluru.

I also declare that the subject matter of my thesis entitled PSYCHOPHYSIOLOGICAL EFFECTS OF TWO MEDITATIVE STATES DESCRIBED IN YOGA TEXTS has not previously formed the basis of the award of any degree, diploma, associate-ship, fellowship or similar titles.

Date:

Place: Bengaluru

**Raghavendra Bhat**

(Candidate)

## A C K N O W L E D G E M E N T

I would like to express the deepest gratitude to my guides, Dr. Shirley Telles and Dr. H.R. Nagendra for their guidance and encouragement. They are my mentors and I am unable to express their contribution in my development through words.

I thank Dr. Naveen K.V., Dr. Manjunath N.K., Dr. R. Nagarathna, Prof. Ramachandra Bhat, and Dr. Ravi Kulkarni for their guidance and support.

I sincerely acknowledge the Indian Council of Medical Research for funding this project.

I thank all the members of the faculty, Deputy Registrar Dr. Ravikumar Itagi and my colleagues and friends Dr. Subramanya, Dr. Balaram, Suhas, Deepesh, Ragavendrasamy and Basavaraj for their help at different stages of this work. Also, I would like to thank all the participants involved in my research as subjects.

I will be always grateful to my university Swami Vivekananda Yoga Anusandhana Samsthana (S-VYASA) for its support in promoting my research career.

I am indebted to my parents for their inspiration, love and support.

Finally I thank that unseen Divine without whose wish, this work wouldn't have been possible.

Date:

Place: Bengaluru

**Raghavendra Bhat**

**STANDARD INTERNATIONAL TRANSLITERATION CODE USED TO  
TRANSLITERATE SANSKRIT WORDS**

a	=	अ	ña	=	ढ	pa	=	प
ā	=	आ	ca	=	च	pha	=	फ
i	=	इ	cha	=	छ	ba	=	ब
ī	=	ई	ja	=	ज	bha	=	भ
u	=	उ	jha	=	झ	ma	=	म
ū	=	ऊ	ñ	=	ञ	ya	=	य
ṛ	=	ऋ	ṭa	=	ट	ra	=	र
ṝ	=	ॠ	ṭha	=	ठ	la	=	ल
e	=	ए	ḍa	=	ड	va	=	व
ai	=	ऐ	ḍha	=	ढ	śa	=	श
o	=	ओ	ṇa	=	ण	ṣa	=	ष
au	=	औ	ta	=	त	sa	=	स
m̐	=	अं	tha	=	थ	ha	=	ह
ḥ	=	अः	da	=	द	kṣa	=	क्ष
ka	=	क	dha	=	ध	tra	=	त्र
kha	=	ख	na	=	न	jña	=	ज्ञ
ga	=	ग						
gha	=	घ						

## ABSTRACT

### BACKGROUND

In ancient yoga texts, there are two meditative states described. One is *dhāraṇā*, which requires focusing, the second is *dhyāna*, during which there is no focusing, but an expansive mental state is reached. The earlier study on changes in brainstem auditory evoked potentials following four mental states described in yoga texts viz., *cañcalatā* (random thinking), *ekāgratā* (focusing without meditation), *dhāraṇā* (focused meditation) and *dhyāna* (meditative defocussing or effortless meditation) showed significant increase in wave V peak latency during *cañcalatā*, *ekāgratā* and *dhāraṇā* but not in *dhyāna* (Kumar et al., 2010). The results suggest that *dhyāna* practice alone does not delay auditory information transmission at the brainstem level, whereas *cañcalatā*, *ekāgratā* and *dhāraṇā* showed delay in auditory information processing at the inferior collicular level since the wave V corresponds to that level. Another study assessed the performance in a cancellation task at the beginning and end of the four types of session viz., *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna* (Kumar & Telles, 2009). The performance in cancellation task improved significantly after *dhāraṇā* and was worse after *cañcalatā*, suggesting better attention after *dhāraṇā*. The changes in mid-latency auditory evoked potentials during these four mental states have not been studied.

## **AIM AND OBJECTIVES**

The present study was intended to study psychophysiological changes following two meditative states described in yoga texts. The objectives of the study were to investigate the effect of *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* on: (i) Mid-latency auditory evoked potentials (MLAEPs), (ii) Performance in the d2 test of attention, (iii) Performance in the digit symbol substitution test (DSST), and (iv) Subjective assessment of following the guided instructions for *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* using visual analog scale.

## **METHODS**

### **Participants**

Sixty male volunteers with ages ranging from 17 to 38 years were studied. They were all students at a yoga University in South India. They had a minimum of 6 months of experience in meditation on Om (group average experience  $\pm$  SD, 20.95 $\pm$ 14.21 months).

### **Design**

For Mid-latency auditory evoked potentials, each participant was assessed in four sessions. Two of them were meditation sessions (*dhāraṇā* and *dhyāna*) and two of them were non-meditation sessions (*ekāgratā* and *cañcalatā*). All four sessions consisted of 3 states: pre (5 minutes), during (20 minutes), and post (5 minutes). Assessments were made on four different days, which were not necessarily on consecutive days, but at the same time of the day. The allocation of participants to the four sessions was random using a standard random number table. For Performance in

attentional tasks [i.e., (a) d2 test of attention and (b) digit symbol substitution test], each participant was assessed before and after the practice of *dhāraṇā* and *ekāgratā*. A visual analog scale was given immediately after the practice of *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* session.

### **Assessments**

- (i) Mid-latency auditory evoked potentials (MLAEPs) recorded at Cz electrode site referenced to linked earlobes (A1-A2), using the Nicolet Bravo system (Nicolet Biomedicals, U.S.A.)

*MLAEPs have been used to assess cortical and subcortical changes.*

- (ii) D2 test of attention

*The d2 test is a timed test of selective attention and concentration.*

- (iii) Digit symbol substitution test

*The digit symbol substitution test is a subset of the Wechsler Adult Intelligence Scale-Revised (WAISR) administered using paper and pencil. It measures sustained attention, response speed, and visuo-motor coordination.*

- (iv) Visual analog scale

*The ability to follow the guided instructions for *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* was measured using the visual analog scale.*

### **Intervention**

Throughout all the sessions, participants sat cross-legged and kept their eyes closed and followed the prerecorded instructions.

### ***Cañcalatā (Random thinking)***

Participants were asked to allow their thoughts to wander freely as they listened to a compiled audio CD consisting of brief periods of conversation, announcements, advertisements, and talks on multiple topics recorded from a local radio station transmission. All these conversations were unconnected and were believed to induce a state of random thinking.

### ***Ekāgratā (Focusing without meditation)***

Participants listened to a prerecorded lecture on meditation. This was not about meditation, on the Sanskrit syllable Om, but about meditation, in general. It was speculated that listening to a lecture on a particular topic could induce the state of non-meditative focused thinking.

### ***Dhāraṇā (Focused meditation)***

Participants were asked to follow the audio instructions for the practice of *dhāraṇā*. The meditative focusing on the Sanskrit syllable Om consisted of mental visualization of the symbol Om. *Dhāraṇā* involves conscious effort to keep the thoughts restricted to those given in the instructions.

### ***Dhyāna (Meditative defocusing or effortless meditation)***

Participants were asked to follow the audio instruction for the practice of *dhyāna*. They were supposed to absorb with the object of meditation without any effort. *Dhyāna* involves effortless defocusing induced by mental chanting of Om.

## **Data analysis**

### **(i) Mid-latency auditory evoked potentials (MLAEPs)**

Statistical analysis was done using SPSS (version 16.0). Data were tested for normality by the Kolmogorov-Smirnov test. Since the same individuals were assessed in repeat sessions on separate days (ie, *cañicalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*), repeated measures analyses of variance (ANOVAs) were performed with 2 within-participant factors, that is factor 1: sessions; *cañicalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* and factor 2: states; “pre,” “during” (Dur1 to Dur4), and “Post.” Repeated measures ANOVAs were carried out for each wave of MLAEPs separately, for both peak latencies and peak amplitudes. This was followed by post hoc analyses with Bonferroni adjustment for multiple comparisons between the mean values of different states (during and post), and all comparisons were made with the respective pre state.

### **(ii) Performance in attentional tasks [i.e., (a) d2 test of attention and (b) Digit symbol substitution test]**

Since the same individuals were assessed in repeat sessions on separate days (i.e., *ekāgratā* and *dhāraṇā*), repeated measures analysis of variance was used (ANOVA). Repeated measures analysis of variance (ANOVA) were performed with two 'within subjects' factors, i.e., Factor 1: Sessions; *ekāgratā* and *dhāraṇā* and Factor 2: States; “Pre”, and “Post”. This was followed by a post-hoc analyses with Bonferroni adjustment comparing ‘pre’ with ‘post’ values.

### **(iii) Visual analog scale**

Repeated measured analysis of variance (ANOVA) was performed with one 'within subjects' factor, i.e., sessions: *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*.

This was followed by a *post-hoc* analysis with a Bonferroni adjustment for multiple comparisons between the mean values of different sessions.

## **RESULTS AND DISCUSSIONS**

### **(i) Mid-latency auditory evoked potentials [MLAEPs]**

Mid-latency auditory evoked potentials were assessed in 60 participants during *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*. During *dhyāna*, latencies of 2 MLAEPs components, the Na and Pa waves were prolonged, suggesting that auditory information transmission at the level of the medial geniculate and primary auditory cortex (i.e., the neural generators corresponding to the Na and Pa waves) was delayed. Hence, meditation influenced MLAEPs, while meditative focusing did not.

### **(ii) Performance in attentional tasks [i.e., (a) d2 test of attention and (b) digit symbol substitution test]**

In the present study, sixty male volunteers were assessed in the d2 test of attention and digit symbol substitution test after *dhāraṇā* and *ekāgratā*. After both types of focusing, there was a significant improvement in all measures of the d2 test of attention (TN, E, TN-E, E%, and CP). However, the performance in the digit symbol substitution test was better after *dhāraṇā* but did not change after *ekāgratā*.

### **(iii) Visual analog scale**

The study was conducted to assess the self-rated ability to follow the instructions to achieve the four mental state's viz., *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna* using a visual analog scale. The results showed that following *dhāraṇā*, scores on the visual analog scale were significantly lower compared to those for *cañcalatā*, *ekāgratā* and *dhyāna*.

### **CONCLUSION**

The present study showed an increase in the peak latency of Na and Pa waves during *dhyāna* which suggests an increase in information processing time at the level of medial geniculate and primary auditory cortex. Following *dhāraṇā*, there was an improvement in performance on all measures of the d2 test of attention (TN, E, TN-E, E%, and CP) and in the digit symbol substitution test. The results suggest that, *dhāraṇā* is associated with better attention, incidental learning, and better accuracy. Subjective assessment about the ability to follow guided instructions showed that *dhāraṇā* is the most difficult state compared to the *cañcalatā*, *ekāgratā* and *dhyāna* states.

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**CHAPTER – 1.0**  
**INTRODUCTION**

## 1.0 INTRODUCTION

The practice of meditation has become increasingly popular all over the world in the last few decades. Positive physiological and psychological changes following meditation are supported by the number of research studies (Cahn & Polich, 2006; Keng et al., 2011). Meditation has been defined as a training in awareness, which when practiced over a period of time improves perception, attention, and cognition (Brown, 1977). Meditation is also recognized as a specific consciousness state in which deep relaxation and increased internalized attention exist at the same time (Murata et al., 2004).

The well-known meditation techniques are Transcendental Meditation, Zazen meditation, Anandamarga meditation, Brahmakumaris Raja Yoga meditation, Sahaja Yoga meditation, Vipassana meditation, Om meditation and Cyclic Meditation. All these meditation techniques are derived within last 300 years. All these practices are intended to have a common end result (viz., a calm, yet alert mind). This is supported by research from the late 1960s, since when there have been investigations on the effects of meditation in experienced as well as inexperienced meditators.

In certain cases meditators practicing the same technique showed the opposite trend of results, specifically for the recordings of electroencephalogram (EEG) and autonomic variables. Some studies reported reduced sympathetic activity during meditation, whereas other studies reported increased sympathetic activity. Particularly, for three meditation techniques, the results appeared suggestive of both increased arousal (in some cases) and reduced arousal (in others). These are Transcendental Meditation, Zazen meditation, and Anandamarga meditation.

Early study on Transcendental Meditation showed a decrease in oxygen consumption, reduced heart and breath rates, lower blood lactate levels, and an increase in slow alpha and occasional theta in the EEG after 20 minutes of practice, suggestive of a quietening effect (Wallace, 1970). In fact most of the studies on Transcendental Meditation showed increase in autonomic stability and sympathetic withdrawal (Orme-Johnson, 1973). In addition, a meta-analysis of 31 studies carried out to evaluate the effect of meditation on reducing somatic arousal (Dillbeck & Orme-Johnson, 1987). The studies showed reduced somatic arousal with some physiological changes suggestive of increased alertness. A study on long term Transcendental Meditators showed increased alertness (Lang et al., 1979). The findings contradict the idea that meditation is simply a state of reduced sympathetic activity but supports the idea of it being a “calm yet alert” state.

Similar findings (increased as well as decreased arousal) were also reported for the eyes open, Zazen meditation. An increase in heart rate during Zazen meditation was reported by Hirai (Hirai, 1960), whereas Sugi and Akatsu reported a decrease in oxygen consumption in Zazen meditators (Sugi & Akatsu, 1968). Hence, the first report was suggestive of activation while the second report was suggestive of relaxation.

Similarly, two reports were also found in Anandamarga meditation, which is a tantric meditation and involves intense concentration. One study reported an increase in autonomic activation and decreased autonomic orienting to external stimulation in advanced meditators (Corby et al., 1978). Another study showed an increase in

galvanic skin resistance, a decrease in breath rate, and a more stable EEG during Ananda Marga meditation (Elson, Hauri & Cunis, 1977).

Hence, these early research studies on different meditation techniques could not present a single model of meditation as either activating or relaxing. However, these studies could substantiate the idea that, the meditation is a state of ‘alertful rest’.

An effort was made to classify all the meditation techniques in two main styles, based on how attention is directed (Lutz et al., 2008). The first category is called focused attention (FA), during which attention is sustained and focused on a chosen object. The second category is called open monitoring (OM), which is featured by non-reactive monitoring of the content of experience from moment to moment. More recently, the third category of meditation was also proposed (Travis & Shear, 2010). This is called “automatic self-transcending” which includes techniques intended to transcend their own activity.

These modern classifications of meditations are somewhat similar to the descriptions in the ancient yoga texts. In Patañjali’s *Yoga Sūtras* (Circa 900 B.C.), there are two meditative states described, one leading to the other (Taimini, 1986). The first stage is *dhāraṇā* or meditative focusing, confining the mind within a limited mental area (Patañjali’s *Yoga Sūtras*, III.1). The next stage is *dhyāna* or effortless meditation (Patañjali’s *Yoga Sūtras*, III.2), which is characterized by the uninterrupted flow of the mind towards the object chosen for meditation. The practice of *dhāraṇā* is supposed to precede *dhyāna*. *Dhāraṇā* and *dhyāna* may be considered as the last two of the four stages, which form a continuum in the process of gaining

mastery over the mind. The first two stages are initial phases of mind training described in another ancient Indian text the *Bhagavad Gītā* (Sarasvati & Swami, 1998). The first stage is *cañcalatā* (random thinking) which is featured by multiple subjects and multiple thoughts. The second stage is *ekāgratā*, during which the attention is directed to a series of associated thoughts.

An effort was made to assess the changes in brainstem auditory evoked potentials in thirty male volunteers following four mental states described in yoga texts viz., *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* (Kumar et al., 2010). The results showed an increase in the peak latency of wave V during *dhāraṇā*, *ekāgratā*, and *cañcalatā* sessions, whereas no change during *dhyāna*. The results suggest that *dhyāna* practice alone does not delay auditory information transmission at the brainstem level, whereas *cañcalatā*, *ekāgratā* and *dhāraṇā* showed delay in auditory information processing at the inferior collicular level since the wave V corresponds to that level.

Another study assessed the changes in autonomic and respiratory variables in thirty healthy male volunteers following *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* (Telles et al., 2012). The results suggest that, during *dhyāna* all the changes were suggestive of reduced sympathetic activity and/or increased vagal modulation.

The performance in a cancellation task was compared in seventy normal healthy male volunteers at the beginning and end of the four types of sessions viz., *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* (Kumar & Telles, 2009). Letter cancellation

task assess selective attention and concentration (Uttl & Pilkenton-Taylor, 2001). The performance in cancellation task significantly improved after *dhāraṇā* and was worse after *cañcalatā*, suggesting better attention after *dhāraṇā*. However, other aspects of attention have not been studied following these four mental states.

There have been no study comparing the four mental states using mid-latency auditory evoked potentials. Hence, the present study was planned to assess the changes in mid-latency auditory evoked potentials in normal healthy volunteers before, during and after the four types of sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā*, *dhyāna*) on separate days. And also, performance in attentional tasks were also studied before and after the practice of *ekāgratā* and *dhāraṇā*. These four mental states are descriptions from the ancient yoga texts and studying them was hoping to increase the understanding about meditation including differences seen in earlier studies.

## CHAPTER – 2.0

# LITERARY RESEARCH ON MEDITATION

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## 2.0 LITERARY RESEARCH ON MEDIATION

### 2.1 BACKGROUND AND SCOPE

The word meditation is derived from the Latin word *meditari*, meaning "to think", "contemplate", "devise", or "ponder". Today, meditation has become extremely popular all over the world. In general, most of the time it has been used to reduce stress, to promote wellness and healing. There are more than 2500 research studies available on meditation. In the last 200 years, different meditation techniques are derived from the traditional yoga texts and promoted by the Yoga masters and spiritual leaders. Although the ultimate goal of meditation is same (calming the mind) the paths are different. However, in the West, meditation is considered as a relaxation technique or technique to promote wellness and healing.

Meditation is a distinct practice in Indian philosophy and it is mentioned in many Indian traditional texts. The first description of meditation occurs in *Vedas* which is one of the oldest scripture of Hindu culture. Meditation was a part of daily life and known to everyone during *Vedic* age. Recently, the archeologists have discovered the sculptures in meditative pose in the ancient civilization, Mohenjo-Daro and Harappa. Specific meditation techniques have been developed for the convenience in the later period. Meditation has been expounded in *Vedas*, *Upaniṣad*, *Bhagavad Gītā*, *Patañjali Yoga Sūtra*, *Haṭha Yoga Pradīpikā*, and *Tantra* texts. Meditation was considered as *upāsana* and practiced by everyone during the *vedic* age. The *Upaniṣads* emphasis on self-analysis through intellect, and establishing the mind on Self. Lord Kṛiṣṇa in *Bhagavad Gītā* says, 'meditate on the Supreme Self by directing all the

senses towards inside using the intellect'. Perhaps, the most profound description of meditation is found in Patañjali Yoga *Sūtra*. Sage Patañjali describes *aṣṭāṅga* yoga (eight limbs of yoga) to realize the ultimate. The sixth and the seventh limb of *aṣṭāṅga* yoga are pertaining to meditation. Haṭha Yoga gives the description of the practice of meditation and its benefits. *Tantra* presents 112 of meditation techniques to realize the ultimate.

In Patañjali Yoga *Sūtra* (PYS), ancient Indian yoga text (Circa 900 B.C.), there are two meditative states described (Taimini, 1986). Sage Patañjali lays out eight stages of yoga in Yoga *Sūtras* (aphorisms). These are (i) *yamās* (social discipline) (ii) *niyamās* (self-discipline) (iii) *āsanas* (physical postures), (iv) *prāṇāyāmas* (voluntarily regulated breathing), (v) *pratyāhāra* (withdrawal, particularly from external sensations), (vi) *dhāraṇā* (focused meditation), (vii) *dhyāna* (defocused meditation or effortless meditation), and (viii) *samādhi* (an experience of transcendence or ultimate realization). The sixth and seventh stages are pertaining to meditation. *Dhāraṇā* (focused meditation), is defined as confining the mind within a limited mental area (PYS 3.1). The next stage is *dhyāna* (effortless meditation or defocused meditation) (PYS 3.2) which is characterized by the uninterrupted flow of the mind towards the object chosen for meditation. *Dhāraṇā* and *dhyāna* may be considered as the last two of four stages, which form a continuum in the process and practice of meditation. The first two stages are described in another ancient Indian text

the *Bhagavad Gita* (Sarasvati & Swami, 1998). The first stage is *cañcalatā*, which is a stage of random thinking. The second stage is *ekāgratā*, during which the attention is directed to a series of associated thoughts.

The present compilation was aimed at collecting the authentic information about the four mental states viz., *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* to classify all the modern derived meditation techniques in to two meditative states (*dhāraṇā* and *dhyāna*).

## 2.2 SUMMARY OF EARLIER WORKS ON MEDITATION

The concept of mind has been discussed in the earlier PhD thesis from S-VYASA, Bengaluru, India (Naveen, 2005; Patil, 2007; Pailoor, 2009; Kumar, 2009). Concept of mind in the yoga philosophy is somewhat different from modern psychology. Mind is a conglomeration of thoughts (Nagendra, 2004). According to yoga, mind has four components (*antaḥkaraṇa*). These are the *manas* (mind), the *buddhi* (intellect), the *ahaṅkāra* (ego) and the *citta* (memory). The *manas* is that which wavers, the *buddhi* is decisive, the *ahaṅkāra* is the creator of the sense of I, and the *citta* is that which makes us cognitive.

संकल्पविकल्पात्मकं मनः । निश्चयात्मिका बुद्धिः । अहंकर्ता अहंकारः । चिन्तनकर्तृ चित्तम् ।

*Saṅkalpavikalpātmakam manaḥ | Niścayātmikā buddhiḥ. Ahaṅkartā  
ahaṅkāraḥ. Cintanakartṛ cittam.*

(Tattvabodha, Ch: 35, V:1)

The concept of Om meditation and its benefits were described in the earlier PhD thesis (Kumar, 2009). Om is the name or symbol of God (*Īśvara, Brahman*) described in *Kaṭha Upaniṣat* (Cinmayānanda, 2002). Om covers the whole three-fold experience of man. It is the combination of three letters, namely, A, U, and M. “A” represents the physical plane. “U” represents the mental and astral plane, the world of intelligent spirits, and all heavens. “M” represents the whole deep-sleep state, which is unknown even in our wakeful state *Māṇḍūkya Upaniṣat* (Cinmayānanda, 1984). This concept has been well described in various Indian scriptures.

The concept of cyclic meditation in traditional texts has been covered in earlier PhD thesis (Patil, 2007; Pailoor, 2009). Cyclic meditation is based on the concept that a combination of both ‘calming’ and ‘stimulating’ measures help in reaching a state of mental equilibrium. It is derived from a statement in Sage *Gauḍapāda’s Māṇḍūkya Upaniṣad Kārikā*:

लये सम्बोधयेत् चित्तं विक्षिप्तं शमयेत् पुनः ।

सकषायं विजानीयात् समप्राप्तं न चालयेत् ॥३.४४॥

*Laye sambodhayet cittam vikṣiptam śamayet punaḥ,*

*Sakaṣāyam vijñānīyāt samaprāptam na cālayet. 3.44*

(*Māṇḍūkya Upaniṣad Kārikā: 3.44*)

**‘In a state of mental inactivity awaken the mind; when agitated, calm it; between these two states realize the possible abilities of the mind. If the mind has reached the state of perfect equilibrium then do not disturb it again’**

For the most persons the mental states while doing routine activities (not necessarily associated with yoga) is neither ‘inactive’ nor ‘excited’, but is somewhere

between these extremes and hence, a combination of ‘awakening and calming’ measures may be better suited to reach a balanced, relaxed state. The above mentioned idea drawn from the traditional texts is the basis for this *yoga* practice called ‘*Cyclic Meditation*’.

Another PhD thesis on meditation compiled the brief information on *dhāraṇā*, *dhyānā*, *samādhi* and comprehensive descriptions of stages of *samādhi* (Naveen, 2005). *Dhāraṇā*, *dhyānā*, *samādhi* taken together constitute *śamīyama*. Two main categories of *samādhis* are (i) *samprajñāta samādhi* and (ii) *asamprajñātā samādhi*. *Samprajñāta samādhi* means *samādhi* with *prajñā*, where the *prajñā* stands for higher consciousness working through the mind in all its stages. *Asamprajñātā samādhi* is therefore not *samādhi* without *prajñā* but a state associated with *prajñā* yet different from *samprajñāta samādhi*.

### 2.3 AIM AND OBJECTIVES

- To compile the authentic information on *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*.
- To classify all the modern derived meditation techniques based on the description in traditional texts.

## 2.4 MATERIALS AND METHODS

### 2.4. A - Source material

The compilation reviewed all the traditional yoga texts and spiritual lore.

- I. Upaniṣads
- II. Patañjali yoga *Sūtras*, Vyāsa *Bhaṣya* and Yoga *Vārtikā* on Patañjali yoga *Sūtras*
- III. Bhagavad Gītā,
- IV. Yoga Vāsiṣṭha
- V. Haṭha Yoga Pradīpikā,
- VI. Tantra texts

### 2.4. B Methods

The above mentioned traditional texts were studied to compile the authentic information on meditation. The verses related to the present topic were collected and compiled and presented in a systematic way. Based on the description in the traditional texts proper conclusion was derived.

## 2.5 STATES OF MIND

**The sage Vyāsa, in his commentary on the Yoga *Sūtras* of Patañjali, defines five planes of the mind (i.e. *cittabhūmi*). These are *kṣipta* (disturbed), *mūḍha* (dull), *vikṣipta* (distracted), *ekāgra* (one-pointed mind), and *niruddha* (mastered).**

**क्षिप्तं मूढं विक्षिप्तम् एकाग्रं निरुद्धम् इति चित्तभूमयः ।**

***Kṣiptam mūḍham vikṣiptam ekāgram nirudhdam iti cittabhūmayah***

### **1. *Kṣipta* (disturbed)**

The *kṣipta* mind is disturbed, restless, troubled, wandering. This is the least desirable of the states of mind, in which the mind is troubled. It might be severely disturbed, moderately disturbed, or mildly disturbed. It might be worried, troubled, or chaotic. It is not merely the distracted mind (*vikṣipta*), but has the additional feature of a more intense, negative, and emotional involvement.

### **2. *Mūḍha* (dull)**

The *mūḍha* mind is stupefied, dull, heavy and forgetful. With this state of mind, there is less of a running here and there of the thought process. It is a dull or sleepy state, somewhat like one experiences when depressed, though we are not here intending to mean only clinical depression. It is that heavy frame of mind we can get into, when we want to do nothing, to be lethargic. The *mūḍha* mind is barely beyond the *kṣipta*, disturbed mind, only in that the active disturbance has settled down, and the mind might be somewhat more easily trained from this place. Gradually the mind can be taught to be a little bit steady in a positive way, only occasionally distracted, which is the *vikṣipta* state. Then, the mind can move on in training to the *ekāgra* and *niruddha* states.

### **3. *Vikṣipta* (distracted)**

The *vikṣipta* mind is distracted, occasionally steady or focused. This is the state of mind often reported by meditators when they are wide awake and alert, neither noticeably disturbed nor dull and lethargic. In this state of mind, one's attention is

easily drawn here and there. The mind can concentrate for short periods of time, and is then distracted into some attraction or aversion. Then, the mind is brought back, only to again be distracted. *Vikṣipta* is better than *kṣipta* but in this state, there is concentration, because of a preponderance of the quality of *sattva* mind. However, it is a combination of *sattva* and *rajas*. This *vikṣipta* mind is the stance one wants to attain through the foundation yoga practices, so that one can then pursue the one-pointedness of *ekāgra*, and the mastery that comes with the state of *niruddha*.

#### **4. *Ekāgra* (one-pointed)**

The *ekāgra* mind is one-pointed, focused, concentrated when the mind has attained the ability to be one-pointed. It is lamp like mind which has its flame-tip in one object alone. Because of pure *sattva* the mind can stay steadily for a decided length of time, in one object alone, like a lamp placed in a windless place. The real practice of meditation begins with *ekāgra*. It means that one can focus on tasks at hand in daily life, practicing karma yoga, the yoga of action, by being mindful of the mental process and consciously serving others. When the mind is one-pointed, other internal and external activities are simply not a distraction. When mind is one-pointed, it is fully in present moment. The one-pointed mind is able to do the practices of concentration and meditation.

#### **5. *Niruddha* (mastered)**

The *niruddha* mind is highly mastered, controlled, regulated, restrained (Yoga *Sūtra* 1.2). When the word *niruddha* is translated as controlled, regulated, or restrained, it

can easily be misunderstood to mean suppression of thoughts and emotions. To suppress thoughts and emotions is not healthy and this is not what is meant here. Rather, it has to do with that natural process when the mind is one-pointed and becomes progressively more still as meditation deepens. It is not that the thought patterns are not there, or are suppressed, but that attention moves inward, or beyond the stream of inner impressions. In that deep stillness, there is a mastery over the process of mind. It is that mastery that is meant by *niruddha*. *Niruddha* state of mind is the goal and definition of Yoga. It is the doorway by which we go beyond the mind. Essentially, it is a state of mastery over the modifications of the mind. In this state, it has a capacity to think very deeply with fullest concentration on one hand and remain quiet for any length of time on the other hand.

### 2.5.1 *Cañcalatā* (Random thinking)

Mind always moves from one state to another state. Most of the time, it dwells either on the past or the future. The haphazard, unconnected, multiple thoughts are experienced most of the time. This randomness is very nature of mind. This random state of mind is called *Cañcalatā* state.

This has been mentioned in the Bhagavad Gita and presented in form of conversation between Lord *Kṛṣṇa* and Arjuna.

Arjuna says: चञ्चलं हि मनः कृष्ण प्रमाथि बलवद्दृढम् ।

तस्याहं निग्रहं मन्ये वायोरिव सुदुष्करम् ॥

*Cañcalam hi manaḥ kṛṣṇa pramāthi balavaddṛḍham*  
*Tasyāham nigraham manye vāyoriva suduṣkaram.*

(Bhagavad Gītā, Ch: 6 V: 34)

**The mind verily is, O Kṛṣṇa, restless, turbulent, strong and unyielding; I deem it quite as difficult to control as the wind.**

Arjuna experiences the restless mind. He feels mind cannot be controlled “as it ever turbulent, strong and unyielding”. The turbulence shows not only the speed in the flow of thoughts but also their restlessness and agitations, creating undulating waves rising on the surface. When turbulence becomes strong it is difficult to control and bring it back from its attachments. When mind has flickered in to any new channel of its own choice, for the moment, it is ‘unyielding’. He beautifully describes controlling the mind is as difficult than controlling the wind.

Lord *Kṛṣṇa* answers:

असंशयं महाबाहो मनो दुर्निग्रहं चलम् ।

अभ्यासेन तु कौन्तेय वैराग्येण च गृह्यते ॥

*Asaṁśayaṁ mahābāho mano durnigrahaṁ calaṁ'*

*Abhyāseṇa tu kaunteya vairāgyeṇa ca gṛhyate.*

(Bhagavad Gītā, Ch: 6 V: 35)

**Undoubtedly, O mighty-armed one, the mind is difficult to control and is restless; but, by practice, O Son of Kunti, and by dispassion, it is restrained.**

Lord *Kṛṣṇa* accepts the argument of Arjuna and answers that there is a method by which the invincible mind can be brought under control. He mentions *abhyāsa* (practice) and *vairāgya* (renunciation) as a method to control the mind.

Even the sage Patañjali also mentions *abhyāsa* and *vairāgya* as a means to control the mind.

अभ्यासवैराग्याभ्याम् तन्निरोधः ।

*Abhyāsavairāgyābhyām tannirodhaḥ |*

(Patañjali's Yoga Sūtras I.12)

**Their suppression by persistent practice and non-attachment**

तत्र स्थितौ यत्नोऽभ्यासः ।

*Tatra sthitau yatno 'bhyāsaḥ |*

(Patañjali's Yoga Sūtras I.13)

**Abhyāsa is the effort of being firmly established in that state (of Citta-Vrtti-Nirodha).**

According to Patañjali, *abhyāsa* is the all effort directed towards the attainment of that ultimate state, in which cessation of modifications of mind happens. He further says in the next sutra, *abhyāsa* should be uninterrupted and continuous with devotion.

दृष्टानुश्रविकविषयवितृष्णस्य वशीकारसंज्ञा वैराग्यम् ।

*Dr̥ṣṭānuśravikaviṣayavitr̥ṣṇasya vaśīkārasañjñā vairāgyam |*

(Patañjali's Yoga Sūtras I.15)

**The consciousness of perfect mastery (of desires) in the case of one who has ceased to crave for objects, seen or unseen, is vairāgya.**

*Vairāgya* plays an important role in gaining mastery over the mind. *Vairāgya* means the absence of any attraction towards objects which gives pleasure. Attraction and repulsion is a pair of opposites and repulsion binds the soul to the objects as much as attraction. The desire in its two expressions of *rāga* (attachment) and *dveśa* (repulsion) is a tremendous driving and disturbing force which is continuously creating *vṛttis* in the mind. Hence, one has to be free from both attraction and repulsion.

The sage Vasiṣṭha explains the fickleness of mind in the yoga *Vāsiṣṭha*.

चेतश्चञ्चलया वृत्त्या चिन्तानिचयचञ्चुरम् ।

धृतिं बध्नाति नैकत्र पञ्जरे केसरि यथा ॥

*Cetaścañcalayā vṛtṭyā cintānicayacañcuram ।*

*Dhṛtiṁ badhnāti naikatra pañjare kesari yathā । ।*

(Yoga Vāsiṣṭha; Ch: I; V: )

The mind, expert in its collection of sorrowful thoughts, does not fasten its hold on one place because of its fickle condition, as a lion in a cage.

चेतः पतति कार्येषु विगतः स्वामिषेष्विव ।

क्षणेन विरन्ति याति बालः क्रीडनकादिव ॥

*Cetaḥ patati kāryeṣu vigataḥ svāmiṣeṣviva ।*

*Kṣaṇena viranti yāti bālaḥ kṛīḍanakādiva । ।*

(Yoga Vāsiṣṭha; Ch: I; V: )

The mind descends on actions (or things) like a bird on its prey. It becomes indifferent in a moment like a child to a toy.

*Cañcalatā* state of mind is featured by (i) multiple subjects and multiple thoughts (ii) unconnected thoughts (iii) turbulent thoughts, and (iv) *rājasik* in nature.

### 2.5.2 *Ekāgratā* (Focusing without meditation)

The word *ekāgratā* refers to concentrated mind. In *Sanskṛta*, *ekāgratā* means concentration, the channelizing of all thoughts in a single direction. Concentration is restraining the mind into smaller and smaller limits. Concentration is the key to success in all endeavors, spiritual or worldly. Concentration plays a major role in all our day to day activity. To gain knowledge about any subject, concentration is very much required. When sun rays pass through a lens, it can generate a fire. Similarly,

when defocused mind is concentrated on a specific subject, it can achieve the same at ease. That is the power of it.

However, the mind is defocused, wandering, and restless in nature. Most of the time, our mind will be in *cañcalatā* state. By practice, one has to train the mind. In *Bhagavad Gītā* Lord Kṛṣṇa mentions about how to still the mind.

तत्रैकाग्रं मनः कृत्वा यतचित्तेन्द्रियक्रियः ।

उपविश्यासने युञ्ज्यात् योगमात्मविशुद्धये ॥६ १२ ॥

*Tatraikāgraṁ manaḥ kṛtvā yatacittendriyakriyaḥ*

*Upaviśyāsane yunjyāt yogamātma viśuddhaye.*

(Bhagavad Gītā, Ch: 6 V: 12)

**There, having made the mind one-pointed, with the actions of the mind and the senses controlled, let him, seated on the seat, practice yoga, for the purification of the self.**

Sitting in a proper place, in an appropriate pose one has to make the mind single pointed. Concentration is the beginning of meditation. The wandering mind has to be controlled and channelised on a single point. This concentration can be inside our body (on certain special spiritual centers) or outside the body. Single pointedness is the very potent nature of the mind. The mind gets stunned by its own silence, or confused and even mad when it gets dynamised by either the inner forces of its own surging imaginations or the outward pull exerted by the attachments of the sense organs. If these two sources of distractions are blocked, mind becomes single pointed.

However, concentration is not meditation. In concentration, there are multiple connected thoughts and single subject. Concentration cannot be done for a long duration since this leads to fatigue. The *cañcala* mind has to be brought under control

and focused on a single object. The *ekāgratā* done on a spiritual centers with its fullest form culminates in to *dhāraṇā*.

### 2.5.3 *Dhāraṇā* (Focused meditation)

*Dhāraṇā* is the sixth limb (*aṅga*) of *aṣṭāṅga* yoga of sage Patañjali. The practice of *yama*, *niyama*, *āsana*, *prāṇāyāma*, *pratyāhāra* are considered as *bahiraṅga* yoga and *dhāraṇā*, *dhyāna*, *samādhi* as *antaraṅga* yoga. These eight limbs can be practiced independently. However, they also have sequential relationship and the effective practice of one *aṅga* needs at least partial mastery of those which precede it. *Yama* and *niyama* eliminate the disturbances which are caused by uncontrolled emotions and desires and lay a strong foundation for the practice of yoga. *Āsana* and *prāṇāyāma* cultures the body and mind. *Pratyāhāra* develops the sense of *vairāgya* and prepares the *sādhakā* for the practice of *antaraṅga* yoga.

The sage Patañjali defines *dhāraṇā* as “fixing the mind in one place”.

देशबन्धश्चित्तस्य धारणा ।

*Deśabandhaścittasya dhāraṇā* ।

(Patañjali's *Yoga Sūtras*, III.1)

Fixing the mind in one place is *dhāraṇā*

While *Patañjali* only mentioned fixing the mind on any place as ‘*dhāraṇā*, *Vyāsa*

further explains about the places where once can concentrate.

नाभिचक्रे हृदयपुण्डरीके मूर्ध्नि ज्योतिषि नासिकाग्रे जिह्वाग्रे इत्येवमादिषु देशेषु बाह्ये वा  
विषये चित्तस्य वृत्तिमात्रेण बन्ध इति धारणा ।१।

*Nābhicakre hṛdayapuṇḍarīke mūrdhni jyotiṣi nāsikāgre jihvāgre  
ityevamādiṣu deśeṣu bāhye vā viṣaye cittasya vṛttimātreṇa bandha iti  
dhāraṇā | 1 |*

**Dharana is fixing the mind, through its modifications, to places such as the navel circle, the heart lotus, the shining center in the head, the tip of the nose, the tip of the tongue, and other such locations; and to external objects.**

These are all the special energy centers in the body and concentrating mind on them would be ideal. One can also do *dhāraṇā* on outside objects like moon, sun, fire, top of the mountain, deity of God, etc. Performing *sāmyama* on them leads to the attainment of divine powers. The mind cannot come into contact with an external object directly but only through the senses. Hence, the word modification (*vṛtti*) is used here. When the object is one's navel, heart lotus etc, the outer sense organs are not involved as in the case of outer objects like moon, sun, etc.

Īśvara Gītā mentions the following:

हृत्पुण्डरीके नाभ्यां वा मूर्ध्नि पर्वतमस्तके ।  
एवमादिप्रदेशेषु धारणा चित्तबन्धनम् ॥  
देशावस्थितमालक्ष्य बुधेर्या वृत्तिसन्ततिः ।  
वृत्त्यन्तरैरसंस्पृष्टा तद्धचानं सूरयो विदुः ॥  
एकाकारसमाधिः स्याद्देशालम्बनवर्जितः ।  
प्रत्ययो ह्यर्थमात्रेण योगसाधनमुत्तमम् ॥ इति ॥

*Hṛtpuṇḍarīke nābhyāṃ vā mūrdhni parvatamastake |  
Evamādiapradeśeṣu dhāraṇā cittabandhanam | |*

*Deśāvastthitamālakṣaya budhdheryā vṛttisantatiḥ |  
Vṛtyantarairasamṣṛṣṭā taddhacānaṁ sūrayo viduḥ | |  
Ekākārasamādhiḥ syāddeśālambanavarjitah |  
Pratyayo hyarthamātreṇa yogasādhanamuttamam | |iti | |*

**Dhāraṇā is the fixing of the mind on places like heart lotus, the navel region, the head and the top of the mountain. The wise understand dhyana to be a continues flow of modifications of the mind with reference to the object being concentrated upon. Samadhi is subject becoming one with the object; thus it is devoid of supporting object such as place. There is knowledge only with reference to the object and this is the best means of yoga.**

*Dhāraṇā* involves intense focusing on the object chosen for meditation. There is an effort involved while concentrating on the object. The concentration here mentioned is not the ordinary one. It is of the highest form and moving within the limited mental area (or object chosen). Mind has to be concentrated on chosen object for meditation. The mind has to be brought back immediately if it wanders. Every object has innumerable aspects and the mind can consider these aspects only one by one. Else, it may be that the object may involve a process of reasoning consisting of many steps connected logically with each other and forming an integrated whole. Hence, there is a movement without really leaving the object of concentration. Sadhaka has to focus continuously on the object chosen. If the continuity breaks, mind has to be brought back immediately. Vague and blurred impressions should be replaced by sharply defined mental images by increasing the degree of alertness and power of attention. The mastery in the practice of dharna leads to *dhyāna*.

#### 2.5.4 *Dhyāna* (Effortless meditation)

A restless mind is like a lake, constantly agitated by the winds of desires, creating thought-waves of diverse nature. Because of this constant agitation, our true Self at the bottom of the lake cannot be perceived. To subside all thought-waves, a single thought is consciously cultivated by the repeated and uninterrupted practice of meditation. Then, the lake (mind) becomes calm and bottom of lake (*ātman*) becomes visible.

Meditation is keeping the mind focused uninterruptedly on a subject for a certain length of time. It is a mental process by which meditator becomes one with the object of meditation. Meditation is the seventh stage in *aṣṭāṅga* yoga of Patañjali. He defines *dhyāna* as follows:

तत्र प्रत्ययैकतानता ध्यानम् ।

*Tatra pratayayaikatānatā dhyānam* ।

(Patañjali's *Yoga Sūtras* III.3)

**Uninterrupted flow of the mind towards the object of meditation**

The sage Vyāsa further explains about *dhyāna* in his commentary to *Yoga Sūtra*.

तस्मिन्देहे धेयालम्बनस्य प्रत्ययस्यैकतानता सदृशः प्रवाहः प्रत्ययन्तरेणापरामृष्टे

ध्यानम् ॥

*Tasmindeśe dheyālabhanasya pratayasyaikatānatā sadṛśaḥ*

*pravāhaḥ pratayantareṇāparāmṛṣṭo dhyānam* । ।

**Meditation is a continuous flow of knowledge which has its support the object of meditation; i.e., similar flow of knowledge untouched by any other knowledge.**

Continuity of mind towards the chosen object is meditation. *Dhāraṇā* on the navel circle, heart lotus, or any other external objects when becomes continues and devoid of other thoughts it culminates in to *dhyāna*. Meditation is achieved through continuous and effortless *dhāraṇā*. The sanskrith word ‘tatra’ means ‘in that place’ and refers to the place where dharana has been done. The word “pratyaya” means total content of the mind. ‘*pratayayaīkatānatā*’ means continuous flow of mind referes to the absense of interruptions from distractions which are present in *dhāraṇā*. This can be compared to the flow of oil from one vessel into other. Meditation is cultivating a single thought of the object of meditation by repeating it over and over again. By following the same method and concentrating on the same subject at the same center of consciousness, that single thought becomes a giant thought-wave. In course of time, the mind develops a channel for that thought-wave and the practice becomes effortless.

The five main features of the dhyana state are (i) single thought, (ii) effortless, (iii) slowness, (iv) wakefulness, and (v) expansiveness. Continuous and dedicated practice of meditation helps one to gain mastery over the mind and leads to a state of superconsciousness called *samādhi*.

In Bhagavad Gītā, Lord Kṛṣṇa explains how to meditate.

शनौः शनौरुपरमेत् बुद्ध्या धृतिगृहीतया ।  
आत्मसंस्थं मनः कृत्वा न किञ्चिदपि चिन्तयेत् ॥

*Śanauḥ śanauruparamet buddhyā dhṛtigrhīṭayā |*

*Ātmasamsthāṁ manaḥ kṛtvā na kiñcidapi cintayet | |*

(Bhagavad Gītā VI.25)

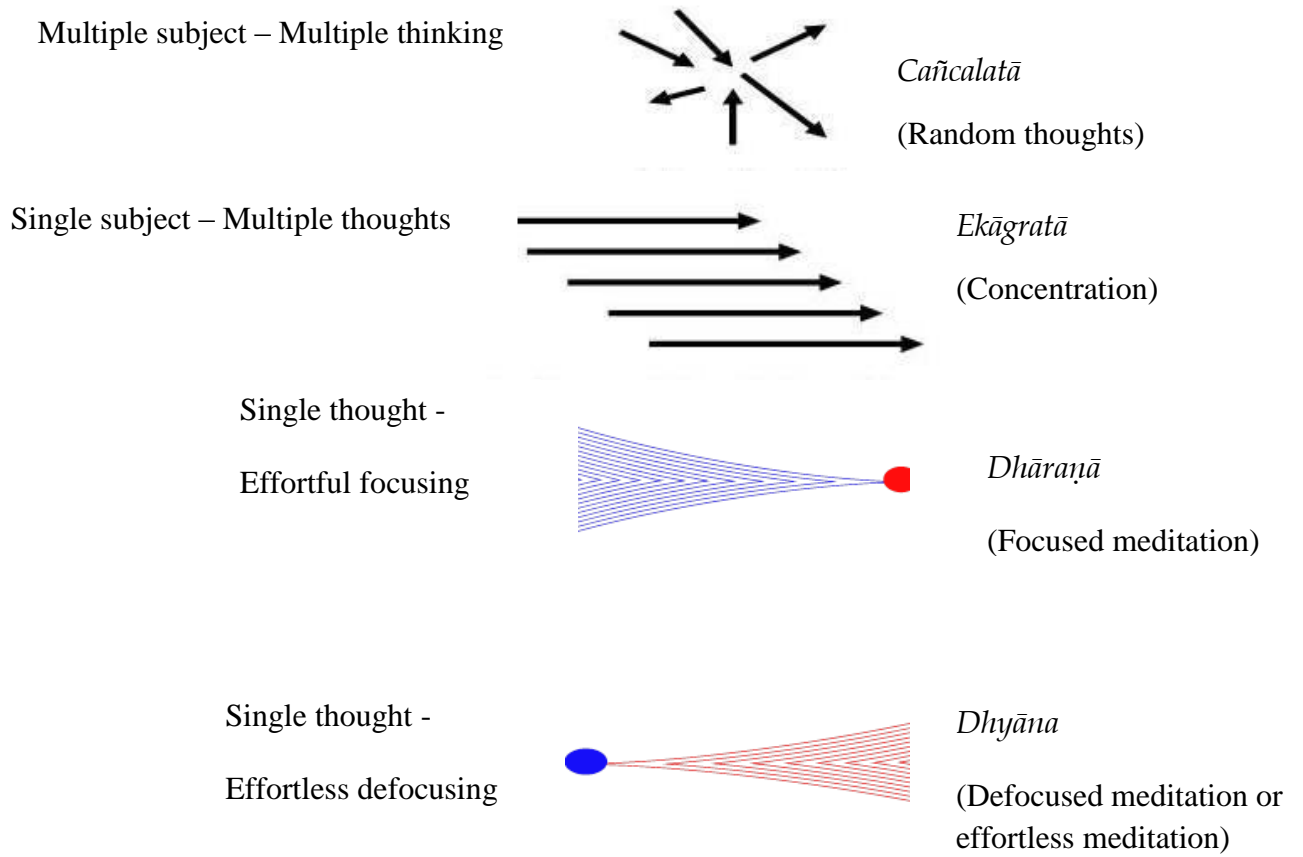
**Little by little, let him attain quietitude by his intellect, held firm; having made the mind established in the Self, let him not think of anything.**

Patiently, with the help of intellect the mind is to be controlled, and rested in the contemplation of the self. He has to completely withdraw himself from the external world. Using the discriminating intellect, the mind has to be controlled. Mind has to be fixed on the 'Self' and there should not be any other thoughts. He has to remain in that inner silence and peace. Key features of four mental states are summarized in Table 1 and the concepts are highlighted in Figure 1.

**Table. 1. Key features of four mental states**

<b>Mental States</b>	<b>Process</b>	<b>Key features</b>
<i>Cañcalatā</i>	Wanderig mind, or random mind	<ol style="list-style-type: none"> <li>1. Multiple thoughts</li> <li>2. Multiple subjes</li> </ol>
<i>Ekāgratā</i>	Focusing the mind on a single topic	<ol style="list-style-type: none"> <li>1. Single subject</li> <li>2. Multiple connected thoughts</li> </ol>
<i>Dhāraṇā</i>	Binding the mind on a object of meditation	<ol style="list-style-type: none"> <li>1. single thought</li> <li>2. intense focus</li> <li>3. effortful</li> </ol>
<i>Dhyāna</i>	Continuous concentration on a object of meditation	<ol style="list-style-type: none"> <li>1. single thought</li> <li>2. effortlessnes</li> <li>3. slowness</li> <li>4. wakefulness</li> <li>5. expansiveness</li> </ol>

**Figure 1. Schematic representation of four mental states described in yoga texts**



## 2.6 MEDITATION: IN THE LIGHT OF VEDĀNTA

*Vedānta* literally means "the end of the *vedās*" but more appropriately it refers to the essence of the *vedās*. It is also called as *upaniśads*. According to *vedānta*, liberation can be achieved only through spiritual knowledge, which requires meditation. *Vedānta*'s main approach is threefold: (1) hearing the teaching with a receptive mind (*śravaṇa*), (2) deep thinking about it (*manana*), and (3) meditating on it consistently called contemplation (*nidhidhyāsana*) until realization dawns which is called *jñāna* (state of *samādhi* or transcendent awareness). *Śravaṇa* (hearing) is not simply noting the words of the teachings; it involves a deep inner listening with an open mind and heart. *Manana* requires full concentration and a firm intent to understand oneself. Contemplation involves self-examination and self-remembrance throughout the day as one's primary mental state. The main feature of vedantic meditation is self enquiry and analysis through intellect. *Vedānta* uses intellect to experience the real nature.

*Dhyāna*, the Sanskrit term for meditation first arises in *vedic* literature. The *Shvetasvatara Upanishads* says, "By the Yoga of meditation (*dhyāna* Yoga) the sages saw the Divine Self-power, hidden in its own qualities".

ते ध्यानयोगानुगता अपश्यन् देवात्मशक्तिम् स्वगुणैर्निगूढाम् ।

यः कारणानि निखिलानि तानि कालात्मयुक्तान्यधितिष्ठत्येकः ॥३॥

*Te dhyānayogānugatā apaśyan devātmaśaktim svaguṇairnigūḍām |  
Yaḥ kāraṇāni nikhilāni tāni kālātmayuktānyadhitiṣṭhatyekah | 3 | |*

(Śvetāśvatara Upaniśad I.3)

**By practicing yoga of meditation they realised the power of the Deity Himself, hidden by its own effects, - the Lord who, alone, rules all those sources associated with time and individual soul.**

Kaṭha Upaniṣad states, "Meditate on Om as the Self" showing the technique of mantra meditation. Perhaps, the most eloquent explication of meditation occurs in the Chandogya, one of the oldest Upanishads. "Meditation (Dhyana) indeed is greater than the mind. The earth as it were meditates. The atmosphere as it were meditates. Heaven as it were meditates. The water as it were meditate. The mountains as it were meditate. Both men and God as it were meditate. He who worships God (Brahman) as meditation, as far as meditation extends, so far does he gain the power to act as he wills" (Chāndogya Upaniṣad VI.1).

**Neti Neti : Not this, Not this**

Neti, Neti, meaning "not this, not this," is the method of vedantic analysis by negation. Negating all thoughts in the mind, the process of meditation leads one to source of all thoughts. Finally, mind is transcended as all has been negated and nothing remains but Self. Then he experiences 'Sat-Chit-Ananda or Absolute existence-Knowledge-Bliss.

**Four Vedānta mahāvākyas**

*Vedānta* gives four *mahāvākyas* describing the process of meditation towards ultimate reality. These are mentioned below:

**1. तत् त्वम् असि ।**

*Tat tvam asi* |  
**That Thou Art**

**(Chāndogya Upaniṣad IV.8.7 of the Sama Veda)**

Tat represents Brhman, Twam refers to the individual, asi is union. This is the first *mahāvākya* in the *vedānta*. This is the first step of *śravaṇa* which the *sādhakā* hears from the teachers. Then he starts *manana* to understand the meaning of this by questions. Then he starts contemplation (experimentation) to find out the truth. This leads to *jñāna* as postulated in the following *mahāvākyas*.

2. अहं ब्रह्मास्मी ।

*Ahaṁ brahmāsmī* ।

**I am Brhman**

(Bṛhadāraṇyaka Upaniśad I.4.10 of the Yajur Veda)

This is the idea on which the aspirant fixes his mind during meditation, identification is with the Supreme, not with limiting adjuncts. The *jñāna* or realisation is the culmination of contemplation. It is leading to *samādhi* in which the *sādhakā* realises that truth that I am that.

3. अयं आत्मा ब्रह्मन् ।

*Ayam ātmā brahman* ।

**This self is Brahman**

(Māṇḍūkya Upaniśad I.2 of the Atharva Veda)

This expresses the inner intuitive experiences of the meditator. Further contemplation leads the *sādhakā* to a realisation that not only me but even others like me are also the same 'Reality'. The source of all human beings (indual Self) is verily that reality, pure consciousness, infinite bliss (आनन्दो

ब्रह्मेतिव्यजानात्।) infinite knowledge (प्रज्ञानं वै ब्रह्म।) and infinite power designated as मोक्षा (eternal freedom).

#### 4. सर्वं खल्विदं ब्रह्म ।

*Sarvam khalvidam brahma ।*

Every thing is brahman

(Chāndogyopaniṣad III.14.1 of the Sama Veda)

The ultimate realization that not only human beings but also all beings, animate and inanimate objects, the whole creation is nothing but brahman or reality.

*Vedānta* concludes that, this manifest universe is ever changing. *Brahman* alone is not changing and real. The individual soul is nothing but *Brahman* itself. This ultimate reality is beyond the reach of the limited mind including the intellect. To manifest the reality is the goal of all lives – said Swami Vivekananda. This can happen by purifying our body-mind complex so that the innate seer will come out to manifest its power, knowledge and bliss more & more in our lives. Meditation is a process for this purification process.

The following are different techniques of meditation used in modern times.

### 2.7 MODERN DERIVED MEDITATION TECHNIQUES AND ITS CLASSIFICATIONS

All though the goal of meditation is same (calmness and peace), there are different ways of reaching it. The *Vijñāna Bhairava Tantrā* presents 112 meditation techniques. These include several variants of breath awareness, concentration on

various centres in the body, non-dual awareness, chanting, imagination and visualisation and contemplation through each of the senses. Basically in the form of a dialogue between lord Shiva and his wife Parvati this text discusses 112 meditation techniques which can be used for realizing our true self. Recently, Lajpat Rai has compiled all these 112 meditation techniques (Rai, 2000). Here, an attempt has been made to describe the well-known derived meditation techniques.

- **Transcendental Meditation (TM)**

Transcendental meditation is a form of mantra meditation which is introduced by Maharsi Mahesh Yogi. Transcendental meditation is practised for 15–20 minutes in the morning and evening, while sitting comfortably with the eyes closed. TM involves mental chanting of a particular *mantrā* with awareness. During this technique, the individual's awareness settles down and experiences a unique state of restful alertness. As the body becomes deeply relaxed, the mind transcends all mental activity to experience the simplest form of awareness, Transcendental Consciousness, where consciousness is open to itself.

- ***Vipassanā* Meditation**

*Vipassanā*, which means to see things as they really are, is one of the ancient techniques of meditation. It was discovered by Gautama Buddha more than 2500 years ago and now popularized by Mr. S. N. Goenka. In *Vipassanā* meditation the meditator, sitting in a comfortable position, initially observes his own breathing and thereafter, observes sensations and feelings in various

part of the body with an attitude of witness. *Vipassanā* is a way of self-transformation through self-observation. It focuses on the subtle interconnection between mind and body, which can be experienced directly by disciplined attention to the physical sensations that form the life of the body, and that continuously interconnect and condition the life of the mind. It is this observation-based self-exploratory journey to the common root of mind and body that dissolves mental impurity, resulting in a balanced mind full of love and compassion.

- **Zen Meditation**

Zazen- Zen meditation is a fundamental part of both the Soto and Rinzai Sects of Zen Buddhism. The aim in this form of meditation is the ultimate state of enlightenment called *Satori*. This technique involves concentration. There are three types in this type of meditation. In the first type, the meditator concentrates on his breathing, counting the breaths or without counting. In second type of meditation, the meditator has to solve koans or say non-logical riddles. In third type of meditation, the meditator just sits and breathes in a prescribed manner without any aids or concentrating on his breath.

- **Ananda Marga Meditation**

In this technique, the meditator has to repeat a sacred *mantra* given by the *guru*, with intense concentration. This meditation is practiced and propagated by the *Ānanda Mārga* organization. The technique consists of two important steps. First, the meditators sit in comfortable relaxed position and withdraw the

attention inwards by ignoring the external stimuli and paying attention to their breathing. Then they silently repeat the two lettered personal *mantra* with their breathing.

- ***Brahmakumārīs Rāja Yoga Meditation***

This meditation technique is preached and practiced by *Brahmakumārīs Īśvarīya Viśvavidyālaya*. During this meditation, aspirants sit in a comfortable position with their eyes open, and with effortless gaze fixed on a *jyoti* (light – representing supreme consciousness). At same time, they actively generate positive thoughts about the Universal force pervading all over, as light and peace.

- **Cyclic Meditation**

Cyclic Meditation (CM) is devised by Dr. H. R. Nagendra, the founder, Vivekananda Yoga Anusandhana Samsthana. The concept has taken from *Māṇḍūkya Kārika*. Cyclic meditation involves a combination of gentle yogic stretching performed with awareness and with very slow movements followed by relaxation. This cycle repeats for three times and ends in deep relaxation and silence. The combination of stimulation and relaxation takes one to the deeper layers of relaxation.

- **Om Meditation**

Om meditation involves mental chanting of Om with awareness. The practitioner has to sit in meditative posture and chant Om mentally with

awareness. The chanting should be very slow and the silence between the two Omkaras has to be experienced. If there are any distractions, chanting should be made faster and after some time once again chanting should be done slowly. Finally, this process leads to a state of Ajapa (no repetition) which is a state of bliss, deep silence and peace.

- **Sahaja Yoga Meditation**

The Sahaja Yoga meditation technique is discovered and propagated by Mataji Nirmala Devi. The process of Sahaja Yoga is spontaneous and natural. It is a technique to awaken the *kuṇḍalinī śakti* which lies in the sleeping state at the base of the spine (muladhara chakra) of each human being. Sahaja Yoga is the state of self-realization produced by cleansing of *cakrās* and *kuṇḍalinī* awakening and is accompanied by the experience of thoughtless awareness or mental silence.

- **Sudarshana Kriya Meditation**

Sudarshana Kriya is developed by Sri Sri Ravishankar, founder of art of living foundation. The Sudarshan Kriya incorporates specific natural rhythms of breath to release stress and bring the mind to the present moment. It involves practice of ujjayi followed by bhastrika pranayama. After pranayama, one has to chant OM for three times and feel the vibrations. Finally, chanting of so ham mantra leads to silence and deep relaxation.

- **Prekṣā Meditation**

This is also an ancient meditation technique practiced in Jainism. *Prekṣā* means

to perceive and realize the subtlest aspects of one's own self, 'to see the Self'. *Prekṣā* is derived from the *Sanskṛta* word "*Pra + ikṣa*" which means to observe carefully. Basically, it sums up the perception of body, psychic centers, breath and observation of mind. In *Prekṣā Dhyāna*, no thought is forcefully stopped. Instead, the art of merely observing the thought process without forming any reaction or attachment is developed. By doing so, thoughts themselves cease to appear.

- **Yoga Nidrā**

Yoga-*nidrā* (yogic psychic sleep) is a meditative technique, derived from ancient *tantra* popularized by Bihar School of Yoga (BSY). Yoga-*nidrā* is described as a systematic method of inducing complete physical, mental and emotional relaxation, while maintaining awareness at deeper levels. Yoga-*nidrā* is performed in *śavāsana* and it consists of progressive relaxation and rotation of awareness all over body, resolve, and visualization of some images of nature and *tāntric* abstract symbols.

- **Qigong Meditation**

Qigong, is a practice of aligning breath, movement, and awareness for exercise, healing, and meditation. With roots in Chinese medicine, martial arts, and philosophy, qigong is traditionally viewed as a practice to cultivate and balance qi (chi) or what has been translated as "intrinsic life energy". Typically a qigong practice involves rhythmic breathing coordinated with slow stylized

repetition of fluid movement, a calm mindful state, and visualization of guiding qi through the body.

- **Metta Meditation (loving-kindness meditation)**

Mettā is loving-kindness, good will, close mental union and active interest in others. It is one of the ten pāramīs of the Theravāda school of Buddhism, and the first of the four sublime states (Brahmavihāras). This is love without clinging (upādāna). The cultivation of loving-kindness (mettā bhāvanā) is a popular form of meditation in Buddhism. In the Theravadin Buddhist tradition, this practice begins with the meditator cultivating loving-kindness towards themselves, then their loved ones, friends, teachers, strangers, enemies, and finally towards all sentient beings.

All these meditation techniques are derived within the last 200 years. The scientific literature shows differences in the results of these ~~between~~ meditation techniques. The differences in results among meditation techniques could be related to the method and principle involved. Hence, it would be helpful if we look at all the meditation techniques based on the traditional yoga texts. All the above mentioned techniques have been classified into two meditative states mentioned in the yoga text as given in the **Table 2**.

**Table. 2. Classification of meditation techniques**

<b>Sl. No.</b>	<b>Meditation Technique</b>	<b>Meditation Type</b>
1.	Transcendental Meditation (TM)	<i>Dhyāna</i>
2.	Vipassana meditation	<i>Dhyāna</i>
3.	Om meditation	<i>Dhyāna</i>
4.	Ananda Marga Meditation	<i>Dhāraṇā</i>
5.	Cyclic Meditation (CM)	<i>Dhāraṇā</i>
6.	Zen Meditation	<i>Dhāraṇā</i>
7.	Brahmakumaris Raja Yoga Meditation	<i>Dhāraṇā</i>
8.	Preksha Meditation	<i>Dhāraṇā</i>
9.	Sudarshana Kriya Meditation	<i>Dhāraṇā</i>
10.	Sahaja Yoga Meditation	<i>Dhāraṇā</i>
11.	Yoga Nidra	<i>Dhāraṇā</i>
12.	Metta meditation (loving-kindness)	<i>Dhāraṇā</i>
13.	Qigong meditation	<i>Dhāraṇā</i>

## 2.8 OBSTACLES IN THE PRACTICE OF MEDITATION

The Sage Patanjali describes nine kind of obstacles during meditation. In this *Sūtra*, Patañjali gives a number of conditions which can cause distractions in the mind and which consequently make the practice of meditation impossible.

व्याधिस्त्यानसंशयप्रमादालस्याविरतिभ्रान्तिदर्शनालब्धभूमिकत्वानवस्थितत्वानि  
चित्तविक्षेपास्तेऽन्तरायाः ।

*Vyādhistyānasamśayapramādālasyaāviratibhrāntidarśanālabdhabhūmikatoṅā  
navasthitatvāni cittavikṣepāste'ntarāyāḥ ।*

(Patañjali's Yoga Sūtras I. 30)

**Disease, languor, doubt, carelessness, laziness, wordly-mindedness, delusion, non-achievement of stage, instability, these cause distraction of the mind and they are the obstacles.**

- 1. Disease:** This draws the mind again and again to the physical body and makes it difficult to keep it directed inwards. Perfect health is a necessity for walking the path of Yoga. Good health is an indispensable necessity for the practice of meditation. The body and the mind are closely related to each other. It is difficult to concentrate the mind when body is unhealthy.
- 2. Languor:** This chronic fatigue is in many cases psychological in origin and due to the absence of any definite and dynamic purpose in life. In other cases, it is due to some defect in the *prāṇamaya kośā* which results in an inadequate supply of vital force to the physical body. Whatever may be the cause, it acts as an obstacle because it undermines all efforts to practice *sādhana*.

- 3. Doubt:** Unshakeable faith is very much needed in the spiritual endeavour. However, various types of doubt may arise while practicing yoga. Doubt may arise about the method of practicing meditation or a particular technique. These doubts distract the mind. During this time, 'śraddhā - unshakeable faith' in his objective, in himself and in the methods which he has adopted is needed.
- 4. Carelessness:** Carelessness is a weakness which prevents a man from achieving eminence in any line of endeavour and condemns him to a mediocre life. But in the field of yoga, it is not only an obstacle with a great danger and the careless *yogi* is like a child who is allowed to play with dynamite. He is bound to do himself serious injury sooner or later. No one should think of walking this path who has not conquered the habit of carelessness and learnt to pay careful attention not only to important things of life but also to those which are considered unimportant.
- 5. Laziness:** It is a bad mental habit acquired by continued yielding to the love of comfort and ease and tendency to avoid exertion. If we may say so, languor is a purely physical defect while laziness is generally a purely psychological condition. A restoration to health automatically cures the former but a prolonged discipline based on the execution of hard and difficult tasks is the only means of curing the latter.
- 6. Worldly-mindedness:** When a person chooses to walk on the path of yoga he has to give-up the worldly mindedness. Worldly desires are hindrance in the path of yoga. It will cause *vikṣepa* in his mind.

- 7. Delusion:** This means taking a thing for what it is not. It is due to generally lack of intelligence and discrimination. For example, a sadhaka may begin to see lights and hear sounds of various kinds during his early practices. These things are very spurious and do not mean much and yet there are many sadhakas who get excited about these trivial experiences and begin to think they have made great progress or seen God. This incapacity to assess our supernormal experiences at their proper worth is basically due to immaturity of soul and those who cannot distinguish between the essential and non-essential things in spiritual unfoldment find their progress blocked at a very early stage.
- 8. Non-achievement of a state:** The essential technique of Yoga consists, in the earlier stages, in establishing the mind firmly in the stages of *dhāraṇā*, *dhyāna* and *samādhi*. And, after *samādhi* has been attained, slowly immerse into the deeper levels of consciousness. In all these stages, change from one state to another is involved and this is brought about by persistent effort of the will. Some times, this passage is easy and comes after a reasonable amount of effort. At other times, the Yogi seems to make no progress and a dead wall appears to be facing him. This failure to obtain a footing in the next stage can cause distraction and disturb the perfect equanimity of the mind unless the Yogi has developed inexhaustible patience and capacity for self-surrender.
- 9. Instability:** Another kind of difficulty arises when the Yogi can get a foothold in the next stage but cannot retain it for long. The mind reverts to its previous stage

and a considerable amount of effort has to be put forth in order to regain the foothold. It is because of the inherent fickleness of the mind.

## **2.9 SUMMARY**

The present literature research compiled the authentic descriptions of meditation from the traditional yoga texts. The various yoga texts like Patañjali *Yoga Sūtra*, *Bhagavad Gītā*, *Upaniṣad*, etc., has been referred to compile the descriptions of various types of meditation. The concept of *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna* which forms a continuum in the practice of meditation have been described. An attempt has been made to classify all the derived meditation techniques in two categories viz., *dhāraṇā* & *dhyāna* based on the descriptions in the traditional yoga texts. This would enhance our knowledge about meditation and will be helpful in understanding the differences seen in the earlier meditation studies.

**CHAPTER – 3.0**  
**REVIEW OF THE  
SCIENTIFIC LITERATURE**

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### **3.0 REVIEW OF SCIENTIFIC LITERATURE**

#### **3.1 MEDITATION AND EVOKED POTENTIALS**

One of the most useful techniques in modern clinical neurophysiology is the recording of evoked potentials. Evoked Potentials are the neurophysiological tool that makes it possible for us to make an extensive study of the cerebral cortex, the brainstem and the spinal cord. Evoked potential (EP) is an electrical response of the brain to a given stimuli which occur in a time locked fashion (Chippa, 1997). Evoked potentials are used in meditation research because the association between different components of evoked potentials and underlying neural generators are well understood (Woods & Clayworth, 1985). Apart from this, it appears that cerebral cortex is actively involved in meditation. It is believed that even if the main changes occur in the cortex, corticoefferent connections would result in subcortical changes (Woods & Clayworth, 1986). Hence, short latency and mid-latency auditory evoked potentials were studied during meditation.

In evoked potentials, a decrease in peak latency is considered suggestive of facilitated transmission due to increased speed of conduction in the underlying neural generators (Malhotra, 1997). On the other hand, an increase in peak latency can be assumed to suggest inhibited transmission due to slower conduction in the underlying neural generators. Increased amplitudes of evoked potential components are interpreted as activation of the underlying neural generator with recruitment of a greater number of neurons (Woods & Clayworth, 1986).

The use of evoked potentials in yoga research started almost 3 decades ago. In 1976, slow cortical auditory responses were recorded from the practitioners of

transcendental meditation (Wandhöfer, Kobal & Plattig, 1976). Latencies for most of the initial peaks during TM as well as during normal consciousness were significantly shorter than in a control group in a dozing state or during normal consciousness. In a subsequent study, auditory evoked potentials to tone stimuli were recorded from eight proficient meditators before, during, and after meditation, and also during light sleep (Barwood et al., 1978). No consistent changes were found between baseline and meditating auditory evoked potentials (AEPs), or between meditating and sleep AEPs. In a subsequent study, visual evoked potentials (N120, P200, P300) and reaction time were studied during choice reaction time situations in 10 meditators and 10 matched controls (Banquet, Bourzeix & Lesèvre, 1979). After meditation, the reaction time significantly increased with less mistakes, and amplitude of P300 increased significantly. After rest, there was a decrease of P300 amplitude and no change in the reaction time of the controls.

In another study, brainstem auditory evoked potentials (BAEPs) were measured in five advanced practitioners of Transcendental Meditation (McEvoy, Frumkin & Harkins, 1980). In this study, peak latencies as well as interwave latencies among major BAEP components were evaluated. Results showed no pre-post meditation differences for experimental subjects at low stimulus intensities (0--35 dB). At moderate intensities (40--50 dB), latency of the wave V increased following meditation, but at higher stimulus intensities (55--70 dB), latency of this wave was slightly decreased.

Changes in mid-latency auditory evoked potentials (MLAEPs) were assessed in seven experienced meditators during the practice of meditation on the Sanskrit

syllable 'Om' (Telles & Desiraju, 1993). The results showed a group significant decrease in the latency of Nb wave. The Nb wave corresponds to the dorso-posterior medial part of the Heschl's gyrus, i.e., the primary auditory cortex (Liégeois-Chauvel et al., 1994). Hence, in experienced meditators, mental repetition of Om, facilitated the transmission of neural information at the level of the dorso-posterior medial part of the Heschl's gyrus.

In a subsequent study on experienced and naïve meditators, who were asked to mentally repeat 'Om' on one day and English syllable 'one' on another day, there was a significant change in the Na component (Telles et al., 1994). When both experienced and naïve meditators repeated 'one', there was a significant decrease in the peak amplitude of the Na wave. Hence, the decreased Na amplitude indicated a possible decrease in neurons recruited at the level of mesencephalic or diencephalic while mentally repeating 'one'.

In contrast, when experienced meditators and naïve persons were asked to mentally repeat 'Om' on another day, the results were quite different. The Na wave peak amplitude significantly increased in experienced meditators but significantly decreased in naïve meditators. These results were suggestive of recruitment of more neurons at the mesencephalic-diencephalic level in experienced meditators repeating 'Om', whereas naïve practitioners had less neurons recruited at that level. Hence, both mentally repeating 'Om' and 'one' cause neural changes at the same level but in opposite directions. In another study, an auditory oddball task was used to assess experienced TM meditators at pretest baseline, after 10 min of rest, or after 10 min of TM practice with conditions counter-balanced across subjects (Travis & Miskov,

1994). The P300 latency decreased at Pz after TM practice relative to no change after the rest condition.

Effect of Sahaja Yoga meditation on AEP and visual contrast sensitivity (VCS) in 32 epileptics was studied (Panjwani et al., 2000). Sahaja Yoga meditation group showed significant improvement in VCS following meditation and also a significant increase in the Na-Pa amplitude. A study on MLAEPs during Brahmakumaris Raja Yoga meditation showed decrease in the peak latency of the Na wave during meditation (Telles & Naveen, 2004). Since the neural generator of this wave lies at the midbrain-thalamic level, during meditation conduction time reduced at this level.

Changes in P300 following two yoga-based relaxation techniques were studied in 42 male volunteers (Sarang & Telles, 2006). There was a reduction in the peak latencies of P300 after cyclic meditation. A similar trend of reduction in P300 peak latencies was also observed after supine rest, although the magnitude of change was less after supine rest compared to after cyclic meditation. The P300 peak amplitudes after CM were higher compared to the "pre" values. In contrast, no significant changes were observed in the P300 peak amplitudes after supine rest. The results support the idea that cyclic meditation enhances cognitive processes underlying the generation of the P300.

The mismatch negativity (MMN) which is an indicator of preattentive processing was studied in Sudarshan Kriya Yoga meditation (combination of breathing exercises and concentrative meditation) (Srinivasan & Baijal, 2007). The results showed larger MMN amplitudes in meditators compared to non-meditators. The meditators also showed significant increase in MMN amplitudes immediately

after the practice of meditation suggesting transient state changes due to meditation. The results suggest that concentrative meditation practice enhances preattentive perceptual processes, enabling better change detection.

Midlatency auditory evoked potentials were studied before and after the practice of cyclic meditation (CM) and supine rest (SR) in 47 male volunteers (Subramanya & Telles, 2009). The results showed a significant increase in peak latency of Pa wave and Nb wave following CM compared to before CM. There was a significant increase in the peak amplitude of the Nb wave compared to before CM. The peak latency of the Na wave significantly increased after SR compared to before SR. Hence, following CM the latencies of neural generators corresponding to cortical areas was prolonged, whereas following SR a similar change occurred at mesencephalic-diencephalic levels. A subsequent study on Vipassana meditation showed reduction in P3a amplitude suggesting decrease in automated reactivity and evaluative processing of task irrelevant attention-demanding stimuli (Cahn & Polich, 2009).

A study was conducted to measure the effect of pranayama and yoga-asana on cognitive brain functions in type 2 diabetes-P3 event related evoked potential (ERP) (Kyizom et al., 2010). There was a significant improvement in the latency, and the amplitude of N200 and P300 in the yoga group as compared to the control group.

Changes in brainstem auditory evoked potentials were studied following four mental states (Kumar et al., 2010). The results showed a significant increase in the wave V peak latency in *cañcalatā*, *ekāgratā* and *dhāraṇā*, but not during *dhyāna* session. These results suggest that information transmission along the auditory

pathway is delayed during *cañcalatā*, *ekāgratā* and *dhāraṇā*, but there was no change during *dhyāna*.

A recent study assessed the impact of meditation on emotional processing using visual ERP in long-term meditators (Sobolewski et al., 2011). Results showed differences in the late positive potential (LPP) in meditators and controls. The study concluded that meditators are less affected by stimuli with adverse emotional load while processing of positive stimuli remained unaltered.

### **3.2 MEDITATION AND MEASURES OF ATTENTION**

Meditation and attention are very closely associated with each other in different ways (Telles, Naveen & Balkrishna, 2010). Meditation was described early on as a training in awareness, which practiced for some time leads to improvements in perception, attention and cognition (Brown, 1977). Meditation is also recognized as a state of consciousness in which deep relaxation and increased internalized attention exist, simultaneously (Murata et al., 2004).

An early study used functional magnetic resonance imaging (fMRI) to recognize and characterize the brain regions that are active during meditation (Lazar et al., 2000). The results indicated that the practice of meditation activates neural structures involved in attention and control of the autonomic nervous system. A study on long-term concentrative meditation using functional magnetic resonance imaging showed activation in brain regions involved in sustained attention (Brefczynski-Lewis et al., 2007). In response to the distracter sound, experienced meditators showed less

brain activation in regions related to discursive thoughts and more activation in regions related to response inhibition and attention compared to novices.

The performance in a six-letter cancellation task was assessed in 69 male volunteers before and after cyclic meditation, supine rest and control session (Sarang & Telles, 2006). The net score significantly increased after cyclic meditation and supine rest while magnitude was more after cyclic meditation compared supine rest. There was a reduction in the scores for wrong cancellations after cyclic meditation but not after supine rest.

A study on short-term practice of traditional Chinese meditation showed greater improvement in conflict scores on the attention network test, lower anxiety, depression, anger, and fatigue, and higher vigor, a significant decrease in stress-related cortisol, and an increase in immune-reactivity compared to control group (Tang et al., 2007). The efficiency of executive processing was assessed using Stroop task in long-term meditators (Chan & Woollacott, 2007). The results showed a reduction in interference on the Stroop task following meditation, suggesting an increase in the efficiency of the executive attentional network.

A study examined three distinct attentional subsystems: alerting, orienting, and conflict monitoring following mindfulness training (Jha, Krompinger & Baime, 2007). The results showed a significant increase in orienting following mindfulness-based stress reduction group (MBSR) compared to intensive concentrative meditation group and control group. In contrast, participants in the concentrative meditation group demonstrated an increase in performance on the alerting component, with

improvements in exogenous stimulus detection compared to control and MBSR groups.

In a subsequent study, an effort was made to classify all the meditation techniques into two main styles, based on how attention is directed (Lutz et al., 2008). One category was called focused attention meditation (FA), during which attention is sustained and focused on a given object. The second category was called open monitoring meditation (OM), where meditators are required not to react, while monitoring the content of ongoing experience. This style is a method by which the practitioner is aware of all mental content from one moment to the next without reacting to any of the thought.

The Stroop interference and the d2-concentration & endurance test was measured in an experienced mindfulness meditators and non-meditators (Moore & Malinowski, 2009). The results showed better performance in all measures of attention in meditators whereas no change in non-meditators. In another study, three months of intensive meditation training reduced variability in attentional processing of target tones, as indicated by both enhanced theta-band phase consistency of oscillatory neural responses over anterior brain areas and reduced reaction time variability (Lutz et al., 2009). A study examined the effects of meditation on mental imagery in Buddhist monks (Kozhevnikov, 2009). They were divided into two groups according to their preferred meditation style: Deity Yoga (focused attention on an internal visual image) or Open Presence (evenly distributed attention, not directed to any particular object) and were assessed before and after meditation using computerized mental-imagery tasks. The results showed a significant increase in the performance on

imagery tasks after Deity Yoga practice suggesting heightened visuospatial processing in Deity Yoga practitioners.

Performance on psychomotor tasks following Cyclic Meditation and Supine Rest was assessed in 57 male volunteers (Subramanya & Telles, 2009). Cyclic Meditation and Supine Rest both showed improvement in digit letter substitution test scores and scores for letter-copying and scores for circle-dotting tasks. A subsequent study assessed the performance in a six-letter cancellation task in 35 male volunteers following four mental states viz., *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna* (Kumar and Telles, 2009). There was a significant increase in the net scores after *dhāraṇā* whereas significant decrease after *cañcalatā* suggesting better attention following *dhāraṇā*. In another study, immediate effect of Cyclic Meditation (CM) and Supine Rest (SR) on attention in school children were assessed using letter cancellation task (Pradhan & Nagendra, 2010). The results showed a significant increase in total score and net score after both the practices, although the magnitude of change was more after CM than after SR in the net scores (14.5 versus 11.31%).

In another study, EEG was recorded during Sudarshan Kriya yoga meditation and during relaxation (Baijal & Srinivasan, 2010). During meditation, theta band activity was enhanced in the frontal lobe. And also, meditators exhibited increased theta coherence compared to controls. The results suggest an increase in attentional processing during meditation.

A study was conducted to examine the differences in various domains of attention in 15 long-term Vihangam meditation (Prakash et al., 2010). The Stroop

test, trail-making test, digit symbol substitution tests, and digit forward and digit backward tests were administered before and after meditation and control session. The performance on all tests of attention was better following Vihangam meditation group compared to control group. The results suggest that, long-term Vihangam meditation improves attention span, processing speed, attention alternation ability, and performance in interference tests. In another study, the attentional processing was assessed in 20 mindfulness meditation practitioners using attention network test (van den Hurk et al., 2010). The results showed better orienting and executive attention after mindfulness meditation compared to control session.

More recently, a study evaluated the performance of regular meditators and non-meditators during an fMRI adapted Stroop word-colour task, which requires attention and impulse control (Kozasa et al., 2012). The findings suggested that meditation training improves efficiency, possibly via improved sustained attention and impulse control.

Previous studies on meditation and evoked potentials, and meditation and measures of attention were summarized in the **Table 3** and **Table 4**, respectively. These studies have substantiated the idea that meditation influences cortex, subcortex and also brainstem. Different meditation techniques have been studied using evoked potentials. There have been changes in the amplitude and latency of the specific waves. Some meditation techniques showed increase in amplitude and decrease in latency where as other showed increase in latency suggesting delay in information processing. The association between meditation and attention was also well-understood by number of research studies. The areas related to attention showed

activation during meditation. Meditation showed significant increase in attention and performance. However, there has been no study assessing the changes in MLAEPs during the four mental states viz., *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*. Hence, the present study was designed to assess changes in MLAEPs during *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*. And also, the present study was designed to assess the effects of *dhāraṇā* and *ekāgratā* using two attention tasks (i) d2 test of attention and (ii) digit symbol substitution test. This was planned because a previous study on performance in a cancellation task at the beginning and end of each of the four states showed an increase in the scores after *dhāraṇā*.

**Table 3: Meditation and evoked potentials**

Author and year of publication	Sample size (n)	Design	Variables studied	Findings
Wandhöfer, A., Kobal, G., & Plattig, K. H. (1976).	-	Two groups, Transcendental meditation and control	Slow cortical auditory responses	Latencies for most of the initial peaks during TM as well as during normal consciousness were significantly shorter than in a control group in a dozing state or during normal consciousness.
Barwood, T. J., Empson, J. A., Lister, S. G., & Tilley, A. J.(1978).	8	Two groups, Meditation, and light sleep	Auditory evoked potentials to tone stimuli	No consistent changes were noted between baseline and meditating AEPs, or between meditating and sleep AEPs.
Banquet, J. P., Bourzeix, J. C., & Lesèvre, N. (1979)	20	Two groups, Meditators & matched control group	Visual evoked potentials (N120, P200, P300)	After meditation the reaction time significantly increased with less mistakes, and amplitude of P300 increased significantly.
McEvoy, T. M., Frumkin, L. R., & Harkins, S. W. (1980).	5	Two group pre – post design TM group and age matched control group	Brainstem auditory evoked potentials (BAEPs)	At moderate intensities (40--50 dB), latency of the wave V increased following meditation, but at higher stimulus intensities (55--70 dB), latency was slightly decreased.
Telles, S., & Desiraju, T. (1993)	14	Two group design Experienced meditators Vs naïve subjects	Middle latency auditory evoked potentials (MLAEPs)	During meditation there was a significant decrease in the latency of Nb wave.
Telles, S., Nagarathna, R., Nagendra, H. R., & Desiraju, T. (1994)	18	Self as control design Meditation Vs Non-meditation(OM vs One)	Middle latency auditory evoked potentials (MLAEPs)	When both experienced and naïve meditators repeated ‘one’ there was a significant decrease in the peak amplitude of the Na wave. The Na wave peak amplitude significantly increased in experienced meditators but significantly decreased in naïve meditators during mentally

				repeating OM.
Travis, F., & Miskov, S. (1994).	11	Before and after TM and rest	Auditory oddball (P300)	The P300 latency decreased at Pz after TM practice.
Panjwani, U., Selvamurthy, W., Singh, S. H., Gupta, H. L., Mukhopadhyay, S., & Thakur, L. (2000).	32	Epilepsy patients; 3 groups Sahaja Yoga group Postural exercises group Control group	Visual Contrast Sensitivity (VCS), BAEP, and MLAEP	Significant improvement in VCS following meditation and also a significant increase in the Na-Pa amplitude.
Telles, S., & Naveen, K. V. (2004).	16	Self as control Meditation and non-meditation session	MLAEPs	Decrease in the peak latency of the Na wave during meditation
Sarang, S. P., & Telles, S. (2006).	42	Self as control; Cyclic Meditation & Supine Rest	P300	There was a decrease in the peak latencies and increase in amplitude of P300 after cyclic meditation.
Srinivasan, N., & Baijal, S. (2007).	20	Two groups, Meditators & Non-meditators	The auditory mismatch negativity	The meditators showed significant increase in MMN amplitudes immediately after the practice of meditation suggesting transient state changes due to meditation.
Subramanya, P., & Telles, S. (2009).	47	Self as control; Cyclic Meditation & Supine Rest	MLAEPs	There was a significant increase in peak latency of Pa wave and Nb wave following CM compared to before CM suggesting cortical inhibition following CM.
Cahn, B. R., & Polich, J. (2009).	-	Self as control; Meditation & non-meditation session	P3a event related brain potentials	Reduction in P3a amplitude suggesting decrease in automated reactivity and evaluative processing of task irrelevant attention-demanding stimuli.
Kyizom et al., (2010)	60	Two groups; Control & Yoga group	P300 (ERP)	Significant improvement in the latency and the amplitude of N200, P300 in the yoga group as compared to the

				control group.
Kumar et al., (2010)	30	Self as control; <i>Canalata, ekagrata, dharana</i> and <i>dhyana</i>	Brainstem auditory evoked potentials (BAEPs)	Significant increase in the wave V peak latency in <i>canalata, ekagrata</i> and <i>dharana</i> , but not during <i>dhyana</i> session.
Sobolewski et al., ( 2011)		Two groups; Long-term meditators & Non-meditators	visual event-related potential (ERP)	The study concluded that, meditators are less affected by stimuli with adverse emotional load, while processing of positive stimuli remained unaltered.

**Table 4: Meditation and measures of attention**

<b>Author and year of publication</b>	<b>Sample size (n)</b>	<b>Design</b>	<b>Variables studied</b>	<b>Findings</b>
Lazar SW, Bush G, Gollub RL, Fricchione GL, Khalsa G, Benson H. (2000)	-	During meditation	Functional magnetic resonance imaging (fMRI)	The results indicated that the practice of meditation activates neural structures involved in attention and control of the autonomic nervous system.
Brefczynski-Lewis JA, Lutz A, Schaefer HS, Levinson DB, Davidson RJ.(2007).	-	Two groups, Long term concentrative meditation and control (novices to meditation)	Functional magnetic resonance imaging (fMRI)	Activation in brain regions involved in sustained attention.
Sarang, S. P., & Telles, S. (2007)	69	Self as control design Cyclic meditation and supine rest	Six-letter cancellation task	The net score significantly increased after cyclic meditation and supine rest while magnitude was more after cyclic meditation compared supine rest.
Tang et al., (2007)	40	Two groups Traditional Chinese meditation group and control group	Attention network test Mood states scale, Cortisol level	Traditional Chinese meditation showed greater improvement in conflict scores on the attention network test, lower anxiety, depression, anger, and fatigue, and higher vigor, a significant decrease in stress-related cortisol, and an increase in immune-reactivity compared to control group.
Chan, D.,& Woollacott, M. (2007).	60	Two groups Meditation group and control group	Stroop test Global-local letters test	Reduction in interference on the Stroop task following meditation, suggesting the increase in efficiency of the executive attentional network.
Jha, A. P., Krompinger, J., & Baime, M. J. (2007)	-	Two groups Mindfulness-based stress reduction (MBSR) Concentrative meditation	Attention network test	Significant increase in orienting following mindfulness-based stress reduction group (MBSR) compared to intensive concentrative meditation

				group and control group. Concentrative meditation group showed an increase in performance in alerting component, with improvements in exogenous stimulus detection compared to control and MBSR groups.
Moore, A., & Malinowski, P. (2009).	-	Two groups; pre-post Mindfulness meditators and non-meditators	Stroop interference test d2-concentration and endurance test	Better performance in all measures of attention in meditators whereas no change in non-meditators
Lutz, A., Slagter, H. A., Rawlings, N. B., Francis, A. D., Greischar, L. L., & Davidson, R. J. (2009).	-	Pre – post design Before and after three months practice of meditation	Dichotic listening task Electroencephalography	Three months of intensive meditation training reduced variability in attentional processing of target tones, as indicated by both enhanced theta-band phase consistency of oscillatory neural responses over anterior brain areas and reduced reaction time variability.
Kozhevnikov, M., Louchakova, O., Josipovic, Z., & Motes, M. A. (2009).	-	Two groups; pre-post Deity yoga group and Open presence group	Computerized mental-imagery tasks Visuospatial tasks	Significant increase in the performance on imagery tasks after Deity yoga practitioners suggesting the heightened visuospatial processing.
Subramanya, P., & Telles, S. (2009)	57	Self as control Cyclic meditation & supine rest	Digit letter substitution task, letter-copying task circle-dotting task	Cyclic meditation and supine rest both showed improvement in digit letter substitution test scores and scores for letter-copying and scores for circle-dotting tasks.
Kumar, S., & Telles, S. (2009)	35	Self as control Four sessions: cancalata, ekagrata, dharana, dhyana	Six-letter cancellation task	There was a significant increase in the net scores after dharana whereas significant decrease after cancalata suggesting better attention following dharana.

Pradhan, B., & Nagendra, H. (2010).	208	Self as control Cyclic meditation & Supine rest	Six-letter cancellation task	Significant increase in total score and net score after both the practices, although the magnitude of change was more after CM than after SR in the net scores (14.5 versus 11.31%).
Baijal, S., & Srinivasan, N. (2010)		Two groups Sudarshan Kriya yoga meditation and relaxation	EEG	During meditation theta band activity was enhanced in the frontal lobe. And also, meditators exhibited increased theta coherence compared to controls.
Prakash, R., Dubey, I., Abhishek, P., Gupta, S. K., Rastogi, P., & Siddiqui, S. V. (2010)	30	Two groups; pre-post Vihangam meditation & non-meditators	Stroop test, trail-making test, digit symbol substitution tests digit forward and digit backward tests	The performance on all tests of attention was better following Vihangam meditation group compared to control group.
Van Den Hurk, P. A., Gionmi, F., Gielen, S. C., Speckens, A. E., & Barendregt, H. P. (2010).	20	Two groups; pre-post mindfulness meditation control group.	Attention network test	Better orienting and executive attention in the mindfulness meditation group compared to control group.
Kozasa et al., (2012).	39	Two groups Meditation group & non- meditation group	fMRI adapted stroop word-colour task	The findings suggested that, meditation training improves efficiency, possibly via improved sustained attention and impulse control.

**CHAPTER – 4.0**  
**AIM AND OBJECTIVES**

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## **4.0 AIM AND OBJECTIVES**

### **4.1 AIM OF THE STUDY**

- To study psychophysiological changes following two meditative states (*dhāraṇā* and *dhyāna*) described in yoga texts

### **4.2 OBJECTIVES OF THE STUDY**

- To compile in-depth information on four mental states viz., *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* from classical yogic and spiritual literature.
- To explore the concept and classification of meditation from different classical and yoga texts.
- To investigate the effect of *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* on:
  - (i) Mid-latency auditory evoked potentials (MLAEPs)
  - (ii) Performance in the d2 test of attention
  - (iii) Performance in the digit symbol substitution test (DSST)
  - (iv) Subjective assessment of following guided instructions on visual analog scale.

### **4.3 RATIONALE OF THE STUDY**

Most recently evolved meditation techniques such as Transcendental Meditation, Brahmakumaris Raja Yoga meditation, Sahaja Yoga meditation, and meditation on OM) have been derived within the last 200 years. Differences in results between meditation techniques could be related to the methods and principles involved. In Patanjali's *Yoga Sūtras*, there are two meditative states (*dhāraṇā* and *dhyāna*) described, one leading to the other. Studying them was hoped to increase the understanding of the physiological changes during meditation.

Mid-latency auditory evoked potentials (MLAEPs) have been used to assess cortical and subcortical changes in meditation. It is believed that even if the main changes occur in the cortex, cortico-efferent connections would result in subcortical changes. There has been no study assessing the changes in MLAEPs during the four mental states viz., *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*. Hence, the present study was intended to assess changes in MLAEPs during *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*. And also, the present study was designed to assess the effects of *dhāraṇā* and *ekāgratā* using two attention tasks, (i) d2 test of attention and (ii) digit symbol substitution test considering a previous study showing an increase in the performance in cancellation test after *dhāraṇā*. There were no previous attempts to study subjective assessment to follow guided instructions for the four mental states. Hence, in the present study, the ability to follow guided instructions for the four mental states was assessed using visual analog scales.

#### **4.4 HYPOTHESIS AND NULL HYPOTHESIS**

##### **HYPOTHESIS**

The present study has hypothesized that, the two meditative states, *dhāraṇā* and *dhyāna* are different in construct and practice and hence they may produce different physiological changes.

**NULL HYPOTHESIS**

The null hypothesis of the present study was that, the two meditative states, *dhāraṇā* and *dhyāna* may not produce different physiological changes.

# **CHAPTER – 5.0**

## **METHODS**

<b>CHAPTER</b>	<b>DETAILS</b>	<b>PAGE.NO.</b>
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## 5.0 METHODS

In this thesis, the changes in (i) mid-latency auditory evoked potentials (MLAEPs), (ii) d2 test of attention, (iii) digit symbol substitution test (DSST), and (iv) subjective assessment (visual analog scale) to follow guided instructions were studied in normal healthy male volunteers following four mental states viz., *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*.

The methodology of the research has been described under the following sub-headings:

### 5.1: PARTICIPANTS

### 5.2: DESIGN OF THE STUDY

### 5.3: VARIABLES STUDIED

### 5.4: INTERVENTIONS

### 5.5: DATA EXTRACTION

### 5.6: DATA ANALYSIS

## 5.1 PARTICIPANTS

### 5.1.1 Sample size

Sixty participants were studied in four separate sessions i.e., *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*. The sample size was calculated based on an effect size obtained from a previous study on changes in brainstem auditory evoked potentials following four mental states (Kumar et al., 2009). It was calculated using G\*Power software, Version 3.0.10 (Faul, Erdfelder, Lang, & Buchner, 2007), where alpha was 0.05, and power was 0.95. The effect size was 0.657 and sample size was 33.

### 5.1.2 Selection and source of participants

The participants had a minimum of six months experience in the practice of meditation on Om, and were regular in their practice. The participants were residential students at Swami Vivekananda Yoga Anusandhana Samsthana, a Deemed University, Bangalore. They had all enrolled for graduate and postgraduate programs in yoga.

### 5.1.3 Inclusion criteria

Participants who fulfilled the following conditions were included in the study: (i) The participants who were healthy with ages ranging from 17 to 38 years (for MLAEPS & visual analog scale; group mean age  $\pm$  S.D.,  $26.5 \pm 4.6$  years & for attentional tasks; group mean age  $\pm$  S.D.,  $24.87 \pm 4.95$ ), (ii) male participants alone were studied as auditory evoked potentials have been shown to vary with the phases of the menstrual cycles (Yadav, Tandon & Vaney, 2002). (iii) willingness to participate in the trial, and (iv) practice of meditation for a minimum of 30 minutes per day, four days per week for a minimum of six months were included in the trial. The regularity of meditation practice was based on self-reporting of the meditators as well as consultations with the meditation teacher (*guru*). (v) Apart from their prior experience of meditation on 'Om', they were given a 3-month orientation program under the guidance of an experienced meditation teacher. The further details of each participant have been given in the **Table 5 and Table 6**.

### 5.1.4 Exclusion criteria

The following criteria were used to exclude the volunteers: (i) The presence of cognitive or neurological disorders, visual deformities, based on a medical history and routine clinical examination, (ii) intake of medication, which is known to influence

cognitive functions, (iii) auditory deficits assessed by checking the auditory thresholds of each ear separately was excluded, (iv) participants who had difficulty in focusing/concentrating, based on interview, and (v) smoking or alcoholism which may have influenced the cognitive functions. None of the participants had to be excluded based on these criteria.

#### **5.1.5 Ethical considerations**

The participants were explained about the aim and method of the study, and the informed consent was signed by all participants (a sample copy is enclosed in **Appendix-1**). None of them were aware of the hypothesis of the study. The study was approved by the institution's ethics committee.

**Table 5: The characteristics of participants in mid-latency auditory evoked potentials recorded pre, during and post of *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* and also for subjective assessment (visual analog scale)**

Sl. No.	Participant code	Age in years	Meditation experience in months	No. of min / day	No. of days / week
1.	PAR	25	24	30	6
2.	SOH	22	48	30	5
3.	SHR	23	48	30	5
4.	RAG	27	48	30	5
5.	SUB	23	12	30	6
6.	ARJ	25	24	30	6
7.	SUH	24	48	30	6
8.	PRA	27	12	30	5
9.	VIR	24	12	30	6
10.	SAU	24	18	30	4
11.	SHA	26	24	30	5
12.	GAU	20	12	30	4
13.	AYU	20	18	30	5
14.	HEM	21	18	30	6
15.	REV	24	12	30	4
16.	ANK	20	12	30	6
17.	AMI	25	12	30	5
18.	HAR	19	30	30	5
19.	ROH	25	12	30	4
20.	MAL	24	30	60	6
21.	VAD	19	24	60	6
22.	PUS	19	6	60	6
23.	RAN	24	12	30	7
24.	SUP	19	12	30	6
25.	SHA	22	60	60	7
26.	KAR	21	60	30	5
27.	AJA	23	24	30	5
28.	ANA	27	6	30	5
29.	BHA	24	6	30	7
30.	JIT	31	6	30	4
31.	VEN	20	12	30	5
32.	ARV	20	18	30	4
33.	DEE	24	24	30	5
34.	SAN	25	24	30	6
35.	NAV	23	12	30	6
36.	ANU	28	24	30	5

37.	MAN1	22	12	30	5
38.	ARU	20	36	30	5
39.	DAT	22	36	60	5
40.	MAN2	19	12	30	4
41.	DIL	22	18	30	6
42.	JAI	21	18	30	4
43.	KUN	28	30	30	5
44.	NID	22	12	45	7
45.	GAJ	19	36	45	6
46.	RAV	23	24	30	5
47.	SUS	25	48	60	5
48.	SUM	20	9	30	5
49.	HEM	26	12	30	4
50.	HAR	19	6	30	5
51.	GAJ	23	6	30	5
52.	SHA	23	36	30	5
53.	RAJ	18	6	30	4
54.	AMI	22	6	30	5
55.	NAV	21	6	30	5
56.	SUD	22	6	30	5
57.	NAG1	22	24	60	5
58.	HAN	24	24	30	4
59.	SAT	22	6	30	5
60.	NAG2	25	24	30	5
<b>Mean</b>		<b>22.78</b>	<b>20.95</b>	<b>34.00</b>	<b>5.04</b>
<b>SD</b>		<b>2.73</b>	<b>14.21</b>	<b>9.91</b>	<b>0.71</b>

**Table 6: The characteristics of participants in attentional tasks (d2 test of attention and digit symbol substitution test) administered before and after *ekāgratā* and *dhāraṇā*.**

Sl. No.	Participant code	Age in years	Meditation experience in months	No. of min / day	No. of days / week
1.	AKA	18	12	30	5
2.	AMI	26	24	30	5
3.	ANA1	21	12	30	5
4.	ANA2	28	24	30	5
5.	ANI	19	6	30	6
6.	ARU	26	24	30	6
7.	BAI	38	24	30	6
8.	BHA	27	24	30	5
9.	BIS	18	6	30	6
10.	CHI	26	12	30	4
11.	HEM	28	36	30	5
12.	IBO	18	6	30	4
13.	JOY	28	6	30	5
14.	KAS	26	18	30	6
15.	KAU	31	24	30	5
16.	KHI	23	6	30	6
17.	KHO	33	6	30	5
18.	KIR	24	6	30	5
19.	KRI	27	6	30	4
20.	KUL	26	12	30	6
21.	LEE	20	6	30	6
22.	MAD	21	6	30	6
23.	MAH	25	12	30	6
24.	MAN1	24	18	30	6
25.	MAN2	17	24	30	7
26.	MAN3	25	12	30	5
27.	MOH	28	12	30	5
28.	NIL	19	6	30	5
29.	PAR	25	6	30	6
30.	PRA1	28	6	30	4
31.	PRA2	26	18	30	5
32.	PRA3	21	12	30	5
33.	PRA4	22	12	30	5
34.	PRA5	25	18	30	6
35.	RAH	25	6	30	6

36.	RAJ1	21	24	30	5
37.	RAJ2	36	36	30	5
38.	RAM1	34	24	30	5
39.	RAM2	26	24	30	5
40.	RAN	21	8	30	4
41.	RAT	18	6	30	6
42.	SAN1	26	6	30	4
43.	SAN2	19	6	30	5
44.	SAN3	25	12	45	7
45.	SAN4	20	6	45	6
46.	SAN5	30	12	30	5
47.	SHA1	26	18	30	5
48.	SHA2	28	18	30	5
49.	SHR1	19	18	30	4
50.	SHR2	23	12	30	5
51.	SUD	19	12	30	5
52.	SUM	27	12	30	5
53.	SUN	21	6	30	4
54.	SUP	21	24	30	5
55.	SUV	19	6	30	5
56.	VAS1	27	24	30	5
57.	VAS2	34	24	60	5
58.	VIJ	26	24	30	5
59.	VIK	28	36	30	5
60.	VIN	36	24	30	5
<b>Mean</b>		<b>24.87</b>	<b>14.83</b>	<b>31.00</b>	<b>5.20</b>
<b>SD</b>		<b>4.95</b>	<b>8.63</b>	<b>4.68</b>	<b>0.71</b>

## 5.2 DESIGN OF THE STUDY

### 5.2.1 Structure of sessions

#### (i) Mid-latency auditory evoked potentials

Each participant was assessed in four sessions. Two of them were meditation sessions (*dhāraṇā* and *dhyāna*) and two of them were non-meditation sessions (*ekāgratā* and *cañcalatā*). All four recording sessions consisted of three states: pre (5 minutes), during (20 minutes), and post (5 minutes). Assessments were made on four different days, which were not necessarily on consecutive days, but at the same time of the day.

#### (ii) Performance in attentional tasks [i.e., (a) d2 test of attention and (b) digit symbol substitution test]

Each participant was assessed in two sessions on separate days. These two sessions were *dhāraṇā* (meditative focusing) and *ekāgratā* (focusing without meditation). Assessments were done before and after the practice of *dhāraṇā* and *ekāgratā* sessions. The time of the day for assessment was kept constant for both sessions. Both sessions were of 20 minutes duration.

#### (iii) Subjective assessment (Visual analog scale)

Each participant was assessed in four sessions. Assessments were made on four different days, which were not necessarily on consecutive days (within one or two days gap), but at the same time of the day. The allocation of participants to the four sessions was random using a standard random number table. The duration of all the four sessions was 20 min. A visual analog scale was given immediately after the practice of *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* session.

### 5.2.2 Order of sessions

#### (i) Mid-latency auditory evoked potentials

The order of the four sessions was randomized for each subject using random number table. This was done to prevent the influence of being exposed to the laboratory for the first time. The randomization of the order of four sessions is explained below.

Subject	Randomization of session
1	1, 3, 4, 2
2	2, 1, 3, 4
3	4, 1, 2, 3
....	.....

**Note:** *cañcalatā* = 1; *ekāgratā* = 2; *dhāraṇā* = 3; *dhyāna* = 4

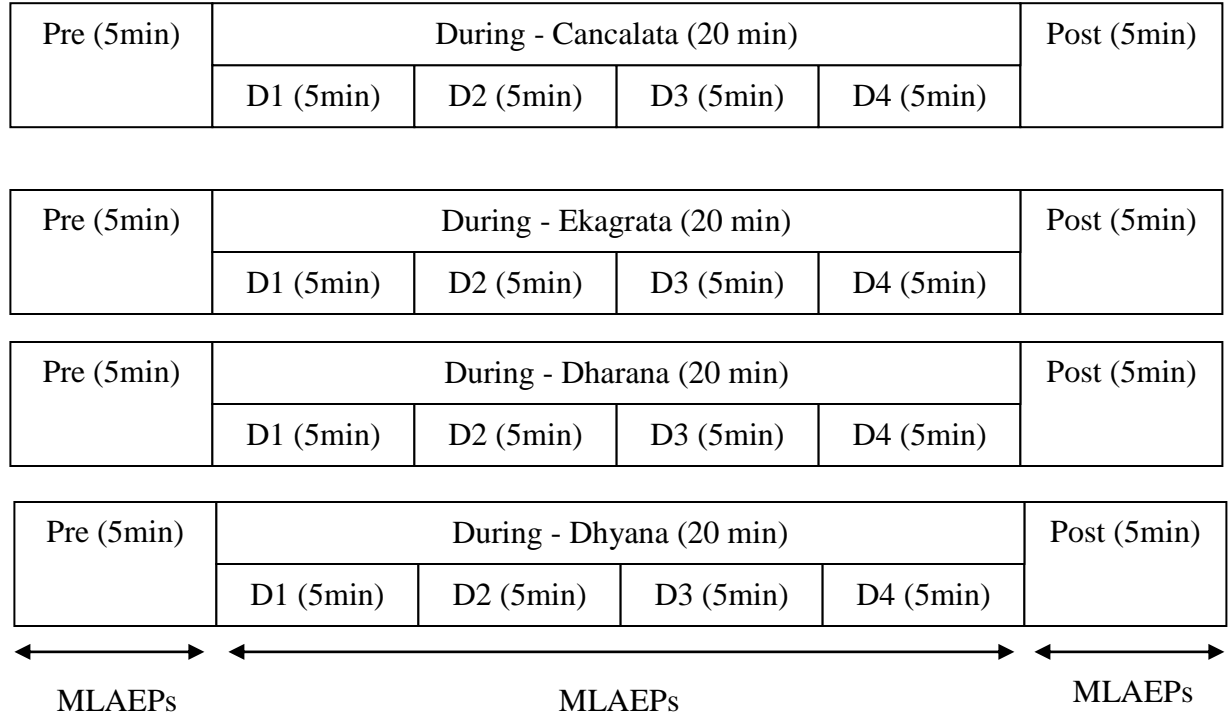
#### (ii) Performance in attentional tasks [i.e., (a) d2 test of attention and (b) digit symbol substitution test]

Half of the total participants were randomly allocated to *dhāraṇā* session first and *ekāgratā* session later and the other half had the order reversed. After one week (as a wash-out period) the order of the sessions was reversed and assessments were done before and after the sessions. Participants who did *dhāraṇā* first, practiced *ekāgratā* second and those who did *ekāgratā* first, practiced *dhāraṇā* second. This one week gap was given to wash out any possible learning effect.

#### (iii) Subjective assessment (Visual analog scale)

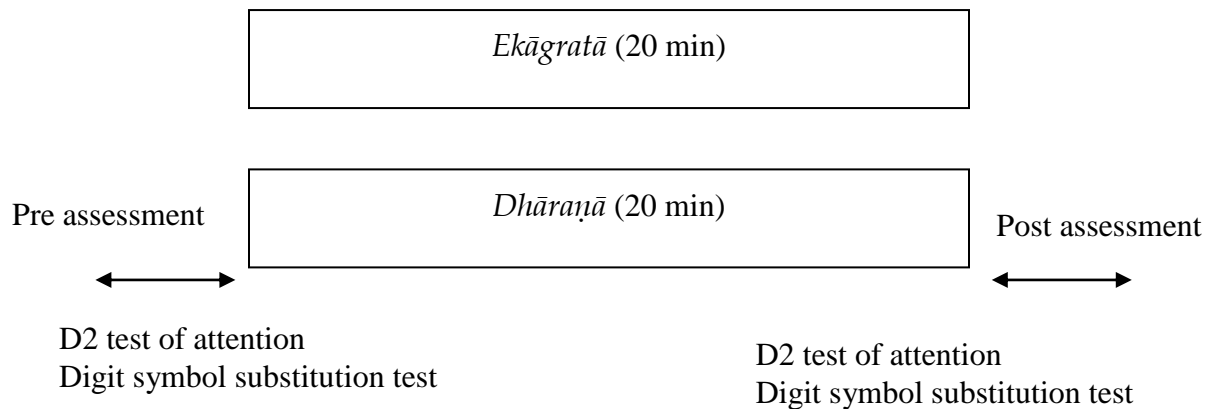
The allocation of participants to the four sessions was random using a standard random number table. The order of four sessions in each participant was randomized as mentioned above.

**Figure 2. Schematic representation of the study design for measurement of mid-latency auditory evoked potentials**

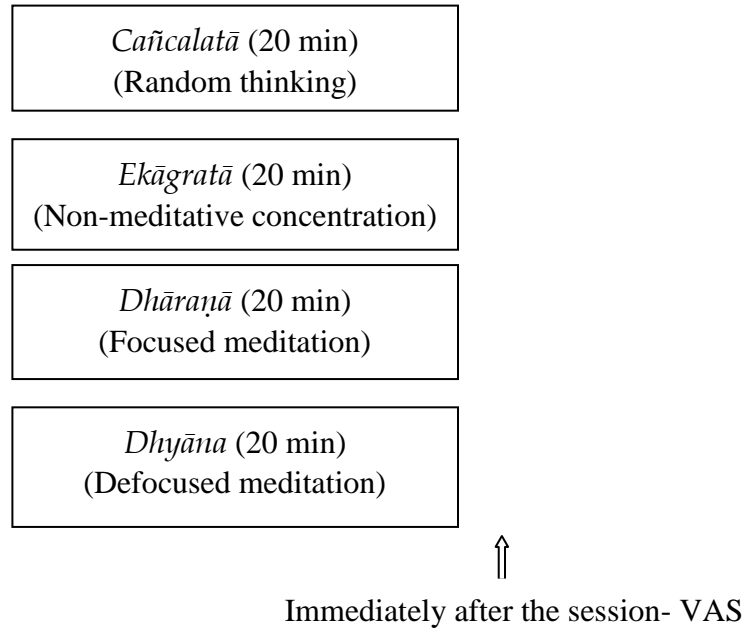


**Note:** D1: During 1; D2: During 2; D3: During 3; D4: During 4

**Figure 3. Schematic representation of the study design of measuring the performance in attentional tasks**



**Figure 4. Schematic representation of the study design for administering visual analog scale to assess the ability to follow guided instructions**



### 5.3 VARIABLES STUDIED

The word parameter is described as ‘characteristic of distribution or relationship in the population which are estimated by statistical analysis of a sample of observations’ whereas, the word variable denotes ‘measurement or attribute on which observations are made’ (Altman, Gore, Gardner & Pocock, 1993). Hence, in this thesis, the term ‘variable’ has been used to describe the assessments studied.

#### 5.3.1 Mid-latency auditory evoked potentials (MLAEPs)

##### 5.3.1. A. Rationale for studying mid-latency auditory evoked potentials.

MLAEPs have been used to assess cortical and subcortical changes in meditation (Telles et al., 1994). It is believed that even if the main changes occur in the cortex,

corticoefferent connections would result in subcortical changes (Woods & Clayworth, 1986). The auditory modality of stimuli was chosen as it was found to be least disturbing to the meditator during their practice (Telles et al., 1993). Hence, in the present study the mid-latency auditory evoked potentials were recorded using Nicolet Bravo System (USA). **Plate 1** shows the Nicolet Bravo EP 4 channels amplifier and closed circuit T.V.

### ***5.3.1. B. Specifications of Nicolet Bravo System***

The Bravo EP (Nicolet, USA) is a 4-channel evoked potential acquisition and review system with options of performing wide variety of tests such as Auditory, Somatosensory, Visual Evoked Potentials and P300 Event Related Potentials (ERP). The Bravo EP amplifier has 4 acquisition channels, a head-box for electrode connections and a LED electrode impedance panel. To perform AEP tests, acoustically shielded earphone is used to deliver either ‘tone’ or ‘click’ stimulus. The acoustic stimulus intensity (in dB) has the following options: sound pressure level (SPL), peak sound pressure level (pSPL), peak equivalent sound pressure level (peSPL) and normal hearing level (nHL). In this study normal hearing level (nHL) was used for acquisition. Percent error calculated for Nicolet Bravo System was 0.03 percent.

**Plate 1: Bravo Evoked Potentials System, Nicolet, USA.**



**Nicolet Bravo system (Nicolet Biomedicals, U.S.A.) a 4-channel EP acquisition and analysis system with a closed circuit TV on the left.**

**A subject seated in a sound attenuated cabin with electrodes at Cz (active) referred to linked ear lobe and a ground electrode (FPz), with acoustically shielded ear phones to deliver binaural clicks during the recording of MLAEPs.**



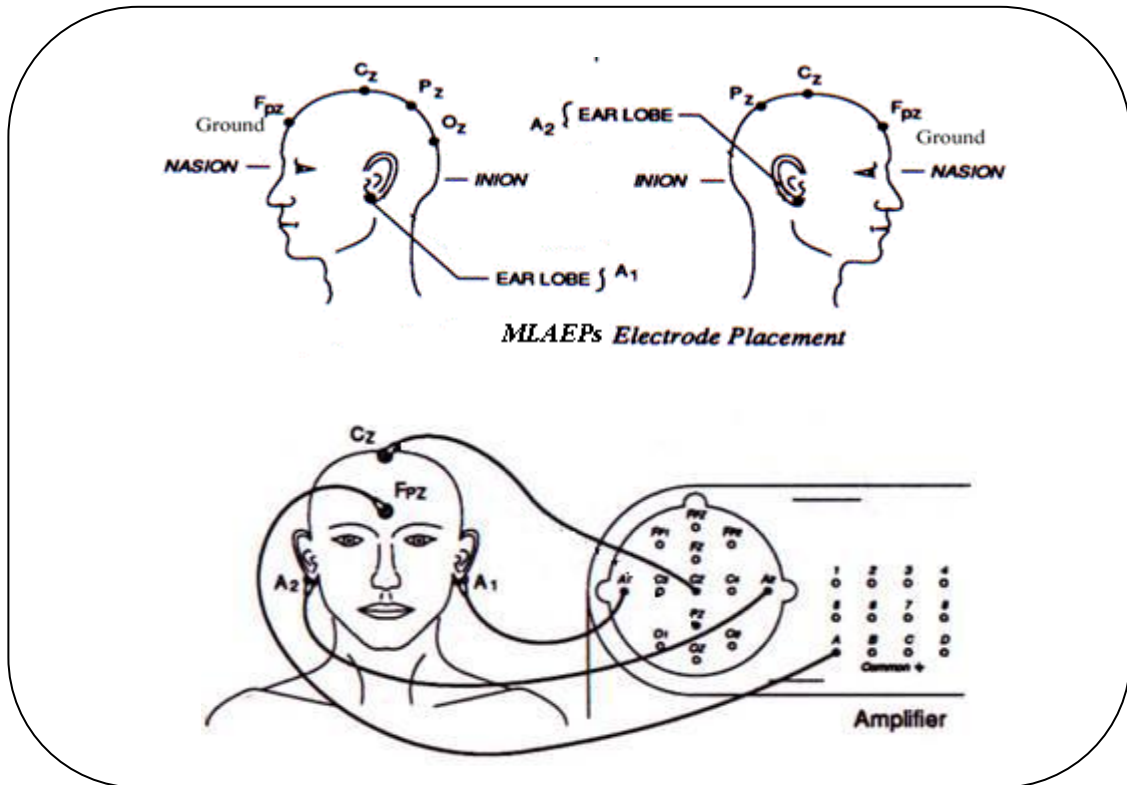
### ***5.3.1. C Recording condition***

The participants were individually assessed in a sound attenuated and dimly lit cabin with eyes closed. The recording leads were led out of the cabin, and connected to the Nicolet Bravo System (USA). The participants were monitored on a closed-circuit television and instructions were given through two-way intercom, so that participants could remain undisturbed during a session.

### ***5.3.1. D Electrode positions***

Silver chloride disk electrodes were affixed with electrode gel (Ten 20 conductive EEG paste, D.O. Weaver and Co. USA) at the Cz (vertex) scalp site, referred to linked earlobes (A1-A2) with a ground electrode on forehead (FPz). The placement of the electrode was done according to the International 10-20 system (Jasper, 1958; Refer to **Figure 5**). In all cases, the electrode impedance was kept below 5 k $\Omega$  at all the sites.

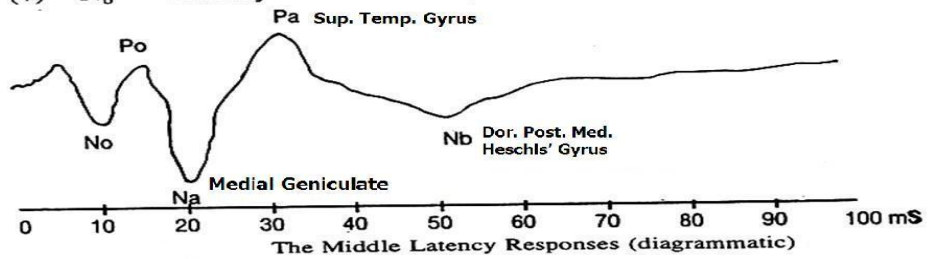
Figure 5. Electrode sites and schematic of measuring latency and amplitude of midlatency responses



**A typical middle latency auditory evoked response**

Universally accepted nomenclature of the MLR waves is :

- |       |                |         |                              |
|-------|----------------|---------|------------------------------|
| (i)   | No.            | Latency | 8–10 ms (mean 9 ms)          |
| (ii)  | P <sub>o</sub> | Latency | 10–14 ms (mean 12 ms)        |
| (iii) | N <sub>a</sub> | Latency | 14–19 ms (mean around 18 ms) |
| (iv)  | P <sub>a</sub> | Latency | 25–32 ms (mean around 30 ms) |
| (v)   | N <sub>b</sub> | Latency | 35–65 ms (mean around 50 ms) |



### ***5.3.1.E. Amplifier settings***

Mid-latency auditory evoked potentials (MLAEPs) were recorded using the Nicolet Bravo System (U.S.A). The MLAEPs were computer averaged in 1500 trial sweeps, in the 10-100 ms range. The electroencephalographic (EEG) activity was amplified with a sensitivity of 50 $\mu$ V and filter bandpass 5 to 1000 Hz. The artifact rejection was kept at 90%. There was no pre-stimulus delay.

### ***5.3.1.F. Stimulus characteristics***

Binaural click stimuli of alternating polarity and 50  $\mu$ s in duration with a frequency of 5 Hz were used to trigger online averaging of the EEG. The stimulus intensity was kept at 80 dBnHL which was shown in a previous study to be adequate to evoke the responses without disturbing the subjects' attention to the breathing practices (Telles, Joseph, Venkatesh & Desiraju, 1993; Raghuraj & Telles, 2004).

### ***5.3.1.G. Recording procedure***

Participants were asked to avoid substances which influence cognitive performance (e.g., coffee, containing caffeine) for the day preceding and the day of the recording. Where this was unavoidable, the session was taken on another day. Mid-latency auditory evoked potentials were recorded with the eyes closed sitting position. A trial session was given to rule out any hearing deficit and their hearing threshold for each ear was determined separately by giving monaural click stimuli through close fitting ear phones (TDH-39, Amplivox, UK). Mid-latency responses were recorded before, during, and after the intervention.

### 5.3.1.H. Variables measured

The following variables were measured:

1. Peak latencies (ms) of mid-latency responses of Na, Pa, and Nb waves were recorded from Cz position (vertex electrode site).
2. Peak amplitudes ( $\mu\text{V}$ ) of mid-latency responses of Na, Pa, and Nb waves recorded from Cz position (vertex electrode site).

### 5.3.2 d2 test of attention

The d2 test of attention is essentially a cancellation task, which measures selective attention and concentration. A sample worksheet of d2 test of attention is given in **Appendix-3**.

#### 5.3.2.A Testing procedure

The d2 test is a timed test of selective attention and concentration (Brickenkamp & Zillmer, 1998). The one page test form provides sections for recording data about the subject, test scores and has a practice sample. On the reverse side is the standardized test, consisting of 14 lines, each comprised of 47 characters for a total of 658 items. The test items are composed of the characters “d” and “p” with one to four dashes, arranged either individually or in pairs above and below the letter. The subject is required to scan across each line to identify and cross out all “d’s” with two dashes. The subject is allowed 20 seconds per line.

This test was administered before and after the practice of the *dhāraṇā* and *ekāgratā*. After one week of wash-out period, the order of the sessions was reversed and assessments were done before and after the sessions. Participants who did

*dharana* first, practiced *ekagrata* second and those who did *ekagrata* first, practiced *dharana* second. This one week gap was given to wash out any possible learning effect.

### **5.3.2.B Reliability and validity of the test**

Reliability refers to the consistency of measurement which is reflected in the reproducibility of the scores. The reliability was tested on different scoring indices and with a variety of methods. The internal stability of test indices, TN, TN – E and CP demonstrated to be very high ( $r > 0.90$ ). Reliability coefficients of E% are expected to be lower. The stability of E% is less affected in test-retest experiments, and thus, this can be improved with re-testing. In a series of test-retests, and intervals of up to 40 months, d2 test indices TN, TN-E and CP demonstrated to be reliable at  $r > 0.70$  (Brickenkamp & Zillmer, 1998).

Validity is defined as the extent to which the instrument measures what it suppose to measure. The validity of the test is documented by multiple clinical and empirical applications of the test in a large number of studies (Brickenkamp & Zillmer, 1998).

### **5.3.3 Digit symbol substitution test (DSST)**

The digit symbol substitution test is a pencil and paper test of psychomotor performance in which the subject is given a key grid of numbers and matching symbols and a test section with numbers and empty boxes. It is used to assess the perceptual - motor speed during copying, visual scanning, and incidental learning. A sample worksheet of letter copying task is given in **Appendix-4**.

### ***5.3.3.A Testing procedure***

The Digit Symbol Test is a subset of the Wechsler Adult Intelligence Scale-Revised (WAISR) administered using paper and pencil (Wechsler, 1981). It measures sustained attention, response speed, and visuo-motor coordination. The participant is given a key grid of numbers and matching symbols and a test section with numbers and empty boxes. The test consists of filling in as many empty boxes as possible with a symbol matching each number. Ninety seconds were given to complete the task. The score was computed as the number of correctly substituted symbols within the 90-s time limit. To avoid a re-test effect parallel worksheets were prepared by changing the digit-symbol pairs in the key and by randomly changing the sequence of digits in the working section. This test was administered before and after the practice of the dharana and ekagrata.

### ***5.3.3.B Reliability and validity of the task***

The digit symbol substitution test has been shown to be reliable and valid based on previous study (Matarazzo and Herman, 1984).

### **5.3.4 Visual analog scale (VAS)**

A Visual Analogue Scale (VAS) is an instrument that tries to measure a characteristic or attitude that is believed to range across a continuum of values and cannot easily be directly measured (Wewers & Lowe, 1990). A sample of visual analog scale is given in **Appendix-5**.

#### ***5.3.4.A Testing procedure***

Visual analogue scale is horizontal line, 10 cm in length, anchored by word descriptors at each end. Immediately after the session, participants were asked to mark on the line which represents how much they were able to follow the guided instructions for the four mental states.

#### ***5.3.4.B Reliability and validity of the task***

Visual analog scale was used to assess the ability to follow the guided instructions for the first time. The visual analog scale is a common method for rapidly gathering quantifiable subjective ratings in both research and clinical settings. This method of rating is thought to provide greater sensitivity for reliable measurement of subjective phenomena, such as various qualities of pain or mood (Pfennings, Cohen & van der Ploeg, 1995). Reliability of visual analog scale in measuring acute pain was observed to be adequately high (Bijur, Silver & Gallagher, 2001). Another study reports that the reliability of visual analog scale in patients with chronic musculoskeletal pain is at moderate to good level however, with questionable validity (Boonstra et al., 2008).

#### 5.4 INTERVENTIONS

Throughout all sessions participants sat cross legged and kept their eyes closed following prerecorded instructions. An emphasis was placed on carrying out the practices slowly, with awareness of physical and mental sensations, and relaxation. Participants were given a 3 month meditation orientation program under the guidance of an experienced meditation teacher. The purpose of this orientation was for all participants to practice the two different states of meditation, viz., *dhāraṇā* and *dhyāna* based on specific instructions. The evaluation of the participants' practice of *dhāraṇā* and *dhyāna* was based on their self-report as well as consultations with the meditation teacher. A brief description of each session is given below.

##### ***Cañcalatā* (Random thinking)**

Participants were asked to allow their thoughts to wander freely as they listened to a compiled audio CD consisting of brief periods of conversation, announcements, advertisements, and talks on multiple topics recorded from a local radio station transmission. All these conversations were unconnected and were believed to induce a state of random thinking.

##### ***Ekāgratā* (Focusing without meditation)**

Participants listened to a prerecorded lecture on meditation. This was not about meditation, on the syllable 'Om', but about meditation, in general. It was speculated that listening to a lecture on a particular topic could induce the state of non-meditative focused thinking.

***Dhāraṇā* (Focused meditation)**

Participants were asked to follow the audio instructions for the practice of *dhāraṇā*. The meditative focusing on the Sanskrit syllable ‘Om’ consisted of mental visualization of the symbol ‘Om’. *Dhāraṇā* involves conscious effort to keep the thoughts restricted to those given in the instructions.

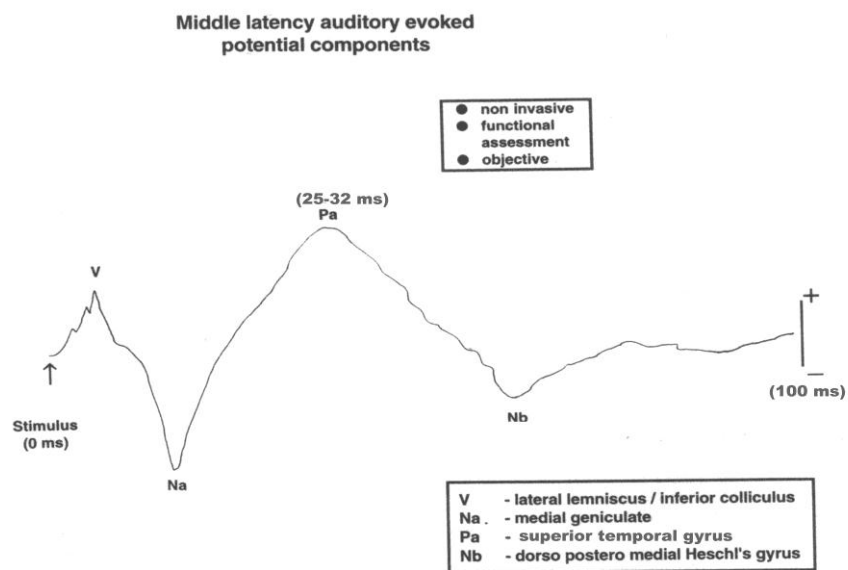
***Dhyāna* (Meditative defocusing or effortless meditation)**

Participants were asked to follow the audio instruction for the practice of *dhyāna*. They were supposed to absorb with the object of meditation without any effort. *Dhyāna* involves effortless defocusing induced by mental chanting of ‘Om’.

## 5.5 DATA EXTRACTION

### 5.5.1. Mid-latency auditory evoked potentials (MLAEPs):

Components of MLAEP, viz, Na, Pa, and Nb waves, were measured from a zero DC baseline. Peak latency was measured from the time of click delivery. The peak latencies and peak amplitudes of the following components were measured: the Na wave (a negative wave between 14 and 19 ms), is the maximum negative peak preceding the Pa wave which is a positive component between 25 and 32 ms. The Nb wave, which is a negative component between 35 and 65 ms, is also the first maximum negative component immediately following the Pa wave (Morlet et al., 1997).



**Figure 6: A typical waveform of mid-latency auditory evoked potentials**

The waveforms were visually inspected off-line for artifact, and the peak latency and the peak amplitude were obtained by selection with the cursor. The

selection was performed by the experimenter. A sample record of middle latency responses using Nicolet Bravo EP system (U.S.A.) is presented in **Plate 1**.

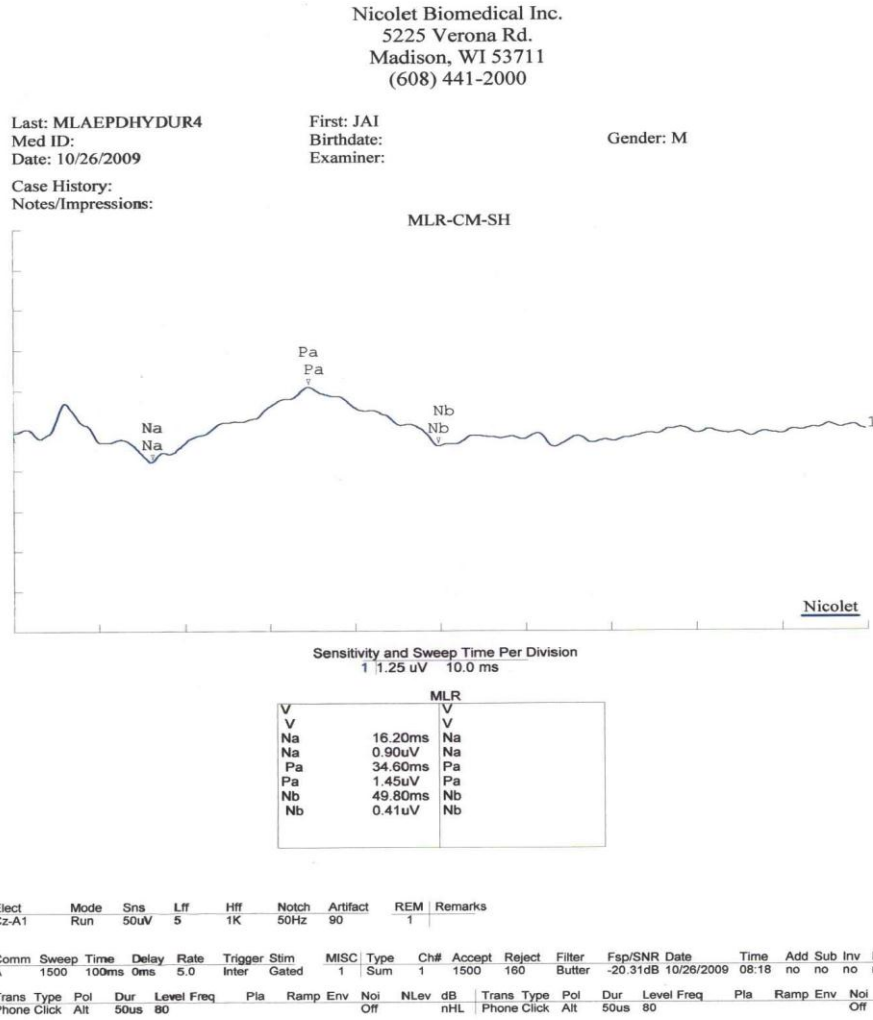
**Neural generators for MLAEPs:**

Peak latency (msec) is defined as the time from stimulus onset to the point of maximum positive amplitude within the latency window. Peak amplitude ( $\mu\text{v}$ ) is defined as the voltage difference between a pre-stimulus baseline and the largest positive peak within a given latency window.

The latencies and the neural generators for the 3 MLAEP components are given below:

<b>MLAEP components</b>	<b>Latency (msec)</b>	<b>Neural Generator</b>
Na wave	14-19	Medial geniculate body
Pa wave	25-32	Superior temporal gyrus
Nb wave	35-65	Dorso-posterior-medial part of the Heschl's gyrus i.e., the primary auditory cortex

**Figure: 7: Sample record of MLR responses measured using Nicolet Bravo EP system**



v 3.2

### 5.5.2 D2 test of attention

Scoring is done with the help of two scoring keys. The following scores have been calculated. TN (total number of items processed), E(errors), E% (percentage of errors), TN-E (total performance), and CP (concentration performance). TN (total number of items processed) is a quantitative, timed measure of all items (both relevant and irrelevant items) that were processed. E (errors) is the sum of all mistakes which includes errors of omission (E1) and the less common errors of commission (E2). TN-E is the total number of items scanned minus error scores (E1+E2). CP (concentration performance) is derived from the number of the correctly crossed out relevant items (“d” with two dashes) minus the errors of commission (E2). E % (percentage of errors) corresponds to the accuracy and the carefulness of performance. TN-E (total performance), and CP (concentration performance) are measures of overall performance on the test.

### 5.5.3 Digit symbol substitution test

The test consists of filling in as many empty boxes as possible with a symbol matching each number. Ninety seconds were given to complete the task. The score was computed by calculating the number of correctly substituted symbols.

The strategy to solve the DSST consists of sequential encoding and retrieval of numbers and matching symbols. First, the number in the test section is encoded in short-term memory and temporarily stored. Then, while the subject visually scans the key grid to search for the number-symbol match, the number in the short-term memory is repeatedly retrieved and compared with the numbers of the key grid. Once the number is recognized, the matching symbol is encoded in short-term memory.

Finally, the attention is turned toward the test section again, and the symbol is retrieved from short-term memory and copied below the number. Incidental memory, perceptual organization, visuomotor coordination, and selective attention are important factors that determine the final score (Wechsler, 1981).

#### **5.5.4 Visual analog scale**

Visual analogue scale is a horizontal line which is 10 cm in length, anchored by word descriptors at each end. Immediately after the session participants were asked to mark on the line which represents how much they were able to follow the guided instructions for the four mental states. The score on a visual analog scale was calculated by measuring the mark using scale. The distance between the mark and left end of the line is the score (in cm).

### **5.6 DATA ANALYSIS**

The raw data obtained for each subject in each recording session were tabulated separately. The group mean values  $\pm$  standard deviation were calculated for all the variables. Statistical analysis was done using SPSS (Version 16.0) in the following steps.

#### **5.6.1 Mid-latency auditory evoked potentials (MLAEPs)**

- Data were tested for normality by the Kolmogorov-Smirnov test.
- Since the same individuals were assessed in repeat sessions on separate days (ie, *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*), repeated measures analyses of variance (ANOVAs) were performed with two ‘within-subjects’ factors, that is factor 1: sessions; *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* and factor 2: states; “pre,” “during” (Dur1 to Dur4), and “Post.”

Repeated measures ANOVAs were carried out for each wave of MLAEPs separately, for both peak latencies and peak amplitudes.

- This was followed by *post hoc* analyses with Bonferroni adjustment for multiple comparisons between the mean values of different states (during and post), and all comparisons were made with the respective pre-state.

### **5.6.2 Performance in attentional tasks [i.e., (a) d2 test of attention and (b) digit symbol substitution test]**

- Data were tested for normality by the Kolmogorov-Smirnov test.
- Since the same individuals were assessed in repeat sessions on separate days (i.e., *ekāgratā* and *dhāraṇā*), repeated measures analysis of variance was used (ANOVA). Repeated measures analysis of variance (ANOVA) was performed with two 'within-subjects' factors, i.e., Factor 1: Sessions; *ekāgratā* and *dhāraṇā* and Factor 2: States; “Pre”, and “Post”.
- This was followed by a *post-hoc* analyses with Bonferroni adjustment comparing ‘pre’ with ‘post’ values.

### **5.6.3 Visual analog scale**

- Data were tested for normality by the Kolmogorov-Smirnov test.
- Repeated measures analysis of variance (ANOVA) was performed with one 'within-subjects' factor, i.e., sessions: *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*.
- This was followed by a *post-hoc* analysis with a Bonferroni adjustment for multiple comparisons between the mean values of different sessions.

**CHAPTER – 6.0**  
**RESULTS**

<b>CHAPTER</b>	<b>DETAILS</b>	<b>PAGE.NO.</b>
<b>6.0</b>	<b>RESULTS</b>	<b>90-110</b>
<b>6.1</b>	<b>MID-LATENCY AUDITORY EVOKED POTENTIALS (MLAEPS)</b>	<b>90</b>
<b>6.2</b>	<b>D2 TEST OF ATTENTION</b>	<b>100</b>
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## 6.0 RESULTS

The results of the variables studied during four independent sessions i.e., *cañicalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* are described below. These are (i) mid-latency auditory evoked potentials (MLAEPs) recorded before, during and after the interventions. (ii) d2 test of attention and (iii) digit symbol substitution test administered before and after *ekāgratā* and *dhāraṇā*. (iv) subjective assessment (visual analog scale) was done immediately after the practice of four sessions.

### 6.1 MID-LATENCY AUDITORY EVOKED POTENTIALS (MLAEPs)

#### 6.1.1 Recapitulation

The mid-latency auditory evoked potentials were recorded in sixty participants during *cañicalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* sessions. Three main components have been studied which occur in the mid-latency range (i.e., 0-100 ms). These 3 components are the Na wave (the maximum negativity occurring between 14 to 19 ms) the Pa wave (the maximum positivity between the Na wave and 35 ms) and the Nb wave (the maximum negativity between 35 and 65 ms). For each of these 3 components the peak latencies and peak amplitudes were calculated. In each session there were six epochs viz., Pre, During 1, During 2, During 3, During 4, and Post. The potentials were recorded from Cz (vertex) site and referenced to linked earlobes (A1-A2). Repeated measures ANOVAs were carried out for each wave of MLAEPs separately, for both peak latencies and peak amplitudes. This was followed by *post hoc* analyses with Bonferroni adjustment for multiple comparisons between the mean values of different states (during and post), and all

comparisons were made with the respective pre state. The group mean values  $\pm$  S.D. are given in **Table 7** and **Table 8**.

**Table 7. Midlatency Auditory Evoked Potentials showing peak latencies for four Sessions in six States for Na, Pa and Nb waves.****Values are group mean  $\pm$  S.D. n = 60**

Peak latency (ms)							
Waves	Sessions	Pre	During				Post
			During1	During2	During3	During4	
Na Wave	<i>Cañcalatā</i>	16.02 $\pm$ 1.59	16.22 $\pm$ 1.71	16.44 $\pm$ 1.80	16.48 $\pm$ 1.97	15.88 $\pm$ 1.94	16.14 $\pm$ 1.78
	<i>Ekāgratā</i>	16.24 $\pm$ 1.80	16.33 $\pm$ 1.55	16.37 $\pm$ 1.53	16.34 $\pm$ 1.90	16.32 $\pm$ 1.73	16.26 $\pm$ 2.08
	<i>Dhāraṇā</i>	16.03 $\pm$ 1.62	16.36 $\pm$ 1.59	16.36 $\pm$ 1.66	16.44 $\pm$ 1.65	16.33 $\pm$ 1.63	16.01 $\pm$ 1.64
	<i>Dhyāna</i>	15.97 $\pm$ 1.59	16.43 $\pm$ 1.58	16.49 $\pm$ 1.72	16.49 $\pm$ 1.75*	16.43 $\pm$ 1.75	16.13 $\pm$ 1.95
Pa Wave	<i>Cañcalatā</i>	34.76 $\pm$ 2.79	34.47 $\pm$ 2.86	34.82 $\pm$ 2.64	34.58 $\pm$ 2.85	35.30 $\pm$ 2.52	35.17 $\pm$ 2.74
	<i>Ekāgratā</i>	35.01 $\pm$ 2.50	35.28 $\pm$ 2.59	35.38 $\pm$ 1.70	35.33 $\pm$ 2.00	34.93 $\pm$ 2.48	35.50 $\pm$ 2.38
	<i>Dhāraṇā</i>	34.95 $\pm$ 2.61	35.44 $\pm$ 1.87	35.08 $\pm$ 2.35	35.70 $\pm$ 2.39	35.32 $\pm$ 2.38	35.17 $\pm$ 3.17
	<i>Dhyāna</i>	34.60 $\pm$ 2.89	35.18 $\pm$ 2.35	35.19 $\pm$ 2.57	35.33 $\pm$ 2.58	35.55 $\pm$ 2.08*	35.25 $\pm$ 2.78
Nb Wave	<i>Cañcalatā</i>	52.73 $\pm$ 9.01	53.01 $\pm$ 8.30	53.63 $\pm$ 8.47	54.01 $\pm$ 8.05	55.48 $\pm$ 8.09	54.77 $\pm$ 8.96
	<i>Ekāgratā</i>	53.76 $\pm$ 9.15	53.38 $\pm$ 7.93	54.01 $\pm$ 7.68	55.88 $\pm$ 8.31	56.09 $\pm$ 8.70	56.86 $\pm$ 9.03*
	<i>Dhāraṇā</i>	53.39 $\pm$ 8.96	53.71 $\pm$ 7.70	55.12 $\pm$ 8.35	55.16 $\pm$ 7.94	54.46 $\pm$ 8.40	54.66 $\pm$ 8.77
	<i>Dhyāna</i>	53.29 $\pm$ 8.75	53.25 $\pm$ 8.17	54.40 $\pm$ 8.35	55.43 $\pm$ 7.89	55.19 $\pm$ 8.21	54.93 $\pm$ 8.55

\*p &lt; 0.05, RM-ANOVA with Bonferroni adjustment comparing During and Post values with Pre values.

**Table 8. Midlatency Auditory Evoked Potentials showing peak amplitude for four Sessions in six States for Na, Pa and Nb waves. Values are group mean  $\pm$  S.D. n= 60**

Peak amplitude ( $\mu$ V)							
Waves	Sessions	Pre	During				Post
			During1	During2	During3	During4	
Na Wave	<i>Cañcalatā</i>	0.60 $\pm$ 0.53	0.47 $\pm$ 0.29	0.51 $\pm$ 0.40	0.44 $\pm$ 0.36	0.48 $\pm$ 0.34	0.50 $\pm$ 0.44
	<i>Ekāgratā</i>	0.58 $\pm$ 0.54	0.52 $\pm$ 0.43	0.51 $\pm$ 0.41	0.50 $\pm$ 0.31	0.50 $\pm$ 0.37	0.44 $\pm$ 0.40
	<i>Dhāraṇā</i>	0.54 $\pm$ 0.47	0.49 $\pm$ 0.38	0.45 $\pm$ 0.38	0.44 $\pm$ 0.42	0.54 $\pm$ 0.42	0.57 $\pm$ 0.58
	<i>Dhyāna</i>	0.49 $\pm$ 0.43	0.52 $\pm$ 0.43	0.49 $\pm$ 0.39	0.42 $\pm$ 0.30	0.47 $\pm$ 0.38	0.64 $\pm$ 0.62
Pa Wave	<i>Cañcalatā</i>	1.33 $\pm$ 0.47	0.84 $\pm$ 0.35***	0.77 $\pm$ 0.30***	0.83 $\pm$ 0.43***	0.90 $\pm$ 0.37***	1.32 $\pm$ 0.59
	<i>Ekāgratā</i>	1.22 $\pm$ 0.61	0.95 $\pm$ 0.43***	0.93 $\pm$ 0.43***	1.00 $\pm$ 0.45*	0.98 $\pm$ 0.52*	1.42 $\pm$ 0.58
	<i>Dhāraṇā</i>	1.28 $\pm$ 0.54	1.08 $\pm$ 0.51**	1.23 $\pm$ 0.48	1.26 $\pm$ 0.47	1.29 $\pm$ 0.47	1.32 $\pm$ 0.48
	<i>Dhyāna</i>	1.30 $\pm$ 0.63	1.20 $\pm$ 0.61	1.13 $\pm$ 0.58*	1.17 $\pm$ 0.52	1.19 $\pm$ 0.60	1.26 $\pm$ 0.62
Nb Wave	<i>Cañcalatā</i>	0.42 $\pm$ 0.30	0.32 $\pm$ 0.29	0.35 $\pm$ 0.30	0.42 $\pm$ 0.29	0.34 $\pm$ 0.30	0.48 $\pm$ 0.40
	<i>Ekāgratā</i>	0.41 $\pm$ 0.37	0.31 $\pm$ 0.28	0.38 $\pm$ 0.27	0.42 $\pm$ 0.33	0.41 $\pm$ 0.30	0.50 $\pm$ 0.38
	<i>Dhāraṇā</i>	0.46 $\pm$ 0.38	0.40 $\pm$ 0.28	0.44 $\pm$ 0.35	0.45 $\pm$ 0.37	0.44 $\pm$ 0.37	0.49 $\pm$ 0.39
	<i>Dhyāna</i>	0.45 $\pm$ 0.37	0.42 $\pm$ 0.31	0.37 $\pm$ 0.31	0.43 $\pm$ 0.32	0.46 $\pm$ 0.38	0.54 $\pm$ 0.37

\* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ ; RM-ANOVA with Bonferroni adjustment comparing During and Post values with Pre values.

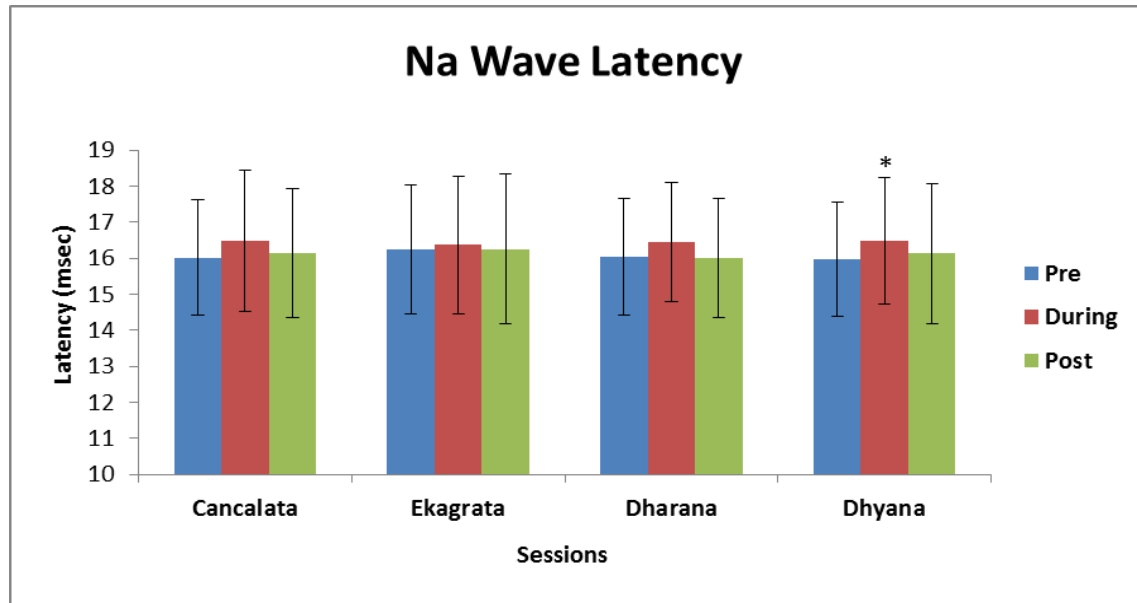
### 6.1.2 Peak latency of MLAEPs

The repeated measures ANOVA which consisted of the two within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā*, *dhyāna*) and (ii) States (Pre, Dur1 to Dur4 and Post) for MLAEPs peak latency (ms) recorded at Cz, showed a significant difference between States for the peak latency of the Na wave [ $F = 3.63$ ,  $df = (4.29, 253.33)$ ,  $p < 0.01$ , Huynh-Feldt epsilon = 0.859] and peak latency of the Nb wave [ $F = 9.30$ ,  $df = (3.58, 211.47)$ ,  $p < 0.001$ , Huynh-Feldt epsilon = 0.717]. And also, there was a significant difference in interaction between Sessions and States for peak latency Pa wave [ $F = 1.86$ ,  $df = (13.38, 789.43)$ ,  $p < 0.05$ , Huynh-Feldt epsilon = 0.892].

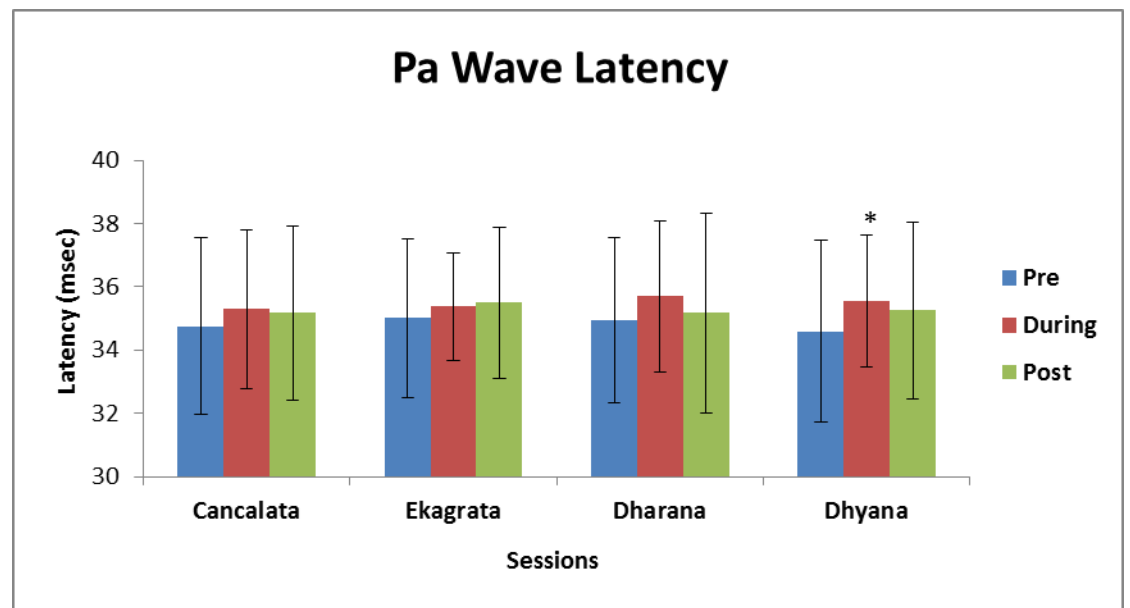
*Post hoc* analyses with Bonferroni adjustment showed significant increase in the peak latencies of Na and Pa waves during meditation ( $P < .05$ ) and of Nb wave in the post-period of ekagrata ( $P < .05$ ) compared to pre-period.

These changes have been indicated in **Table 7** and in graphs - **Figure 8**, **Figure 9** and **Figure 10**. The actual data of individual participants in *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna* sessions are presented with group mean  $\pm$  SD in **Table 15 to Table 26** (See **Appendix-6**).

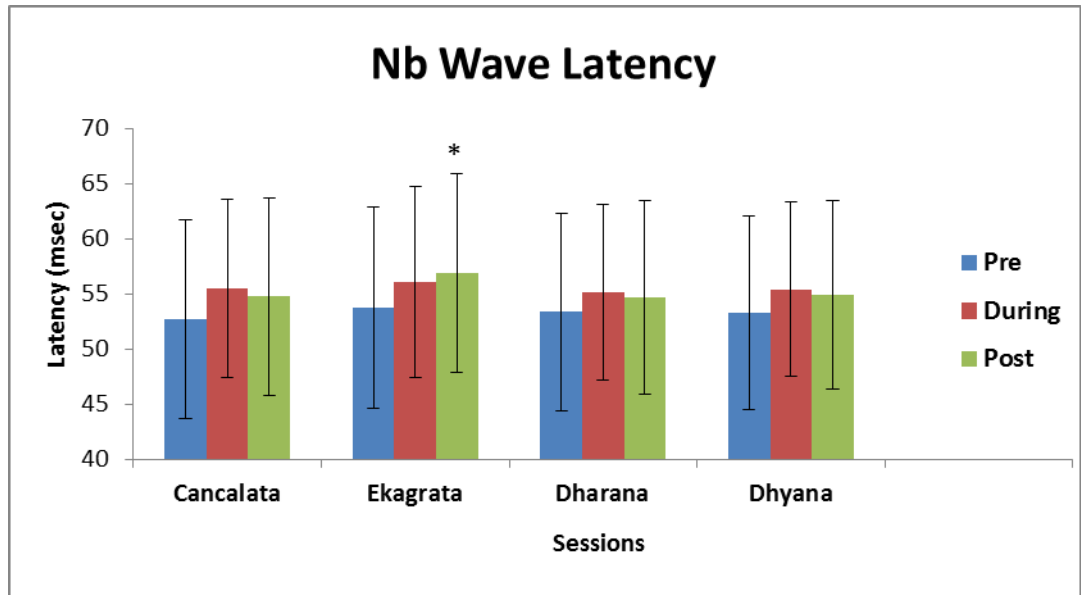
**Figure 8: Peak latencies for Na wave recorded at pre, during and post of *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna* sessions. Values are group mean  $\pm$  SD.**



**Figure 9: Peak Latencies for Pa wave recorded at pre, during and post of *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna* sessions. Values are group mean  $\pm$  SD.**



**Figure 10: Peak Latencies for Nb wave recorded at pre, during and post of *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna* sessions. Values are group mean  $\pm$  SD.**



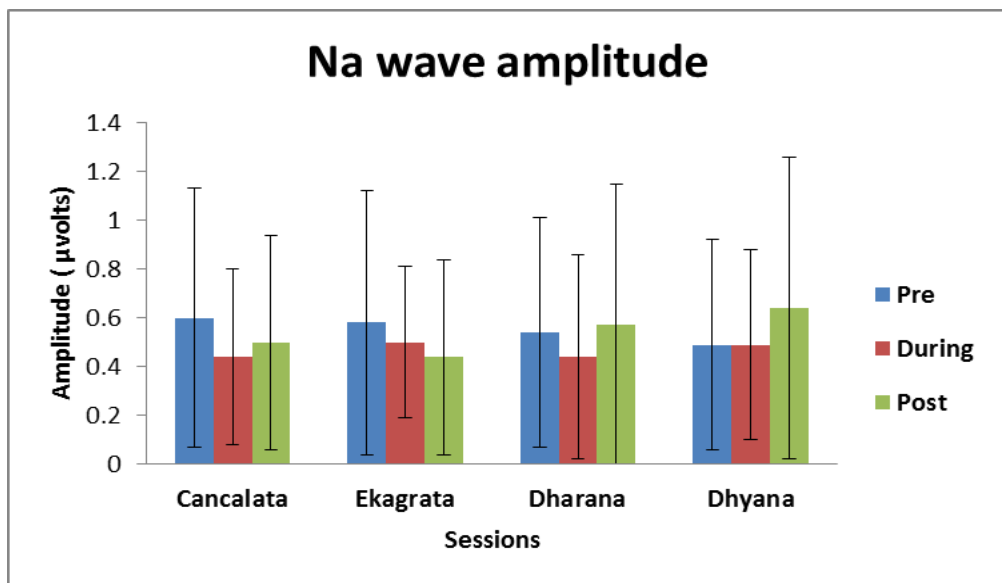
### 6.1.3 Peak amplitude of MLAEPs

The repeated measures ANOVA which consisted of the two within-subjects factors, i.e., (i) Sessions (*cañcalatā*, *ekāgratā*, *dhāraṇā*, *dhyāna*) and (ii) States (Pre, Dur1 to Dur4 and Post) for MLAEPs peak amplitude (ms) recorded at Cz, showed a significant difference between Sessions for the peak amplitude of the Pa wave [ $F = 18.05$ ,  $df = (2.7, 159.56)$ ,  $p < 0.01$ , Huynh-Feldt epsilon = 0.901] and between States for the peak amplitude of the Na wave [ $F = 3.19$ ,  $df = (3.65, 215.35)$ ,  $p < 0.05$ , Huynh-Feldt epsilon = 0.73], peak amplitude of the Pa wave [ $F = 31.56$ ,  $df = (4.27, 252.15)$ ,  $p < 0.001$ , Huynh-Feldt epsilon = 0.855], peak amplitude of the Nb wave [ $F = 5.40$ ,  $df = (4.42, 261.02)$ ,  $p < 0.001$ , Huynh-Feldt epsilon = 0.885]. And also, there was a significant difference in interaction between Sessions and States for peak amplitude of Na wave [ $F = 2.58$ ,  $df = (11.52, 679.91)$ ,  $p < 0.01$ , Huynh-Feldt epsilon = 0.768] and peak amplitude of Pa wave [ $F = 9.69$ ,  $df = (15, 885)$ ,  $p < 0.001$ , Huynh-Feldt epsilon = 0.967].

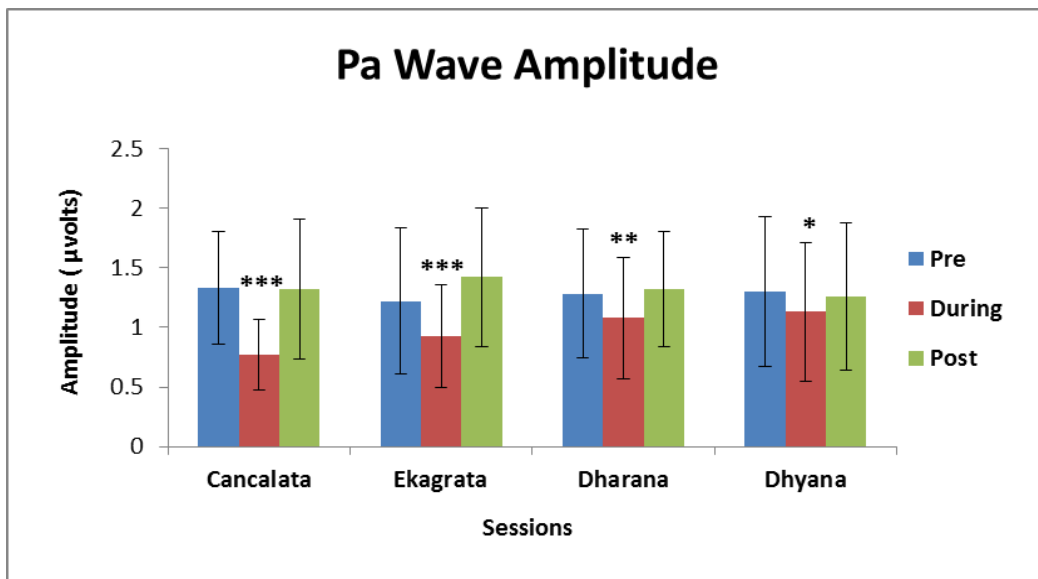
*Post hoc* analyses with Bonferroni adjustment showed significant decrease in peak amplitude of Pa wave during *cañcalatā* ( $P < .001$ ), *ekāgratā* ( $P < .001$ ), *dhāraṇā* ( $P < .01$ ), and *dhyāna* ( $P < .05$ ) compared to the respective pre-states.

These changes have been indicated in **Table 8** and in graphs - **Figure 11**, **Figure 12** and **Figure 13**. The actual data of individual participants in *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna* sessions are presented with group mean  $\pm$  SD in **Table 27** to **Table 38** (See **Appendix-6**).

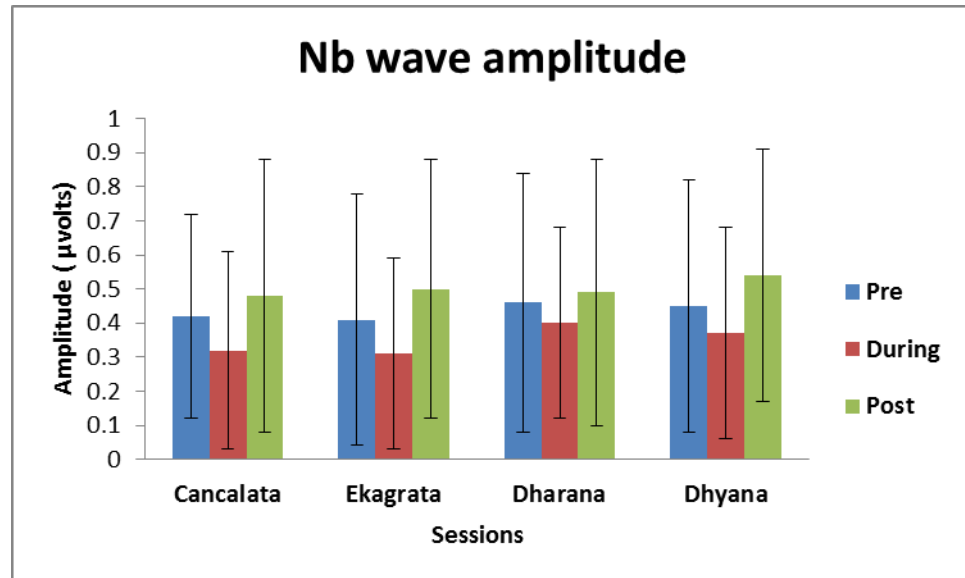
**Figure 11: Peak amplitudes for Na wave recorded at pre, during and post of *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna* sessions. Values are group mean  $\pm$  SD.**



**Figure 12: Peak amplitudes for Pa wave recorded at pre, during and post of *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna* sessions. Values are group mean  $\pm$  SD.**



**Figure 13: Peak amplitudes for Nb wave recorded at pre, during and post of *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna* sessions. Values are group mean  $\pm$  SD.**



## 6.2 D2 TEST OF ATTENTION

### 6.2.1 Recapitulation

The d2 test of attention was administered in sixty participants before and after *ekāgratā* and *dhāraṇā* session. Repeated measures analysis of variance (ANOVA) were performed with two 'within subjects' factors, i.e., Factor 1: Sessions; *ekāgratā* and *dhāraṇā* and Factor 2: States; “Pre”, and “Post”. This was followed by a *post-hoc* analyses with Bonferroni adjustment comparing ‘pre’ with ‘post’ values. The group average values  $\pm$  S.D. are given in **Table 9**.

**Table 9: Scores obtained in d2 test of attention before and after *ekāgratā* and *dhāraṇā*. Values are group mean  $\pm$  S.D. n = 60**

Variable	<i>Ekāgratā</i>		<i>Dhāraṇā</i>	
	Pre	Post	Pre	Post
<b>TN</b>	528.67 $\pm$ 84.27	572.13 $\pm$ 70.83***	531.37 $\pm$ 77.98	580.50 $\pm$ 62.75***
<b>E</b>	53.63 $\pm$ 39.82	45.35 $\pm$ 32.12**	50.22 $\pm$ 33.70	36.92 $\pm$ 26.14***
<b>TN - E</b>	475.03 $\pm$ 82.42	526.78 $\pm$ 73.40***	481.15 $\pm$ 80.09	543.58 $\pm$ 64.09***
<b>E %</b>	10.08 $\pm$ 6.85	7.96 $\pm$ 5.41***	9.52 $\pm$ 5.92	6.36 $\pm$ 4.24***
<b>CP</b>	176.10 $\pm$ 49.45	207.90 $\pm$ 45.79***	181.35 $\pm$ 47.95	219.68 $\pm$ 39.86***

\*\*\* $p < 0.001$ ; RM ANOVA with Bonferroni adjustment comparing Post values with Pre values.

TN: Total number processed; E: Error; CP: Concentration performance

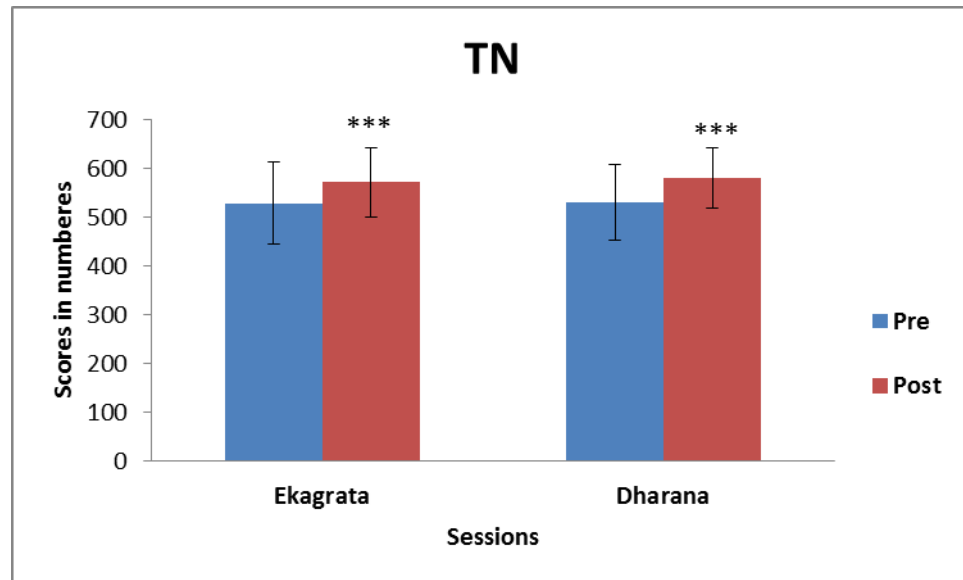
### 6.2.2 TN, E, TN-E, E% and CP

The repeated measures analysis of variance (ANOVA) which consisted of the two within-subjects factors, i.e., (i) Sessions (*ekāgratā* and *dhāraṇā*) and (ii) States (Pre and Post) for d2 test of attention showed a significant difference between States for TN [ $F = 79.13$ ,  $df = (1, 59)$ ,  $p < 0.001$ , Huynh-Feldt epsilon = 1], for E [ $F = 26.69$ ,  $df = (1, 59)$ ,  $p < 0.001$ , Huynh-Feldt epsilon = 1], for TN-E [ $F = 161.88$ ,  $df = (1, 59)$ ,  $p < 0.001$ , Huynh-Feldt epsilon = 1], for E% [ $F = 59.14$ ,  $df = (1, 59)$ ,  $p < 0.001$ , Huynh-Feldt epsilon = 1], and for CP [ $F = 201.43$ ,  $df = (1, 59)$ ,  $p < 0.001$ , Huynh-Feldt epsilon = 1]. There was no change in Sessions and interaction between Sessions and States.

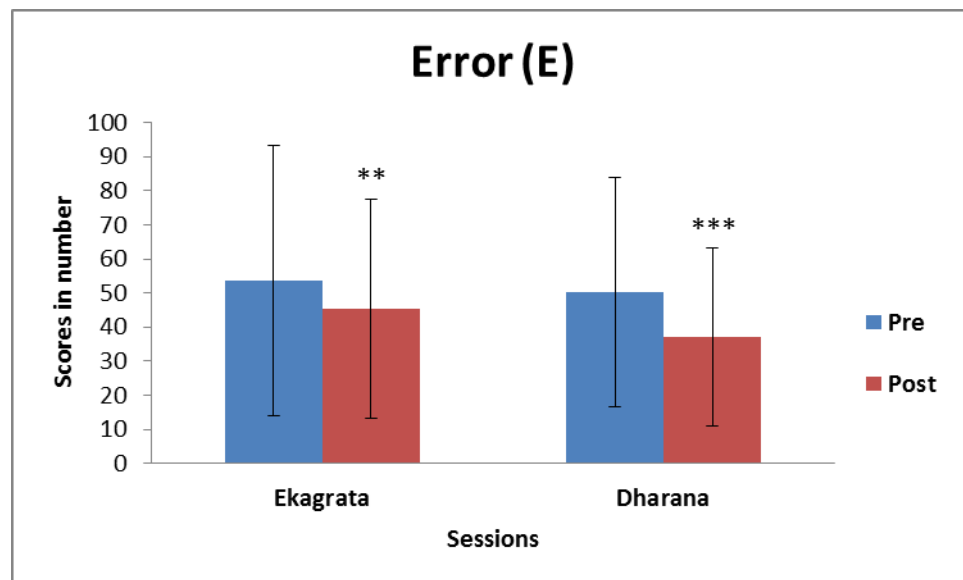
*Post hoc* analyses with Bonferroni adjustment showed significant increase in total number processed (TN), TN – E, and concentration performance (CP) after *ekāgratā* as well as *dhāraṇā* ( $P < 0.001$ ). There was a significant decrease in errors (E) after *ekāgratā* ( $P < 0.01$ ) and *dhāraṇā* ( $P < 0.001$ ). And also, there was a significant decrease in E% after *ekāgratā* ( $P < 0.001$ ) and *dhāraṇā* ( $P < 0.001$ ).

These changes have been indicated in **Table 9** and in graphs - **Figure 14**, **Figure 15**, **Figure 16**, **Figure 17**, and **Figure 18**. The actual data of individual participants in *ekāgratā* and *dhāraṇā* sessions are presented with group mean  $\pm$  SD in **Table 39 to Table 43** (See **Appendix-6**).

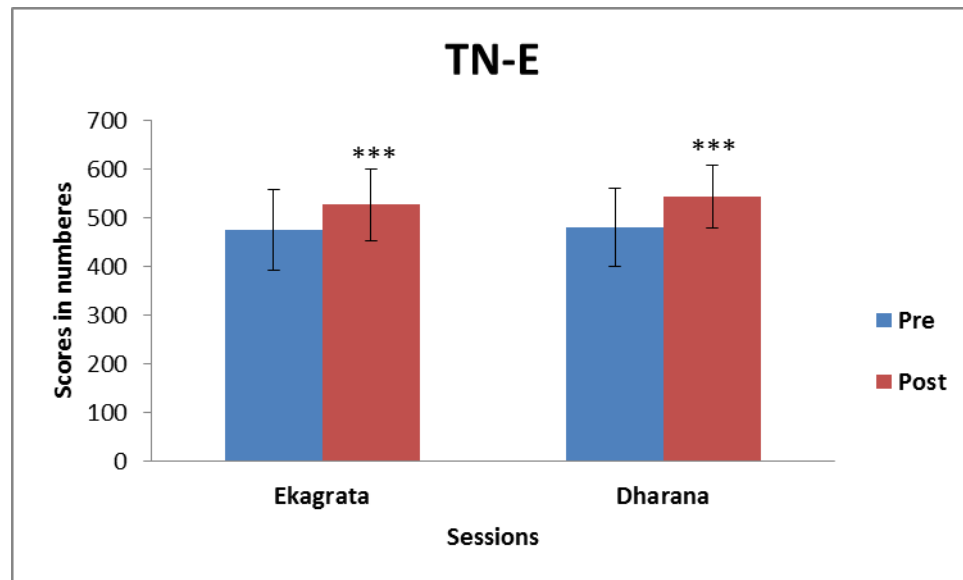
**Figure 14: Total number processed (TN) in d2 test of attention administered before and after *ekāgratā* and *dhāraṇā* session. Values are groups mean  $\pm$  S.D.**



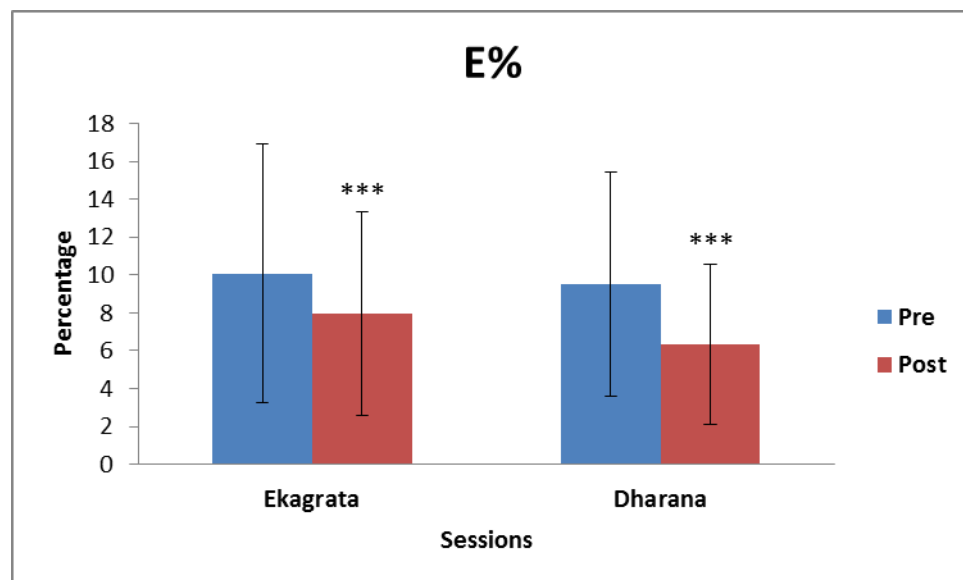
**Figure 15: Error (E) in d2 test of attention administered before and after *ekāgratā* and *dhāraṇā* session. Values are groups mean  $\pm$  S.D.**



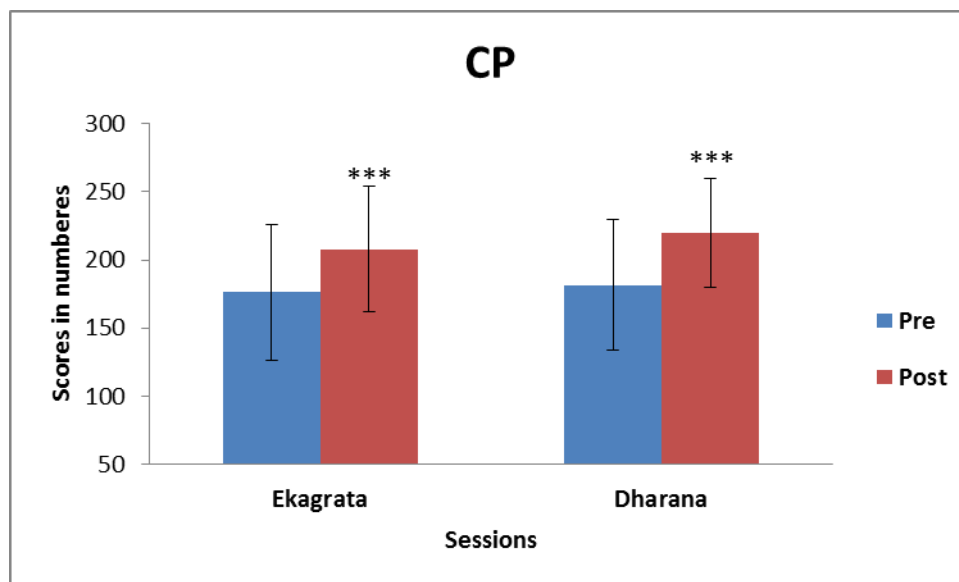
**Figure 16: TN - E in d2 test of attention administered before and after *ekāgratā* and *dhāraṇā* session. Values are groups mean  $\pm$  S.D.**



**Figure 17: E% in d2 test of attention administered before and after *ekāgratā* and *dhāraṇā* session. Values are groups mean  $\pm$  S.D.**



**Figure 18: Concentration performance (CP) in d2 test of attention administered before and after *ekāgratā* and *dhāraṇā* session. Values are groups mean  $\pm$  S.D.**



### 6.3 DIGIT SYMBOL SUBSTITUTION TEST

#### 6.3.1 Recapitulation

The digit symbol substitution was administered in sixty participants before and after *ekāgratā* and *dhāraṇā* session. Repeated measures analysis of variance (ANOVA) were performed with two 'within subjects' factors, i.e., Factor 1: Sessions; *ekāgratā* and *dhāraṇā* and Factor 2: States; “Pre”, and “Post”. This was followed by a *post-hoc* analyses with Bonferroni adjustment comparing ‘pre’ with ‘post’ values. The group average values  $\pm$  S.D. are given in **Table 10**.

**Table 10: Scores obtained in digit symbol substitution test before and after *ekāgratā* and *dhāraṇā*. Values are group mean  $\pm$  S.D. n = 60**

Variable	<i>Ekagrata</i>		<i>Dharana</i>	
	Pre	Post	Pre	Post
<b>Total scores</b>	55.53 $\pm$ 11.76	57.82 $\pm$ 10.80	57.13 $\pm$ 11.43	64.67 $\pm$ 10.54 ***

\*\*\* $p < 0.001$ ; RM ANOVA with Bonferroni adjustment comparing Post values with Pre values.

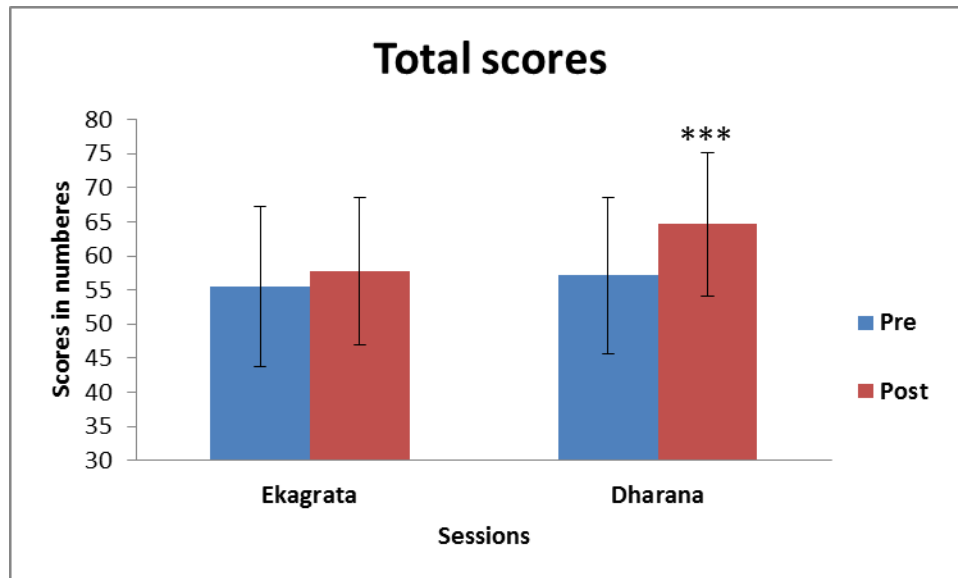
### 6.3.2 Total score

The repeated measures analysis of variance (ANOVA) which consisted of the two within-subjects factors, i.e., (i) Sessions (*ekāgratā* and *dhāraṇā*) and (ii) States (Pre and Post) for total scores in digit symbol substitution test showed a significant difference between Sessions [ $F = 14.86$ ,  $df = (1, 59)$ ,  $p < 0.001$ , Huynh-Feldt epsilon = 1], and between States [ $F = 40.43$ ,  $df = (1, 59)$ ,  $p < 0.001$ , Huynh-Feldt epsilon = 1]. And also, there was significant difference in interaction between Sessions and States [ $F = 11.13$ ,  $df = (1, 59)$ ,  $p < 0.01$ , Huynh-Feldt epsilon = 1].

*Post hoc* analyses with Bonferroni adjustment showed significant increase in digit symbol substitution test scores after *dhāraṇā* ( $P < 0.001$ ) while *ekāgratā* showed no change.

These changes have been indicated in **Table 10** and in graph - **Figure 19**. The actual data of individual participants in *ekāgratā* and *dhāraṇā* sessions are presented with group mean  $\pm$  SD in **Table 44** (See **Appendix-6**).

**Figure 19: Scores obtained in digit symbol substitution test before and after *ekāgratā* and *dhāraṇā*. Values are group mean  $\pm$  S.D.**



## 6.4 VISUAL ANALOG SCALE

### 6.4.1 Recapitulation

Subjective assessment (visual analog scale) to follow guided instructions was studied in sixty participants following *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*. Repeated measured analysis of variance (ANOVA) performed with one 'within subjects' factor, i.e., sessions: *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna*. The group mean values  $\pm$  S.D. are given in **Table 11**.

### 6.4.2 Scores on visual analog scale

Repeated measured analysis of variance (ANOVA) performed with one 'within subjects' factor, i.e., sessions: *cañcalatā*, *ekāgratā*, *dhāraṇā*, and *dhyāna* showed significant differences between sessions [ $F = 31.04$ ,  $df = (2.46, 145.13)$ , Huynh-Feldt epsilon = 0.820,  $p < 0.001$ ].

*Post-hoc* analyses with a Bonferroni adjustment were performed to see the changes between the sessions. Following *dhāraṇā*, scores on the visual analog scale were significantly lower compared to those for *cañcalatā* ( $p < 0.001$ ), *ekāgratā* ( $p < 0.001$ ), and *dhyāna* ( $p < 0.001$ ).

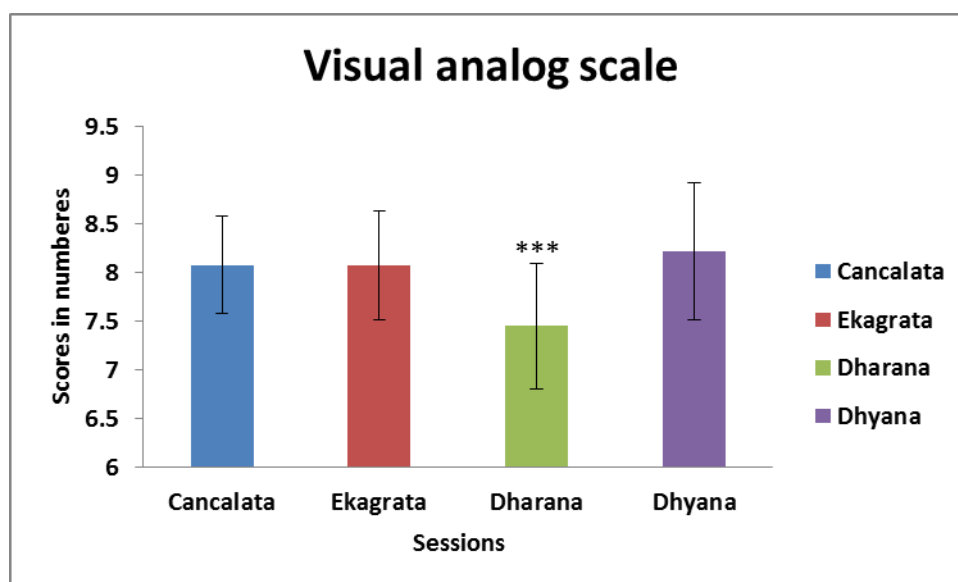
These changes have been indicated in **Table 11** and in graph - **Figure 20**. The actual data of individual participants in *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* sessions are presented with group mean  $\pm$  SD in **Table 45** (See **Appendix-6**).

**Table 11: Scores on visual analog scale following *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*. Values are groups mean  $\pm$  S.D. n = 60**

Sessions	<i>Cañcalatā</i>	<i>Ekāgratā</i>	<i>Dhāraṇā</i>	<i>Dhyāna</i>
Mean	8.08 $\pm$ 0.50	8.07 $\pm$ 0.56	7.45 $\pm$ 0.65	8.22 $\pm$ 0.70
$\pm$ S.D.			***	

\*\*\* Comparing *dhāraṇā* with *cañcalatā*, *ekāgratā*, and *dhyāna* sessions shows significant differences with all three ( $p < 0.001$  for each).

**Figure 20: Scores on visual analog scale following *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*. Values are groups mean  $\pm$  S.D.**



# **CHAPTER – 7.0**

## **DISCUSSIONS**

<b>CHAPTER</b>	<b>DETAILS</b>	<b>PAGE.NO</b>
<b>7.0</b>	<b>DISCUSSIONS</b>	<b>111-124</b>
<b>7.1</b>	<b>MID-LATENCY AUDITORY EVOKED POTENTIALS (MLAEPS)</b>	<b>111</b>
<b>7.2</b>	<b>PERFORMANCES IN ATTENTIONAL TASKS</b>	<b>119</b>
<b>7.3</b>	<b>SUBJECTIVE ASSESSMENT (VISUAL ANALOG SCALE)</b>	<b>123</b>

## 7.0 DISCUSSIONS

The most important results detailed in the previous section are discussed under the three main categories of variables (i) Mid-latency auditory evoked potentials measured pre, during and post of *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* sessions. (ii) Performance in attentional tasks (d2 test of attention & digit symbol substitution test) administered before and after *ekāgratā* and *dhāraṇā*. (iii) subjective assessment (visual analog scale) to follow the guided instructions administered immediately after *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* sessions.

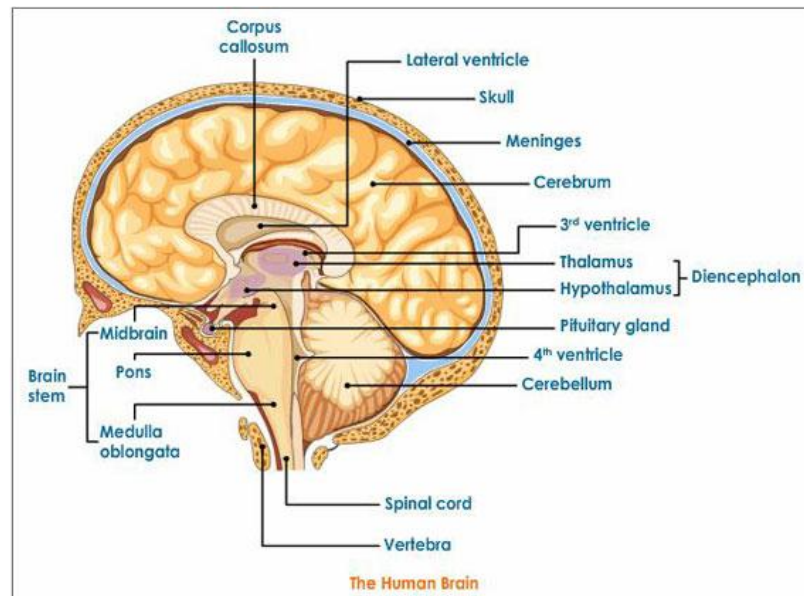
### 7.1 MID-LATENCY AUDITORY EVOKED POTENTIALS

Mid-latency auditory evoked potentials (MLAEPs) were recorded during *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*. A consistent finding was prolonged peak latencies of two components (the Na wave and the Pa wave) during *dhyāna*. The Pa wave amplitude decreased during all four sessions.

Among midlatency auditory evoked potentials, the Na wave is believed to be due to activity at the mesencephalic or diencephalic level (Deiber et al., 1988), and the Pa wave corresponds to activity at the superior temporal gyrus (Morlet et al., 1997), while the Nb wave appears relatively localized in the dorso-posterior medial part of the Heschl's gyrus, i.e., the primary auditory cortex (Liégeois-Chauvel et al., 1994).

A decrease in peak latency is considered suggestive of facilitated transmission due to increased speed of conduction in the underlying neural generators (Malhotra,

1997). On the other hand, an increase in peak latency can be assumed to suggest inhibited transmission due to slower conduction in the underlying neural generators. Increased amplitudes of evoked potential components are interpreted as activation of the underlying neural generator with the recruitment of a greater number of neurons (Woods & Clayworth, 1986).



**Illustration of human brain**

In the present study the prolonged latencies of the Na and Pa waves suggest slowing of auditory information transmission at mesencephalic-diencephalic levels and at the level of the primary auditory cortex. These findings are similar to those of an earlier study which reported a prolonged latency of the Nb wave related to the practice of a meditation called cyclic meditation (Subramanya & Telles, 2009). The results following cyclic meditation were believed to be related to activation of inhibitory mechanisms in cortical areas within the auditory pathway. A previous study

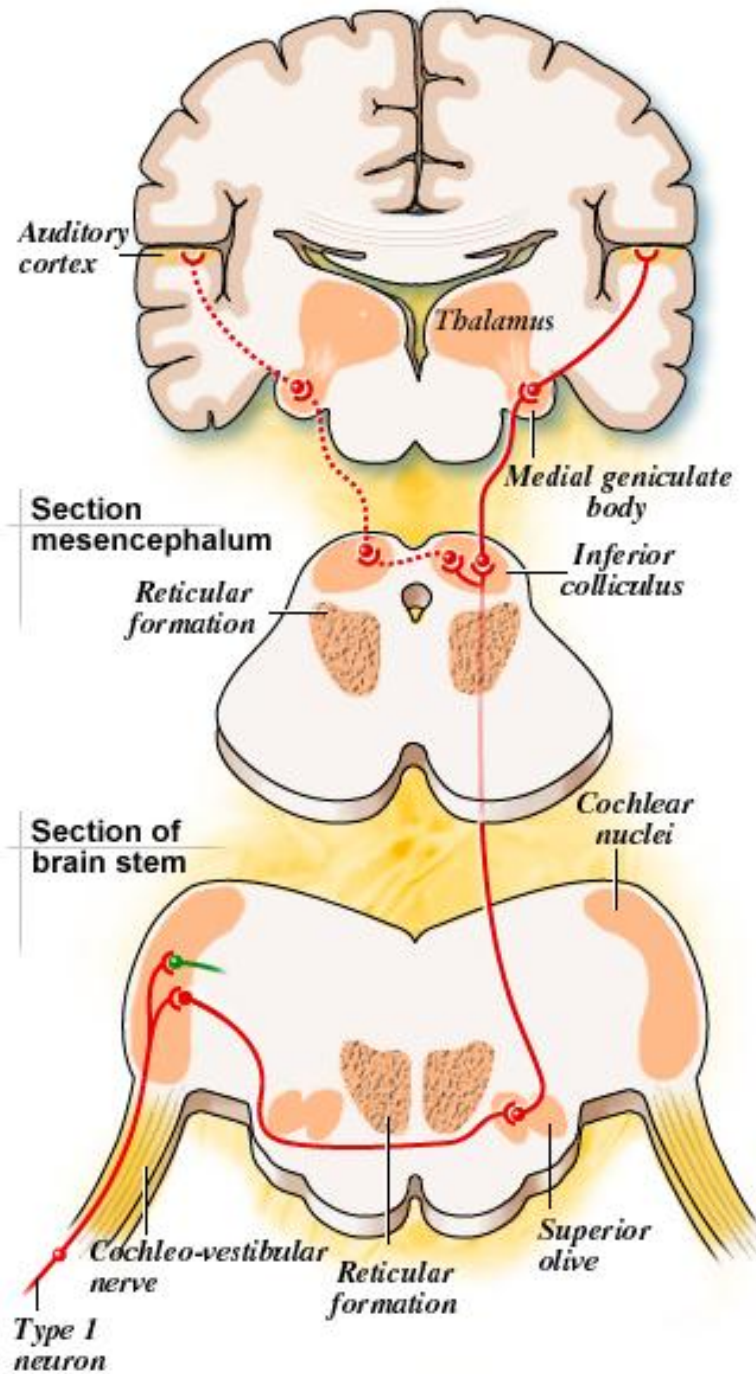
which reported increased gamma-amino-butyric-acid (GABA) levels following a one hour yoga session (Streeter et al., 2007) was considered to support the results. This is because GABA is a well recognized inhibitory neurotransmitter in the central nervous system (Kandel et al., 2000).

As described above GABA activity increased after yoga practice. In one study experienced yoga practitioners had a significant 27 percent increase in GABA levels using magnetic resonance spectroscopy (Streeter et al., 2007). The increase in GABA levels was seen in experienced yoga practitioners after a 60 - minute session of practicing yoga postures compared to no change in GABA levels in controls after they were asked to read for the same amount of time. This study raised the question whether the increase in GABA levels was specific to yoga or was due to an overall increase in physical activity. The same authors provided the answer for this in the subsequent study which compared GABA levels in a yoga and a walking group (Streeter et al., 2010). The twelve week yoga intervention was associated with greater improvements in mood and lower anxiety, compared to a metabolically matched walking exercise group. This study was also the first to demonstrate that increased thalamic GABA levels are associated with improved mood and decreased anxiety. The implications of the study were that GABA may be mediating some, if not all of the beneficial effects of yoga on mood and anxiety. The present results cannot be directly compared to these studies, as meditation differs from yoga postures. However, the mental state during yoga postures is ideally the same as in meditation (Taimini, 1986).

The increased latency of the Nb wave after *ekāgratā* in the present study suggests that following but not during, focusing without meditation there is also cortical inhibition, though at a different level along the auditory pathway, compared to meditation. The Nb wave corresponds to a neural generator which is more distal along the auditory pathway, viz. the Heschl's gyrus (Liégeois-Chauvel et al., 1994). The delay in auditory transmission following non-meditative focusing may be related to the fact that attention modulates excitatory and inhibitory lateral interactions in the cortex (Setić et al., 2008). During selective attention there is effective filtering of irrelevant information by modulatory influences (Erickson, 2009). Hence for selective attention during *ekāgratā*, inhibition of auditory transmission at the level of the Heschl's gyrus may be necessary.

Decreased amplitudes of the Pa wave occurred during all four sessions. As already mentioned an increase in amplitude suggests that a greater number of neurons were recruited. It may have been expected that listening to the pre recorded instructions during the sessions would have activated the primary auditory cortex in all four sessions. The present results show that this did not occur. The reason for the decrease in Pa amplitudes in all sessions may be due to selective inhibition of certain areas within the primary auditory cortex. Hence sensory responses may have been suppressed to reduce distracting auditory stimuli, so that participants could direct their attention to the taped instructions (Nuñez & Malmierca, 2007). This is a speculation.

**Illustration of auditory pathway**



The findings are limited by the fact that (i) there was no way to be certain that the participants were in the two meditative states, except for their self-reports and reports of the teacher, and (ii) it was also not possible to rule out that participants fell asleep during recordings despite CCTV monitoring and reviewing the raw EEG trace. These limitations may be corrected in future studies if a reliable physiological marker for the two stages is found and the EEG is recorded throughout along with the eye movements and muscle tone, to rule out sleep episodes. Despite these limitations, the present study showed that when meditation was considered as two stages, as it is described in the ancient texts, changes in midlatency evoked potentials occurred in one stage, i.e., meditation without focusing (*dhyāna*) but not in the other, i.e., meditative focusing (*dhāraṇā*). Hence separating the stages based on the way they were described in the ancient texts may yield new and different effects of meditation.

**Table 12: Summary of trend of changes in peak latency of mid-latency auditory evoked potentials during *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*. Values are percent change.**

Waves	Sessions	During				Post
		During1	During2	During3	During4	
Na Wave	<i>Cañcalatā</i>	NS	NS	NS	NS	NS
	<i>Ekāgratā</i>	NS	NS	NS	NS	NS
	<i>Dhāraṇā</i>	NS	NS	NS	NS	NS
	<i>Dhyāna</i>	NS	NS	↑ 3.26 %	NS	NS
Pa Wave	<i>Cañcalatā</i>	NS	NS	NS	NS	NS
	<i>Ekāgratā</i>	NS	NS	NS	NS	NS
	<i>Dhāraṇā</i>	NS	NS	NS	NS	NS
	<i>Dhyāna</i>				↑ 2.75%	NS
Nb Wave	<i>Cañcalatā</i>	NS	NS	NS	NS	NS
	<i>Ekāgratā</i>	NS	NS	NS	NS	↑ 5.46%
	<i>Dhāraṇā</i>	NS	NS	NS	NS	NS
	<i>Dhyāna</i>	NS	NS	NS	NS	NS

**Note:** n = 60; ↑: Increase; ↓ : Decrease, which was statistically significant; NS: No significant change

**Table 13: Summary of trend of changes in peak latency of mid-latency auditory evoked potentials during *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*. Values are percent change.**

Waves	Sessions	During				Post
		During1	During2	During3	During4	
Na Wave	<i>Cañcalatā</i>	NS	NS	NS	NS	NS
	<i>Ekāgratā</i>	NS	NS	NS	NS	NS
	<i>Dhāraṇā</i>	NS	NS	NS	NS	NS
	<i>Dhyāna</i>	NS	NS	NS	NS	NS
Pa Wave	<i>Cañcalatā</i>	↓ 36.84%	↓ 42.11%	↓ 37.59%	↓ 32.33%	
	<i>Ekāgratā</i>	↓ 22.13 %	↓ 23.77	↓ 18.00%	↓ 19.67%	
	<i>Dhāraṇā</i>	↓ 15.63%				
	<i>Dhyāna</i>		↓ 13.08%			
Nb Wave	<i>Cañcalatā</i>	NS	NS	NS	NS	NS
	<i>Ekāgratā</i>	NS	NS	NS	NS	NS
	<i>Dhāraṇā</i>	NS	NS	NS	NS	NS
	<i>Dhyāna</i>	NS	NS	NS	NS	NS

**Note:** n = 60; ↑: Increase; ↓ : Decrease, which was statistically significant; NS: No significant change

## 7.2 PERFORMANCES IN ATTENTIONAL TASKS

In the present study sixty male volunteers with experience in meditation were assessed in the d2 test of attention and digit symbol substitution test after *dhāraṇā* (meditative focusing) and *ekāgratā* (focusing without meditation).

The digit symbol substitution test is used to assess perceptual-motor speed during copying, visual scanning, and incidental learning (Joy, Fein & Kaplan, 2003; Joy, Kaplan, & Fein, 2004). The d2 test of attention is essentially a cancellation task, which measures selective attention and concentration (Brickenkamp and Zillmer, 1998; Rose et al., 2007). After both types of focusing there was a significant improvement in all measures of the d2 test of attention (TN, E, TN-E, E%, and CP). However, the performance in the digit symbol substitution test was better after *dhāraṇā* but did not change after *ekāgratā*.

The main difference between two tests is that the digit symbol substitution test has a component of incidental learning. It is possible that, incidental learning improves after dharana due to greater relaxation which may not be occurring after ekagrata. Learning and memory are closely related to relaxation (Nava et al., 2004). A previous study showed that 23 minutes of a ‘moving meditation’ called cyclic meditation (CM) improved primary working memory (Subramanya & Telles, 2009). The improvement was attributed to better relaxation following cyclic meditation. The same reason may be the basis for the results in the present study though this is just a speculation as it was not actually studied by objective variables. With respect to the d2 test of attention, following

both ekagrata and dharan, there was a comparable improvement, particularly in the (i) total number processed (TN) (ii) TN-E and (iii) concentration performance (CP).

The total number processed is a reliable measure of attention allocation, processing speed, amount of work completed, and motivation (Brickenkamp & Zillmer, 1998). When the errors are subtracted from total number (TN-E), the value is a measure of attentional and inhibitory control, and the relationship of speed and accuracy of performance (Brickenkamp & Zillmer, 1998). Concentration performance (CP) is derived from the number of correctly crossed out relevant items minus the errors of commission or over-inclusion when irrelevant letters are crossed out. This is good indicator of the coordination of speed and accuracy of performance (Brickenkamp & Zillmer, 1998). Despite the fact that concentration performance (CP) appeared comparably improved after ekagrata and dharana, the reduction in errors was more after *dhāraṇā* (26.48%) compared to *ekāgratā* (15.44%).

Errors (E) include both errors of omission (E1) or under-inclusion and errors of commission (E2) or over-inclusion. The number of errors is sensitive to attentional control, rule compliance, accuracy of visual scanning, carefulness and cognitive flexibility. Perhaps the only difference between the two states (*dhāraṇā* and *ekāgratā*) with respect to the d2 test could be related to the accuracy of visual scanning, and cognitive flexibility. Though, even this is difficult to conclude the given comparable scores in concentration performance (CP) after *dhāraṇā* (21.14%) and *ekāgratā* (18.06%).

The findings did not reveal noticeable results between *dhāraṇā* and *ekāgratā* except for the digit symbol substitution test performance. This suggests that *dhāraṇā* and *ekāgratā* did not bring about marked differences in attention task performance. It would have been ideal to have a simultaneous assessment of the physiological measures to assess the level autonomic arousal during the two states. This is particularly of interest as attention is known to modulate sympathetic activation (Moses, Luecken & Eason, 2007). The other limitation of the study is that, there was no assessment on third day when a participant was given no intervention.

Hence in summary, *dhāraṇā* (meditative focusing) and *ekāgratā* (focusing without meditation) produce nearly comparable results though *dhāraṇā* results in better incidental learning and better accuracy (based on the digit symbol substitution test performance).

**Table 14: Summary of trend of changes in d2 test of attention and digit symbol substitution test in *ekāgratā* and supine *dhāraṇā*; values are percent change.**

Task	Variable	<i>Ekāgratā</i>	<i>Dhāraṇā</i>
<b>D2 test of attention</b>	<b>TN</b>	↑ 8.22 %	↑ 9.25%
	<b>E</b>	↓ 15.44%	↓ 26.48%
	<b>TN - E</b>	↑ 10.89%	↑ 12.98%
	<b>E %</b>	↓ 21.03%	↓ 33.19%
	<b>CP</b>	↑ 18.06%	↑ 21.14%
<b>DSST</b>	<b>Scores on DSST</b>	NS	↑ 13.20%

**Note:** n = 60; ↑: Increase; ↓ : Decrease, which was statistically significant; NS: No significant change

### 7.3 SUBJECTIVE ASSESSMENT (VISUAL ANALOG SCALE)

The present study was conducted to assess the self-rated ability to follow the instructions to achieve the four mental state's viz., *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* using visual analog scale. The results showed that following *dhāraṇā*, scores on visual analog scale were significantly lower compared to *cañcalatā*, *ekāgratā* and *dhyāna*.

A study has shown brain areas involved in FA (Focused Attention) and OM (Open Monitoring) meditations are distinct and different (Lutz et al., 2008). FA meditation improves the practitioner's ability to sustain attention on a particular object for prolonged periods. During FA meditation, functional magnetic resonance imaging (fMRI) showed activation in which brain regions involved in monitoring, engaging attention and attentional orienting. In contrast, OM meditation showed activation in which brain regions implicated in monitoring, vigilance and disengaging attention from stimuli which could distract attention from the experience at that moment. Hence, it is very much evident that brain areas involved in these four mental states are different.

*Dhāraṇā* involved mental visualization, and intense focusing on the Sanskrit syllable Om. Some people may find difficulty in mentally visualizing the symbol for a long time. And also, participants might have found difficulty in keeping the intense focus on syllable Om for 20 minutes. The average attention span in healthy adults is

between 15 - 20 minutes. *Dhāraṇā* requires focused attention whereas *dhyāna*, *ekāgratā* and *cañcalatā* do not need focused attention.

The usefulness of practicing *dhāraṇā* is well known. Focused attention on a single object removes *cañcalatā* and takes us to a higher state than *ekāgratā* by moving the mind from multiple thoughts to a single thought of a visual picture as ‘Om’ used here. However, according to yoga, it is well known that *dhāraṇā* involves intense effort to keep the focus on the given object for longer durations. It causes fatigue as it drains away the energy. But, it is useful to shatter drowsiness (Tamas) and induce alertness.

Hence, traditionally (PYS 3.2) *dhāraṇā* is used for a short duration, about a minute and proceed to perform *dhyāna* by making the mind to stay on a single thought effortlessly. The five main features of *dhyāna* state are single thought, effortlessness, slowness, wakefulness, and expansiveness. Long duration of meditation helps one to gain mastery over the mind and lead to a state of superconsciousness called *samādhi* (PYS 3.4).

In summary, the study has shown that, (i) *cañcalatā* and *ekāgratā* and *dhyāna* can be done with equal ease. (ii) *dhāraṇā* is the most difficult state compared to *cañcalatā*, *ekāgratā* and *dhyāna* state.

## **CHAPTER – 8.0**

# **APPRAISAL OF THE STUDY**

<b>CHAPTER</b>	<b>DETAILS</b>	<b>PAGE.NO</b>
<b>8.0</b>	<b>APPRAISAL</b>	<b>125-129</b>
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## 8.0 APPRAISAL

To understand the limitations of the present study as well as to get insight into new ideas for future research a critical review of the work done has been made.

This has been presented under the following headings:

1. Summary of the findings
2. Conclusion
3. Implications and applications of the study
4. Strength of the study
5. Limitations of the study
6. Suggestions for future studies

## 8.1 SUMMARY OF THE FINDINGS

The present study was conducted on sixty healthy male participants with ages ranging from 18 to 31 years (group average age  $\pm$  S.D.,  $22.8 \pm 2.7$  years). They were studied in four sessions, viz., *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*. Each session consisted of Pre (5 minutes), During (20 minutes) and Post (5 minutes) states. Mid-latency auditory evoked potentials (MLAEPs) were recorded in the pre, during and post states whereas performance in the attentional tasks was studied before and after *ekāgratā* and *dhāraṇā* session. Visual analog scales to measure the ability to follow guided instructions were given immediately after the practice of all four sessions.

For each of the variables the data were analyzed separately using repeated measures ANOVA followed by *post-hoc* analyses. During *dhyāna*, latencies of two

MLAEPs components, the Na and Pa waves were prolonged, suggesting that auditory information transmission at the level of the medial geniculate and primary auditory cortex was delayed.

The present study also showed significant improvement in all measures of the d2 test of attention [TN (total number of items processed), E (errors), E% (percentage of errors), TN-E (total performance), and CP (concentration performance)] after *dhāraṇā* and *ekāgratā*. However, the performance in the digit symbol substitution test was better after *dhāraṇā* but did not change after *ekāgratā*. *Dhāraṇā* and *ekāgratā* produce nearly comparable results (in the digit symbol substitution test performance) though *dhāraṇā* results in better incidental learning and better accuracy.

The subjective assessment to follow the guided instructions showed that, *dhāraṇā* is the most difficult state compared to *cañcalatā*, *ekāgratā* and *dhyāna* states.

## 8.2 CONCLUSION

The present study showed an increase in the peak latency of Na and Pa waves during *dhyāna* which suggests an increase in information processing time at the level of medial geniculate and primary auditory cortex. In contrast, following *dhāraṇā* there was an improvement in performance on all measures of the d2 test of attention (TN, E, TN-E, E%, and CP) and in the digit symbol substitution test. The results suggest that, *dhāraṇā* (meditative focusing) is associated with better attention, incidental learning, and better accuracy. Subjective assessment about the ability to follow guided instructions showed that, *dhāraṇā* is the most difficult state compared to the *cañcalatā*,

*ekāgratā* and *dhyāna* states. Hence this also shows that *dhāraṇā* and *dhyāna* are two distinct and different meditative states.

### **8.3 IMPLICATIONS AND APPLICATIONS OF THE STUDY**

In the present study, the prolonged latencies of the Na and Pa waves suggest slowing of auditory information transmission at mesencephalic–diencephalic levels and at the level of the primary auditory cortex. Increase in latency is correlated with the activation of inhibitory mechanisms in cortical areas within the auditory pathway. GABA is a well-known inhibitory neurotransmitter in the central nervous system. The implications of a study on yogasana were that GABA may be mediating some, if not all, of the beneficial effects of yoga on mood and anxiety (Streeter et al., 2007; Streeter et al., 2010). The present results cannot be directly compared to these studies, as meditation differs from yoga postures. However, the mental state during yoga posture is ideally the same as in meditation. The practice of *dhyāna* may be useful in treating anxiety and mood disorders.

The present study also showed, better incidental learning and better accuracy (based on the digit symbol substitution test performance) after *dhāraṇā*. The practice of *dhāraṇā* is helpful in improving incidental learning and better accuracy. Hence, *dhāraṇā* may be helpful for slow learners, mentally challenged persons with various types of disorders, attention deficits and attention-deficit hyperactivity disorder (ADHD).

#### **8.4 STRENGTH OF THE STUDY**

The present study evaluated the psychophysiological changes following *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* using mid-latency auditory evoked potentials and performance on attentional tasks in sixty participants. In this study meditation has been studied in two separate meditative states based on the descriptions from the yoga texts. The findings revealed that *dhāraṇā* and *dhyāna* are different and distinct meditative states, hence they produce different results. This may explain the differences found in earlier meditation studies and shows the importance of taking descriptions from traditional texts.

#### **8.5 LIMITATIONS OF THE STUDY**

The main limitation of the study was that, there was no way to be certain that the participants were in *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna* states, except for their self-reports and reports of the teacher. Another limitation is that it was also not possible to rule out that participants fell asleep during recordings despite CCTV monitoring and reviewing the raw electroencephalogram (EEG) trace. The performance in attentional tasks was studied only in *dhāraṇā* and *ekāgratā* which is a limitation of the study.

#### **8.6 SUGGESTIONS FOR FUTURE STUDIES**

The limitations of the present study may be corrected in future studies if a reliable physiological marker for the four mental (*cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*) states is found. Also, it would be helpful if the EEG is recorded throughout, along with

the eye movements and muscle tone to rule out sleep episodes and to assess the electrical activity of the brain. Studying performance in attentional tasks during all four states along with autonomic variables may give more information. In order to get the more conclusive idea about the cortical activity, function magnetic resonance imaging (fMRI) could be used. The clinical application of *dhāraṇā* and *dhyāna* may be studied.



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# APPENDICES

**APPENDIX – 1 : INFORMED CONSENT : A SAMPLE COPY**

**APPENDIX – 2 : INSTRUCTIONS FOR *DHĀRAṆĀ* AND *DHYĀNA***

**APPENDIX – 3 : D2 TEST OF ATTENTION : SAMPLE WORKSHEET**

**APPENDIX – 4 : DIGIT SYMBOL SUBSTITUTION TEST : SAMPLE  
WORKSHEET**

**APPENDIX – 5 : VISUAL ANALOG SCALE**

**APPENDIX – 6 : LIST OF TABLES OF ACTUAL DATA**

**APPENDIX – 7 : PUBLICATIONS FROM THIS DOCTORAL THESIS**

**APPENDIX-1**  
**INFORMED CONSENT FORM**

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**Title of the project** : Psychophysiological effects of two meditative states described in yoga texts

**Investigator** : Raghavendra Bhat, M.Sc., Ph.D. Scholar

**Name of the guides** : Shirley Telles, M.B.B.S., M.Phil., Ph.D.  
Nagendra, H. R, M.E., Ph.D.

**The purpose of the study** : To understand the psychophysiological changes following *cañcalatā ekāgrata dhāraṇā* and *dhyāna*.

**Procedure for measurement:** In this study mid-latency auditory evoked potentials, performance in attentional tasks (using paper pencil tests) and subjective assessment on visual analog scale will be measured.

MLAEPs will measure auditory information processing at the level of cortex and subcortex. Mid-latency auditory evoked potentials (MLAEPs) will be recorded using the Nicolet Bravo System (U.S.A). During the procedure you will be given an auditory click stimulus through ear phones. The electrical response of your brain to the clicks would be recorded by placing small metal electrodes on your scalp. As a preparation for this the area on your scalp will have to be cleaned. As the electrodes record the activity of the brain there is no risk that you can get an electrical shock. This technique is in routine use in hospitals for the last 25 years and there have been no reported side effects.

Performance in attentional tasks will be measured using (i) d2 test of attention and (ii) digit symbol substitution test simple paper pencil tests. These are simple paper pencil tests.

**Please note:**

- All information obtained during the study will be kept confidential and individual report of the test will be given.
- You can withdraw from the study at any point of time unconditionally.
- In case the study does cause any adverse effects, the institution is not
- liable.

I have understood the all above and consent voluntarily to participate in the study.

Place\_\_\_\_\_

Date\_\_\_\_\_

**Signature of the Participant**

## APPENDIX – 2

### INSTRUCTIONS FOR *DHĀRAṆĀ* AND *DHYĀNA*

#### INSTRUCTIONS FOR *DHĀRAṆĀ* WAS AS FOLLOWS:

**General:** Sit comfortably. Close your eyes. Observe your breathing. Slow down your breathing. Calm down your mind. Relax the whole body.

#### *Dhāraṇā:*

- Open your eyes gently with few blinks. Slowly bring your awareness on the picture of OM in front of you.
- Allow the random thoughts to flow freely as you are observing the picture of OM.
- Now gradually replace these random thoughts with the thoughts related to OM.
- Let us start this process by observing the attributes of OM.
- From the gross awareness, observe the first attribute, the shape of the symbol OM.
- Scan through the symbol OM from the upper part and move slowly downwards. As you reach the bottom, move your attention again to the upper part and start moving down. Let this process continue.
- Now slowly shift your awareness to the center of the symbol OM. Move your concentration to the extension of OM on the right. Observe slowly and come back to the center. Now gradually move your attention to the upper right corner of the picture and focus on the crescent and the dot. Now slowly observe the complete picture.
- Gently close your eyes and try to visualize the picture of OM mentally.
- Open your eyes with few blinks. Now gradually shift your concentration from the shape to the color of OM. Observe the orange color.
- Slowly expand your vision and observe the blue color surrounding the orange OM. Slowly combine the awareness of the shape and color and have a complete picture of OM.
- Try not to blink in between, focus your attention on the picture of OM.
- Experience the process of dharana. *Deśabandhaścittasya dhāraṇā*. *Dhāraṇā* is the process of fixing the mind on a single object in a given space and time. Hold on to it as long as you can without any distractions.

- Now slowly close your eyes. Visualize the symbol OM in between your eyebrows and fix it there.
- Continue internal focusing on OM between the two eyebrows. As the symbol starts fading away, slowly open your eyes and observe the same in front of you again. Continue the process of focusing.
- Let your mind be fixed on the symbol OM.
- No other thoughts in the mind. Mind is filled with the thoughts of OM and no other distractions.
- Slow down your thoughts and gradually reach at one single thought. But no compromise on the intensity of focusing.
- Once again slowly close your eyes and visualize the Symbol of OM in between your eyebrows.
- Gradually increase the duration of internal focusing and try to remain there as long as you can.
- Your attention is focused on the single object OM. Make it as one pointed awareness and enjoy being with OM and your mind is totally engrossed in this process.
- From full size OM, reduce the size of OM in the mind to smaller and smaller size. As small as rice seed. But with full clarity of OM in all its vividness. Let the mind get fixed on this smallest picture.
- Let it come back quickly to full size OM. Again focus the mind by making the OM smaller and smaller, focusing deeper and deeper. Bringing the full power of attention on OM as small as a rice seed, retain the same for as long as you can with full clarity for at least 10 seconds. Suddenly take it back to full size OM.
- Retain the full OM at least for 20 seconds (This process has to be repeated).
- Now slowly try to come out of this state of intense focusing.
- Allow your mind to remember the attributes of symbol OM. Visualize the orange OM surrounded by the blue color, visualize the shape of OM.
- **General:** Gently rub your palms (palming) and make a cup of your palms and place them on the eyes. Relax your eyes by the warmth produced by palming. Gently massage your face and release slowly. Open your eyes with few blinks.

## **INSTRUCTIONS FOR *DHYĀNA* WAS AS FOLLOWS:**

**General:** Sit comfortably. Close your eyes. Observe your breathing. Slow down your breathing. Calm down your mind. Relax the whole body.

### ***Dhyāna:***

- Prepare yourself for the practice of meditation.
- Observe different thoughts passing through your mind. Be a witness to your thoughts and observe them without any judgment.
- Gradually replace these different thoughts by the thoughts related to OM.
- Slowly start dwelling upon the thoughts of OM. Slowly observe and listen to the background chanting. You will start hearing the chanting OM.
- Enjoy listening to the repetition of OM. As the sound starts fading away slowly start chanting OM mentally.
- Increase the speed of mental chanting if there are any distractions.
- Now gradually slow down the mental repetition of OM.
- Try to observe the gap between two OMkaras as you continue this process. Make an attempt to observe the silence between two OMkaras.
- Mentally chant OM observe the silence. Chant OM again. Observe the silence
- Chant OM and observe the fine resonance of OMkara in the end taking you to deeper levels of silence each time. Merge yourself with OM.
- Remain there with complete awareness. Now gradually try to expand the gap featured by silence.
- Try to remain in that state of silence as long as you can enjoy the silence and expand yourself.
- Feel the expansion. The mind is filled with happiness and bliss. Enjoy the silence. You are merging with expanded space of OM.
- Enjoy being there with complete awareness and relaxation. Slowly come back from the state of expansion. Observe the slow and repeated chanting of OM in the background.
- **General:** Gently rub your palms (palming) and make a cup of your palms and place them on the eyes. Relax your eyes by the warmth produced by palming. Gently massage your face and release slowly. Open your eyes with few blinks.

# APPENDIX – 3

## D2 TEST OF ATTENTION

Name: \_\_\_\_\_

Age: \_\_\_\_\_ Sex:  male  female

Handedness:  L  R

Years of education: \_\_\_\_\_

Occupation: \_\_\_\_\_

**d2 Test of Attention**  
Rolf Brickenkamp & Eric A. Zillmer

Examiner: \_\_\_\_\_ Date: \_\_\_\_\_

Example:     $\overset{''}{d}$      $\underset{''}{d}$      $\overset{|}{d}$

Practice line:     $\overset{''}{d}$      $\overset{''}{p}$      $\underset{|}{d}$      $\underset{|}{d}$      $\overset{''}{d}$      $\underset{''}{d}$      $\overset{''}{p}$      $\underset{|}{d}$      $\underset{''}{d}$      $\underset{|}{p}$      $\underset{|}{d}$      $\overset{''}{d}$      $\underset{''}{d}$      $\underset{|}{d}$      $\underset{''}{p}$      $\overset{''}{p}$      $\underset{''}{d}$      $\overset{''}{d}$      $\overset{''}{d}$      $\underset{''}{p}$      $\underset{|}{d}$      $\underset{|}{d}$

1    2    3    4    5    6    7    8    9    10    11    12    13    14    15    16    17    18    19    20    21    22

	Raw Score	Percentage	Percentile Rank	Standard Score
TN (total number)				
Omissions: E1				
Commissions: E2				
E (errors)				
TN-E (total-errors)				
CP(concentration performance)				
FR (fluctuation rate)				

S-Syndrome:

APPENDIX - 3

D2 TEST OF ATTENTION

	TN	E <sub>1</sub>	E <sub>2</sub>	CP
1	d d " d d d p p d p d d d d p d p d d d p p d d d d p d p d p d d d p p d p d d p			
2	p d p p d d d d p d p d d d p d d p d p d p d d p d p d d d d p d p d p d p d d d p d p d d			
3	d d d d p p d p d p p p d d p d p d p d d p d p d d p d p d d p d p d d d d d p d			
4	d d " d d d p p d p d d d d p d p d d d p p d d d d d p d p d p p d d d d p p d p d d p			
5	p d p p d d d d p d p d d d p d d p d d p d p d p d d p d p d d d d p d p d p d p d d d p d p d d			
6	d d d d p p d p d p p p d d p d p d d p d p d d p d d p d d p d d p d d p d d d d p d			
7	d d " d d d p p d p d d d d p d p d d d p p d d d d d p d p d d p p d d d d p p d p d d p			
8	p d p p d d d d p d p d d d p d d p d d p d p d p d d p d p d d d d p d p d p d p d d d p d p d d			
9	d d d d p p d p d p p p d d p d p d p d d p d p d d p p d d d d p d d p d p d d d d p d			
10	d d " d d d p p d p d d d d p d p d d d p p d d d d d p d p d d p p d d d d p p d p d d p			
11	p d p p d d d d p d p d d d p d d p d d p d p d p d d p d p d d d d p d p d p d p d d d p d p d d			
12	d d d d p p d p d p p p d d p d p d p d d p d p d d p d p d d p p d d d d p d d p d p d d d p d			
13	d d " d d d p p d p d d d d p d p d d d p p d d d d d p d p d d p p d d d d p p d p d d p			
14	p d p p d d d d p d p d d d p d d p d d p d p d p d d p d d d d p d p d p d p d d d p d p d d			

**APPENDIX – 4**

**DIGIT SYMBOL SUBSTITUTION TEST**

**Name:**

**Age:**

**Date:**

**Instructions:**

1. Substitute the symbol with the corresponding digit as per the given key
2. Substitute as many possible symbols within the given time
3. Start and stop only when told

<b>Digit</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>
<b>Symbol</b>	—	⊥	⊐	└	┘	○	^	×	=

2	1	3	7	2	4	8	2	1	3	2	1	4	2	3	5	2	3	1	4	5	6	3	1	4

1	5	4	2	7	6	3	5	7	2	8	5	4	6	3	7	2	8	1	9	5	8	4	7	3

6	2	5	1	9	2	8	3	7	4	6	5	9	4	8	3	7	2	6	1	5	4	6	3	7

9	2	8	1	7	9	4	6	8	5	9	7	1	8	5	2	9	4	8	6	3	7	9	8	6

Total Substitution:

Wrong Substitution:

Net Score:

## DIGIT SYMBOL SUBSTITUTION TEST

Name: \_\_\_\_\_

Age: \_\_\_\_\_

Date: \_\_\_\_\_

Instructions:

1. Substitute the symbol with the corresponding digit as per the given key
2. Substitute as many possible symbols within the given time
3. Start and stop only when told

<b>Digit</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>
<b>Symbol</b>	⊥	∧	=	×	—	○	☐	└	┘

8	2	1	8	4	4	8	7	1	2	4	7	8	5	4	2	3	5	6	6	3	6	2	7	2

6	7	8	9	8	2	1	7	4	1	2	8	6	3	6	1	1	9	1	4	2	3	2	9	5

2	1	3	9	4	5	8	7	2	3	8	1	5	1	2	9	8	2	7	6	9	9	6	9	3

6	2	2	8	3	5	3	8	6	4	9	9	2	2	6	9	7	5	5	4	7	5	5	6	8

Total Substitution: \_\_\_\_\_

Wrong Substitution: \_\_\_\_\_

Net Score: \_\_\_\_\_

## DIGIT SYMBOL SUBSTITUTION TEST

Name: \_\_\_\_\_

Age: \_\_\_\_\_

Date: \_\_\_\_\_

Instructions:

1. Substitute the symbol with the corresponding digit as per the given key
2. Substitute as many possible symbols within the given time
3. Start and stop only when told

<b>Digit</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>
<b>Symbol</b>	∧	□	—	⊥	≡	○	⊥	×	=

5	4	3	9	7	4	7	9	1	9	9	7	2	3	9	4	6	7	8	3	9	3	3	9	7

6	2	3	4	4	8	7	3	2	4	7	4	7	4	9	6	9	5	1	5	5	1	9	2	5

5	6	3	3	6	6	3	9	9	8	5	9	7	1	9	7	9	2	8	9	7	5	7	7	4

1	7	6	5	8	8	9	3	7	9	9	3	9	1	6	4	7	4	4	8	2	8	1	1	6

Total Substitution: \_\_\_\_\_

Wrong Substitution: \_\_\_\_\_

Net Score: \_\_\_\_\_

## DIGIT SYMBOL SUBSTITUTION TEST

Name: \_\_\_\_\_

Age: \_\_\_\_\_

Date: \_\_\_\_\_

Instructions:

1. Substitute the symbol with the corresponding digit as per the given key
2. Substitute as many possible symbols within the given time
3. Start and stop only when told

<b>Digit</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>
<b>Symbol</b>	×	⊥	○	⊐	⊥	^	—	=	⊐

2	1	9	7	4	9	9	6	3	3	7	6	2	1	7	4	4	6	4	8	9	6	4	9	1

4	4	7	3	9	1	6	7	6	9	7	9	3	1	4	5	1	3	2	9	7	1	7	1	3

4	1	1	5	9	7	3	6	6	5	2	2	7	5	7	4	6	2	4	9	8	9	2	1	4

7	8	1	5	3	8	7	8	5	4	2	3	2	3	8	6	5	1	9	2	7	7	6	5	5

Total Substitution: \_\_\_\_\_

Wrong Substitution: \_\_\_\_\_

Net Score: \_\_\_\_\_



**APPENDIX - 6**

**Table. 15: Peak latencies of Na wave recorded at pre, during and post *cañcalatā* session.**

<b>Sl.No.</b>	<b>Participant's code</b>	<b>Pre</b>	<b>Dur1</b>	<b>Dur 2</b>	<b>Dur 3</b>	<b>Dur 4</b>	<b>Post</b>
1.	PAR	17.20	17.40	15.60	16.60	19.20	16.20
2.	SOH	14.20	15.80	14.00	14.00	12.20	12.00
3.	SHR	15.80	15.80	15.40	16.00	15.40	17.60
4.	RAG	16.80	16.60	17.00	17.00	17.20	18.20
5.	SUB	14.00	15.00	15.00	16.20	15.20	17.40
6.	ARJ	15.20	16.00	16.20	16.80	14.80	16.00
7.	SUH	15.40	16.00	15.60	15.40	15.80	15.80
8.	PRA	17.80	18.20	17.80	18.40	17.80	17.00
9.	VIR	18.80	17.40	17.20	17.40	18.60	17.00
10.	SAU	14.40	16.60	14.80	15.60	16.80	14.20
11.	SHA	13.40	14.60	14.00	13.40	14.00	13.80
12.	GAU	14.20	16.60	14.80	14.40	14.40	14.20
13.	AYU	16.80	16.20	16.20	16.40	16.00	13.00
14.	HEM	16.40	17.80	17.80	19.00	18.00	19.20
15.	REV	14.20	18.60	17.80	20.00	14.80	15.60
16.	ANK	18.60	18.60	18.20	18.40	17.80	18.40
17.	AMI	17.20	17.40	18.00	17.40	17.80	17.00
18.	HAR	17.40	14.40	20.00	19.60	14.00	17.20
19.	ROH	19.40	14.80	20.40	16.60	18.00	18.20
20.	MAL	18.40	18.20	18.40	18.60	17.40	18.80
21.	VAD	15.80	18.60	18.60	21.00	18.00	17.20
22.	PUS	14.40	14.00	15.20	17.20	15.60	15.40
23.	RAN	15.60	16.00	16.60	19.20	16.20	16.80
24.	SUP	19.20	11.80	14.40	14.80	15.00	16.60
25.	SHA	15.00	16.80	17.00	16.60	17.80	16.60
26.	KAR	16.20	17.40	17.60	18.00	16.20	16.80
27.	AJA	13.80	15.40	15.00	14.60	15.00	15.00
28.	ANA	15.00	15.20	17.40	17.40	16.40	15.60
29.	BHA	16.80	18.40	17.80	17.40	17.80	17.00
30.	JIT	15.40	20.60	17.40	17.80	12.60	12.80
31.	VEN	17.20	16.60	16.40	16.60	18.20	18.40
32.	ARV	14.20	16.00	17.40	13.40	14.00	14.00
33.	DEE	14.40	15.80	17.00	16.00	13.20	13.60
34.	SAN	18.00	18.00	17.80	17.60	18.40	18.60
35.	NAV	11.80	11.80	11.80	12.00	11.80	11.60
36.	ANU	14.60	17.20	17.60	16.40	17.20	17.60
37.	MAN1	16.80	11.60	17.80	20.20	11.40	11.40
38.	ARU	14.60	14.20	14.00	14.80	14.80	14.80
39.	DAT	17.20	16.60	17.40	17.60	18.20	17.60
40.	MAN2	18.20	17.20	17.60	18.60	17.20	16.60
41.	DIL	15.60	16.80	14.00	16.00	17.40	17.40

42.	JAI	16.40	17.60	14.80	14.00	17.60	17.60
43.	KUN	15.20	15.20	16.00	15.20	14.60	16.00
44.	NID	17.60	17.00	20.40	19.40	12.80	16.40
45.	GAJ	15.40	15.80	16.40	15.60	15.80	17.00
46.	RAV	16.40	16.40	14.00	14.40	14.80	16.00
47.	SUS	17.40	18.00	18.00	17.20	17.60	18.60
48.	SUM	16.60	16.60	17.00	17.20	16.20	15.20
49.	HEM	15.40	14.40	14.60	14.60	14.60	16.80
50.	HAR	17.40	17.40	18.60	17.60	18.00	16.80
51.	GAJ	14.80	16.60	15.00	17.40	18.60	15.00
52.	SHA	15.80	17.20	17.20	16.80	15.80	15.80
53.	RAJ	17.60	17.00	18.40	17.60	17.00	16.80
54.	AMI	15.00	14.80	13.40	11.60	13.80	16.80
55.	NAV	15.40	16.60	16.40	15.20	14.80	17.00
56.	SUD	15.60	14.80	14.80	16.00	14.00	16.60
57.	NAG	14.20	14.80	13.80	14.20	13.40	14.00
58.	HAN	18.00	13.60	17.00	16.00	17.60	15.80
59.	SAT	16.40	15.60	16.20	13.80	13.80	16.80
60.	NAG	15.00	15.60	14.20	14.80	14.60	15.00
<b>Mean</b>		<b>16.02</b>	<b>16.22</b>	<b>16.44</b>	<b>16.48</b>	<b>15.88</b>	<b>16.14</b>
<b>SD</b>		<b>1.59</b>	<b>1.71</b>	<b>1.80</b>	<b>1.97</b>	<b>1.94</b>	<b>1.78</b>

**Table. 16: Peak latencies of Na wave recorded at pre, during and post *ekāgratā* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	19.20	16.00	16.40	15.00	16.60	14.80
2.	SOH	17.20	17.20	18.20	19.60	16.60	16.00
3.	SHR	15.60	16.80	18.00	18.60	19.60	20.00
4.	RAG	17.00	17.20	16.80	18.20	16.80	17.20
5.	SUB	14.80	14.80	15.20	14.80	15.20	17.20
6.	ARJ	15.00	14.80	15.00	15.00	15.20	14.60
7.	SUH	15.60	15.20	15.60	15.20	15.60	15.40
8.	PRA	18.60	16.20	17.80	18.20	17.80	19.00
9.	VIR	19.20	20.60	16.80	17.00	17.40	16.20
10.	SAU	14.40	16.00	17.00	17.00	16.60	16.00
11.	SHA	12.20	12.00	12.00	12.20	12.60	12.00
12.	GAU	15.40	14.20	13.80	14.40	13.60	14.20
13.	AYU	15.40	15.60	15.40	15.40	15.40	15.40
14.	HEM	17.20	18.40	17.40	18.20	18.20	18.20
15.	REV	19.20	14.20	15.80	14.00	14.00	15.40
16.	ANK	18.00	18.00	16.80	17.20	18.60	18.00
17.	AMI	14.80	15.20	15.40	15.40	15.60	15.40
18.	HAR	16.20	18.80	19.80	14.40	20.60	18.20
19.	ROH	15.20	16.60	17.40	15.40	16.60	15.40
20.	MAL	18.40	16.60	18.80	16.40	17.80	18.40
21.	VAD	16.40	16.80	15.60	19.80	16.20	15.60
22.	PUS	16.60	16.20	15.60	15.40	15.60	15.80
23.	RAN	17.40	17.00	16.60	17.00	15.80	16.00
24.	SUP	16.40	15.40	16.60	16.60	15.40	16.40
25.	SHA	16.00	16.80	17.00	17.40	14.40	18.40
26.	KAR	18.40	16.80	16.80	16.40	19.00	16.40
27.	AJA	14.20	14.80	14.60	15.00	15.00	15.00
28.	ANA	12.00	17.60	17.00	17.80	16.80	15.20
29.	BHA	16.80	17.80	18.00	18.00	17.80	17.80
30.	JIT	18.60	18.40	16.20	21.40	15.80	24.40
31.	VEN	17.80	17.80	18.00	19.20	16.60	16.60
32.	ARV	15.60	17.00	15.00	14.20	14.40	14.00
33.	DEE	17.20	16.80	14.20	13.40	14.00	14.20
34.	SAN	19.80	18.20	17.00	17.20	16.80	17.20
35.	NAV	14.80	15.40	14.60	15.20	12.60	11.60
36.	ANU	18.00	17.60	16.60	15.40	17.40	15.00
37.	MAN1	11.00	11.40	11.40	11.00	12.00	11.80
38.	ARU	15.40	14.80	15.20	14.20	14.80	14.80
39.	DAT	17.60	18.20	17.80	17.80	16.40	17.00
40.	MAN2	17.80	16.80	17.00	16.20	16.80	19.00
41.	DIL	16.20	16.80	17.40	18.20	16.40	16.40

42.	JAI	15.60	17.00	18.00	17.80	17.80	17.80
43.	KUN	15.00	15.80	15.80	16.40	16.40	14.80
44.	NID	17.20	17.40	17.00	19.00	18.60	17.00
45.	GAJ	14.80	16.60	15.40	15.40	16.00	15.00
46.	RAV	15.40	16.20	16.40	16.80	17.80	14.60
47.	SUS	16.80	17.40	17.20	17.60	17.60	18.40
48.	SUM	14.80	14.80	17.00	17.60	16.20	15.80
49.	HEM	15.40	15.20	16.00	16.60	16.80	18.40
50.	HAR	18.20	18.40	18.60	14.80	17.40	18.60
51.	GAJ	16.80	16.60	18.20	19.00	20.40	19.60
52.	SHA	15.00	16.40	17.80	17.60	17.40	16.20
53.	RAJ	19.00	16.60	17.40	16.40	15.60	15.20
54.	AMI	15.80	15.80	15.40	15.60	16.00	15.60
55.	NAV	16.00	16.60	16.20	15.80	16.20	16.80
56.	SUD	15.40	15.60	15.40	16.20	15.80	15.80
57.	NAG	13.40	13.80	13.80	14.40	14.00	13.80
58.	HAN	15.80	16.40	17.20	15.20	16.60	16.20
59.	SAT	16.20	15.00	15.80	14.60	17.00	15.20
60.	NAG	15.20	15.20	16.00	15.20	15.20	15.40
<b>Mean</b>		<b>16.24</b>	<b>16.33</b>	<b>16.37</b>	<b>16.34</b>	<b>16.32</b>	<b>16.26</b>
<b>SD</b>		<b>1.80</b>	<b>1.55</b>	<b>1.53</b>	<b>1.90</b>	<b>1.73</b>	<b>2.08</b>

**Table. 17: Peak latencies of Na wave recorded at pre, during and post *dhāraṇā* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	14.4	19.6	16.4	15.4	15	14.6
2.	SOH	14.0	15.4	14.4	15.0	14	14.2
3.	SHR	16.0	16.2	15.6	15.8	17	17.6
4.	RAG	16.6	17.0	18.0	17.4	17	17.0
5.	SUB	14.8	14.8	14.8	14.8	15	14.2
6.	ARJ	14.6	14.8	15.0	14.8	15	14.8
7.	SUH	14.6	16.0	15.4	15.2	15	16.2
8.	PRA	17.8	17.8	17.8	17.4	19	19.8
9.	VIR	19.8	20.4	19.0	18.8	18	16.6
10.	SAU	14.6	14.2	13.8	14.4	15	14.4
11.	SHA	12.0	15.4	15.6	15.2	14	14.8
12.	GAU	14.0	16.8	19.4	16.8	17	15.0
13.	AYU	13.2	13.8	13.2	12.2	12	12.6
14.	HEM	17.2	17.6	18.4	16.0	18	17.4
15.	REV	14.2	13.4	17.8	17.6	15	13.2
16.	ANK	18.0	16.8	18.0	18.2	17	16.6
17.	AMI	15.4	15.8	15.6	16.0	15	15.6
18.	HAR	20.4	20.8	18.8	20.2	16	17.0
19.	ROH	14.4	15.6	16.2	15.6	16	15.4
20.	MAL	19.2	16.6	18.8	18.6	20	16.8
21.	VAD	14.6	15.4	16.0	14.8	16	16.2
22.	PUS	15.6	16.0	15.6	17.0	15	16.0
23.	RAN	15.6	15.2	15.6	16.6	16	14.8
24.	SUP	16.4	16.6	17.8	16.8	18	14.8
25.	SHA	14.8	17.0	15.2	17.8	17	17.0
26.	KAR	17.0	16.4	16.6	18.6	17	16.8
27.	AJA	14.0	14.4	14.8	15.0	15	14.8
28.	ANA	17.4	16.2	16.2	15.6	16	16.0
29.	BHA	16.8	18.6	17.4	17.6	18	17.6
30.	JIT	15.4	13.2	15.4	17.2	17	19.4
31.	VEN	15.8	17.6	18.6	18.6	17	17.2
32.	ARV	15.8	14.2	14.0	15.4	16	15.2
33.	DEE	17.4	15.4	17.2	15.2	15	15.0
34.	SAN	17.8	16.2	17.0	18.4	18	19.2
35.	NAV	15.4	15.6	13.0	12.6	12	11.2
36.	ANU	16.8	18.0	17.2	15.0	15	17.0
37.	MAN1	18.8	18.0	11.0	16.4	19	15.4
38.	ARU	14.8	14.8	14.2	14.0	15	14.4
39.	DAT	17.0	16.0	17.4	17.6	17	16.8
40.	MAN2	16.4	19.8	18.0	16.4	19	17.6
41.	DIL	15.4	16.8	17.4	17.0	18	18.0

42.	JAI	16.2	17.2	16.2	15.4	15	16.0
43.	KUN	13.8	15.0	16.4	13.4	14	15.4
44.	NID	17.6	16.8	16.2	17.0	18	12.6
45.	GAJ	14.8	16.4	16.4	15.0	15	15.4
46.	RAV	15.6	15.6	14.8	15.4	16	16.4
47.	SUS	16.4	17.0	17.6	18.6	18	18.4
48.	SUM	17.4	16.8	18.0	18.4	17	16.8
49.	HEM	16.4	19.2	18.2	19.2	19	17.4
50.	HAR	18.4	17.8	16.2	18.2	17	17.6
51.	GAJ	15.8	16.6	19.0	16.0	19	14.6
52.	SHA	17.0	17.0	16.4	16.0	16	16.6
53.	RAJ	16.2	15.8	17.2	17.8	16	16.2
54.	AMI	15.4	15.6	16.4	16.6	15	14.6
55.	NAV	16.2	15.6	15.8	15.4	16	16.0
56.	SUD	15.6	16.8	16.8	16.8	16	15.6
57.	NAG	17.6	16.0	16.2	19.0	18	18.4
58.	HAN	17.2	16.0	15.0	17.2	16	16.4
59.	SAT	14.8	14.4	15.2	16.0	16	16.2
60.	NAG	15.4	16.0	15.8	15.8	16	16.0
<b>Mean</b>		<b>16.03</b>	<b>16.36</b>	<b>16.36</b>	<b>16.44</b>	<b>16.33</b>	<b>16.01</b>
<b>SD</b>		<b>1.62</b>	<b>1.59</b>	<b>1.66</b>	<b>1.65</b>	<b>1.63</b>	<b>1.64</b>

**Table. 18: Peak latencies of Na wave recorded at pre, during and post *dhyāna* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	14.20	14.80	14.80	15.40	14.60	15.20
2.	SOH	11.80	13.60	14.00	11.80	13.80	13.40
3.	SHR	15.40	18.40	18.20	18.60	18.40	19.40
4.	RAG	17.60	17.20	17.80	18.40	18.20	17.80
5.	SUB	14.80	14.60	14.60	15.40	14.80	14.20
6.	ARJ	15.80	15.80	15.20	15.40	15.60	15.40
7.	SUH	14.20	14.80	14.60	15.20	14.60	14.60
8.	PRA	18.00	17.60	17.60	19.20	18.00	17.60
9.	VIR	16.80	17.80	15.00	16.80	17.40	16.40
10.	SAU	14.20	14.40	15.40	17.60	17.00	14.20
11.	SHA	16.60	16.00	16.00	16.40	15.80	14.40
12.	GAU	16.80	16.60	18.80	15.00	17.00	14.40
13.	AYU	13.20	12.60	12.80	12.40	12.40	12.60
14.	HEM	14.60	19.80	19.40	18.20	18.00	18.60
15.	REV	16.80	14.80	14.00	14.60	14.00	14.20
16.	ANK	18.40	17.80	18.20	17.60	18.20	17.80
17.	AMI	15.20	15.20	16.60	16.00	15.80	15.40
18.	HAR	21.80	19.60	17.80	19.60	20.80	12.40
19.	ROH	16.80	16.80	17.00	18.20	17.20	17.40
20.	MAL	17.40	18.20	17.40	17.00	16.40	19.40
21.	VAD	15.40	17.80	21.20	16.80	16.60	14.80
22.	PUS	15.60	15.60	15.40	16.60	16.60	16.40
23.	RAN	16.20	16.00	17.00	16.20	15.60	17.00
24.	SUP	15.20	15.40	16.80	17.40	16.60	15.80
25.	SHA	15.60	17.20	16.20	16.20	16.00	18.60
26.	KAR	18.00	17.00	17.20	17.80	16.80	17.00
27.	AJA	13.60	14.40	15.00	14.80	14.80	14.20
28.	ANA	16.60	17.80	17.00	17.40	16.00	15.80
29.	BHA	16.60	17.60	17.20	16.80	17.40	18.00
30.	JIT	15.60	18.60	19.00	18.00	18.00	18.00
31.	VEN	16.40	17.80	18.80	19.20	17.60	17.80
32.	ARV	14.60	14.00	14.40	14.20	13.60	14.00
33.	DEE	13.60	16.80	13.80	14.60	12.00	16.40
34.	SAN	18.80	19.20	19.20	19.20	19.40	16.80
35.	NAV	13.80	14.40	13.40	13.80	13.00	12.80
36.	ANU	16.60	16.00	15.20	15.40	17.60	16.20
37.	MAN1	17.40	19.00	18.20	18.00	16.80	12.20
38.	ARU	15.00	14.80	14.80	14.40	14.80	14.40
39.	DAT	17.00	17.60	17.00	17.00	17.20	16.40
40.	MAN2	16.60	17.20	18.20	20.00	15.20	18.20
41.	DIL	16.60	16.20	16.80	17.00	16.80	15.40

42.	JAI	16.00	17.00	17.00	16.00	16.20	16.40
43.	KUN	15.20	16.60	16.20	16.60	13.80	12.80
44.	NID	16.20	16.80	18.80	17.40	18.40	17.40
45.	GAJ	14.80	15.80	16.20	16.20	15.80	16.00
46.	RAV	16.60	16.00	17.40	16.00	16.40	15.40
47.	SUS	17.40	17.40	17.00	18.60	17.60	18.40
48.	SUM	17.20	17.60	17.20	17.80	17.40	17.40
49.	HEM	15.20	16.40	14.00	16.00	19.40	17.20
50.	HAR	15.20	17.40	18.40	13.20	18.80	18.40
51.	GAJ	14.80	14.20	17.40	18.00	17.60	17.60
52.	SHA	16.00	16.60	16.60	15.20	18.00	17.40
53.	RAJ	18.80	18.80	18.20	18.80	16.80	21.20
54.	AMI	14.80	14.80	15.40	15.20	14.40	14.40
55.	NAV	16.80	16.20	16.20	16.00	16.00	16.00
56.	SUD	15.40	15.80	15.00	15.80	18.00	18.00
57.	NAG	14.80	14.60	14.80	14.80	15.40	13.80
58.	HAN	16.40	16.60	16.40	17.40	17.60	16.40
59.	SAT	15.80	15.00	15.20	15.80	16.40	17.20
60.	NAG	15.40	15.20	15.20	15.20	15.60	15.40
<b>Mean</b>		<b>15.97</b>	<b>16.43</b>	<b>16.49</b>	<b>16.49</b>	<b>16.43</b>	<b>16.13</b>
<b>SD</b>		<b>1.59</b>	<b>1.58</b>	<b>1.72</b>	<b>1.75</b>	<b>1.75</b>	<b>1.95</b>

**Table. 19: Peak latencies of Pa wave recorded at pre, during and post *cañcalatā* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	31.20	36.60	34.40	35.00	36.40	33.20
2.	SOH	35.40	35.00	33.80	35.20	35.00	35.80
3.	SHR	37.80	37.20	38.00	38.00	37.80	38.40
4.	RAG	34.20	37.00	37.60	34.20	35.80	36.20
5.	SUB	30.20	30.20	31.40	31.60	32.80	33.40
6.	ARJ	29.60	32.20	37.20	35.40	31.20	32.80
7.	SUH	36.20	34.00	35.80	35.60	35.40	37.40
8.	PRA	36.20	37.40	35.00	34.00	35.60	35.60
9.	VIR	32.60	35.60	36.40	36.80	36.60	35.00
10.	SAU	36.80	35.80	36.60	36.00	36.40	36.20
11.	SHA	32.60	35.60	35.00	33.80	34.00	37.80
12.	GAU	35.00	35.20	35.60	35.00	35.00	34.60
13.	AYU	39.60	36.20	38.20	38.80	38.80	31.40
14.	HEM	35.20	36.00	36.20	35.20	36.80	34.80
15.	REV	34.60	33.20	34.60	31.80	34.80	35.80
16.	ANK	38.60	34.80	36.60	36.60	36.60	36.00
17.	AMI	35.80	24.80	24.40	23.20	25.40	25.40
18.	HAR	37.00	36.40	37.00	35.20	38.00	38.40
19.	ROH	32.60	32.80	35.00	35.40	34.40	35.40
20.	MAL	34.80	36.20	35.00	32.80	36.00	34.80
21.	VAD	35.20	37.40	36.00	37.20	37.60	38.40
22.	PUS	36.00	32.80	35.80	36.60	36.40	34.80
23.	RAN	32.00	32.20	30.00	33.20	34.80	32.00
24.	SUP	39.40	35.60	38.00	36.60	37.80	37.40
25.	SHA	34.20	35.00	33.60	33.80	35.00	34.80
26.	KAR	36.60	36.20	34.80	34.20	34.00	35.60
27.	AJA	34.40	36.00	35.20	32.00	36.80	36.60
28.	ANA	35.00	31.00	34.20	32.00	34.60	35.60
29.	BHA	35.60	35.80	36.60	35.40	35.60	37.80
30.	JIT	36.20	36.80	38.00	34.80	36.20	38.00
31.	VEN	33.00	35.80	33.80	37.40	36.60	38.20
32.	ARV	33.40	33.60	34.60	34.00	34.80	33.00
33.	DEE	32.40	33.60	36.20	32.80	36.00	33.80
34.	SAN	35.40	37.00	33.00	36.80	38.40	35.20
35.	NAV	28.00	33.00	34.60	24.80	24.80	24.20
36.	ANU	36.40	35.00	34.60	37.60	37.40	33.80
37.	MAN1	35.00	33.60	36.40	35.00	35.80	35.00
38.	ARU	36.00	34.20	35.00	34.60	36.40	34.20
39.	DAT	36.40	36.40	35.80	36.00	35.80	35.60
40.	MAN2	36.80	35.80	36.80	36.60	37.20	36.60
41.	DIL	36.40	34.20	35.40	35.20	38.40	37.20

42.	JAI	35.60	34.60	36.60	33.40	34.80	34.80
43.	KUN	36.80	36.60	34.80	34.40	34.60	35.60
44.	NID	36.40	36.00	28.40	36.80	36.40	35.00
45.	GAJ	33.80	35.20	35.00	36.80	34.00	33.40
46.	RAV	39.60	37.60	38.00	37.00	37.40	40.20
47.	SUS	34.40	33.00	36.40	35.40	34.40	37.20
48.	SUM	36.80	35.80	35.60	36.60	35.40	35.60
49.	HEM	30.40	32.20	31.80	33.00	32.20	35.40
50.	HAR	35.20	25.40	27.60	28.40	37.80	39.60
51.	GAJ	33.20	37.40	34.60	36.20	36.00	34.40
52.	SHA	34.40	35.20	33.80	33.20	33.40	34.80
53.	RAJ	36.60	36.40	37.20	37.40	37.00	36.80
54.	AMI	33.00	33.00	34.20	34.60	35.20	33.60
55.	NAV	24.40	23.80	32.00	28.60	31.40	31.60
56.	SUD	37.20	38.00	35.60	38.20	37.20	38.60
57.	NAG	30.20	32.60	35.00	35.60	34.40	32.00
58.	HAN	37.80	34.20	35.40	34.20	35.00	34.80
59.	SAT	36.60	33.00	36.00	34.80	33.80	34.60
60.	NAG	33.40	35.00	28.80	34.00	34.40	36.20
<b>Mean</b>		<b>34.76</b>	<b>34.47</b>	<b>34.82</b>	<b>34.58</b>	<b>35.30</b>	<b>35.17</b>
<b>SD</b>		<b>2.79</b>	<b>2.86</b>	<b>2.64</b>	<b>2.85</b>	<b>2.52</b>	<b>2.74</b>

**Table. 20: Peak latencies of Pa wave recorded at pre, during and post *ekāgratā* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	32.40	33.40	33.20	32.00	32.80	33.60
2.	SOH	36.00	38.00	35.60	35.80	36.00	38.20
3.	SHR	36.40	37.20	39.00	36.80	37.00	39.00
4.	RAG	35.40	36.80	35.00	33.20	35.60	34.60
5.	SUB	29.40	31.00	32.60	30.00	29.60	33.80
6.	ARJ	32.00	35.00	34.80	33.60	34.80	31.80
7.	SUH	33.80	34.80	35.00	33.80	36.80	33.40
8.	PRA	36.40	34.40	36.20	31.60	36.00	35.20
9.	VIR	34.40	37.20	33.60	36.40	36.00	36.20
10.	SAU	38.40	37.40	36.80	35.40	36.80	37.60
11.	SHA	36.00	34.00	34.40	32.80	34.80	38.20
12.	GAU	37.80	32.00	34.00	36.20	34.80	35.40
13.	AYU	34.60	34.60	33.80	34.40	36.20	34.80
14.	HEM	34.40	33.60	36.20	35.80	34.87	36.00
15.	REV	29.20	31.40	32.20	29.40	32.20	37.80
16.	ANK	36.20	37.40	36.40	34.80	34.60	37.20
17.	AMI	38.00	33.40	34.80	35.60	34.40	35.20
18.	HAR	36.00	37.40	36.60	39.00	35.80	37.40
19.	ROH	31.40	33.00	35.60	33.60	34.60	31.00
20.	MAL	33.00	36.20	35.20	36.20	35.20	34.60
21.	VAD	34.40	36.40	36.40	38.00	34.60	36.20
22.	PUS	36.60	38.60	32.40	34.80	32.00	36.60
23.	RAN	32.00	34.40	35.20	36.00	33.80	34.20
24.	SUP	37.00	37.60	37.00	34.60	36.40	38.80
25.	SHA	33.80	22.60	33.80	34.60	30.60	32.80
26.	KAR	38.80	36.80	35.00	37.20	36.00	37.00
27.	AJA	34.20	33.40	34.00	35.40	36.40	36.00
28.	ANA	34.40	36.60	35.80	35.60	35.00	35.40
29.	BHA	37.60	37.60	37.00	36.20	37.60	37.00
30.	JIT	36.20	37.40	37.20	38.60	38.00	37.60
31.	VEN	36.20	38.20	36.00	37.80	31.20	30.60
32.	ARV	32.80	33.20	35.40	33.80	31.60	31.20
33.	DEE	35.20	35.80	34.80	34.80	33.60	35.80
34.	SAN	34.20	33.20	34.00	36.80	34.20	35.20
35.	NAV	29.00	36.20	34.40	35.20	25.80	26.20
36.	ANU	36.40	34.60	35.80	37.80	35.60	36.60
37.	MAN1	34.40	34.40	34.60	34.80	35.40	36.40
38.	ARU	37.40	36.80	36.20	35.80	36.40	36.80
39.	DAT	36.40	37.00	38.00	37.00	35.20	34.80
40.	MAN2	36.40	33.20	35.60	34.80	35.80	37.40
41.	DIL	36.20	36.00	34.40	34.00	32.60	36.80

42.	JAI	33.40	34.80	35.40	36.60	33.40	36.40
43.	KUN	30.20	33.60	34.00	34.60	34.60	35.20
44.	NID	35.60	35.60	36.20	35.80	36.80	34.20
45.	GAJ	34.20	34.40	32.80	33.40	32.00	34.60
46.	RAV	38.60	38.00	36.40	37.20	39.60	39.60
47.	SUS	36.40	37.60	36.00	37.00	36.20	34.00
48.	SUM	36.40	35.20	38.20	36.60	38.40	36.80
49.	HEM	38.60	38.00	37.20	37.20	39.60	38.40
50.	HAR	33.20	32.80	35.60	35.00	31.40	32.20
51.	GAJ	41.20	37.00	37.80	39.20	37.20	39.80
52.	SHA	36.40	36.20	34.60	37.20	36.20	36.20
53.	RAJ	37.20	36.80	37.00	35.80	37.00	35.40
54.	AMI	35.60	33.60	33.60	34.00	35.20	35.60
55.	NAV	30.80	32.60	32.60	31.80	31.40	34.00
56.	SUD	35.80	38.80	36.20	37.20	36.80	36.80
57.	NAG	32.60	32.80	31.80	35.20	33.00	33.80
58.	HAN	36.40	37.60	40.20	36.80	38.00	37.20
59.	SAT	33.00	35.60	35.80	33.00	35.60	34.00
60.	NAG	34.40	37.40	37.60	36.20	36.80	35.60
	<b>Mean</b>	<b>35.01</b>	<b>35.28</b>	<b>35.38</b>	<b>35.33</b>	<b>34.93</b>	<b>35.50</b>
	<b>SD</b>	<b>2.50</b>	<b>2.59</b>	<b>1.70</b>	<b>2.00</b>	<b>2.48</b>	<b>2.38</b>

**Table. 21: Peak latencies of Pa wave recorded at pre, during and post *dhāraṇā* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	30.40	33.40	31.60	34.20	33.00	30.20
2.	SOH	34.40	36.40	34.40	35.00	34.20	35.00
3.	SHR	37.60	37.00	36.40	38.20	38.00	37.20
4.	RAG	37.80	33.60	34.80	33.80	32.60	34.60
5.	SUB	29.60	30.80	30.40	29.20	30.80	31.20
6.	ARJ	34.20	31.80	29.20	37.00	34.20	32.60
7.	SUH	34.00	34.20	35.20	35.60	36.60	36.20
8.	PRA	32.20	35.00	34.40	32.80	34.80	37.40
9.	VIR	32.20	35.00	37.00	34.40	33.20	34.00
10.	SAU	38.20	37.80	34.20	37.40	37.80	38.80
11.	SHA	33.40	36.20	35.60	33.60	34.80	34.40
12.	GAU	31.60	35.60	36.80	39.80	38.60	37.00
13.	AYU	33.20	35.60	26.80	28.40	32.00	26.80
14.	HEM	36.20	35.40	36.80	36.60	36.60	36.00
15.	REV	37.00	35.80	35.00	35.40	34.40	35.80
16.	ANK	35.20	38.00	36.40	36.00	34.40	35.80
17.	AMI	36.60	36.20	36.60	37.40	36.60	36.00
18.	HAR	36.40	37.80	38.80	38.80	38.20	36.20
19.	ROH	30.00	34.40	33.40	34.60	31.80	31.40
20.	MAL	37.40	36.00	36.40	37.80	35.80	36.40
21.	VAD	33.60	36.00	35.80	34.80	35.40	34.80
22.	PUS	34.20	35.60	33.80	34.40	35.40	31.80
23.	RAN	34.40	34.80	31.80	34.80	32.20	24.20
24.	SUP	37.80	36.40	36.60	38.00	38.60	39.40
25.	SHA	31.60	31.20	30.20	33.60	28.60	32.00
26.	KAR	36.20	36.40	35.60	36.80	36.60	37.20
27.	AJA	36.00	34.80	36.00	37.00	34.00	34.00
28.	ANA	36.40	37.00	36.00	34.60	36.00	35.40
29.	BHA	36.60	37.00	36.60	36.00	37.00	37.60
30.	JIT	38.80	36.00	35.20	37.60	39.20	36.40
31.	VEN	30.80	34.40	36.60	36.00	36.40	37.40
32.	ARV	34.20	35.40	34.40	33.20	33.80	33.60
33.	DEE	35.80	36.00	36.40	33.00	33.80	33.80
34.	SAN	34.80	35.00	33.60	36.40	35.40	34.60
35.	NAV	28.00	30.00	31.20	28.80	27.40	26.60
36.	ANU	36.80	36.80	36.40	37.00	36.20	37.80
37.	MAN1	35.40	36.80	35.80	36.20	36.40	36.00
38.	ARU	37.20	35.80	35.20	36.20	37.80	37.80
39.	DAT	33.40	36.80	35.20	35.20	35.00	37.60
40.	MAN2	35.40	35.40	35.00	36.40	37.00	33.80
41.	DIL	35.60	35.80	36.80	36.80	36.80	36.80

42.	JAI	35.00	35.20	33.40	35.20	35.40	35.60
43.	KUN	35.00	35.00	36.80	35.20	32.60	35.20
44.	NID	35.00	34.20	33.00	36.00	36.40	32.80
45.	GAJ	34.00	34.40	37.00	36.60	33.00	33.00
46.	RAV	38.80	37.20	38.00	36.40	37.00	40.40
47.	SUS	35.40	36.60	36.80	36.80	37.80	36.60
48.	SUM	36.40	38.40	37.60	38.40	37.20	38.20
49.	HEM	38.80	38.60	35.20	38.60	37.60	41.40
50.	HAR	34.00	35.20	35.60	38.20	36.60	32.40
51.	GAJ	39.20	39.00	39.60	42.20	36.20	39.60
52.	SHA	34.80	33.00	33.60	35.00	33.80	32.60
53.	RAJ	37.00	36.60	37.20	36.40	36.80	37.40
54.	AMI	32.80	33.40	33.80	35.40	34.00	34.80
55.	NAV	27.80	32.60	34.00	32.80	33.40	35.00
56.	SUD	37.60	37.60	36.40	36.60	37.20	38.40
57.	NAG	37.00	36.40	36.80	37.40	38.40	36.20
58.	HAN	37.40	36.80	38.40	36.20	36.80	38.00
59.	SAT	34.60	32.60	33.00	36.60	35.20	35.60
60.	NAG	35.60	34.20	34.40	33.20	36.40	35.40
<b>Mean</b>		<b>34.95</b>	<b>35.44</b>	<b>35.08</b>	<b>35.70</b>	<b>35.32</b>	<b>35.17</b>
<b>SD</b>		<b>2.61</b>	<b>1.87</b>	<b>2.35</b>	<b>2.39</b>	<b>2.38</b>	<b>3.17</b>

**Table. 22: Peak latencies of Pa wave recorded at pre, during and post *dhyāna* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	31.80	34.60	32.80	33.60	34.60	33.60
2.	SOH	34.20	31.20	34.80	31.80	34.20	32.40
3.	SHR	38.40	39.00	38.80	37.40	38.00	38.20
4.	RAG	35.60	36.00	36.00	37.00	34.80	36.80
5.	SUB	29.80	31.00	32.00	30.20	30.80	31.20
6.	ARJ	30.00	30.00	28.60	32.20	36.80	34.60
7.	SUH	33.40	33.20	33.80	34.60	34.00	35.20
8.	PRA	37.40	37.00	35.40	31.40	36.60	35.20
9.	VIR	33.60	32.40	35.20	36.20	34.20	35.60
10.	SAU	39.80	38.00	38.60	37.40	37.40	36.40
11.	SHA	34.80	36.40	33.80	34.40	33.40	32.00
12.	GAU	35.00	35.20	37.60	37.40	37.60	38.00
13.	AYU	29.60	31.60	33.60	31.20	32.60	25.00
14.	HEM	35.60	36.80	37.00	36.80	34.60	35.20
15.	REV	31.00	32.20	34.60	35.20	35.40	38.20
16.	ANK	33.80	35.40	33.20	37.00	36.60	37.00
17.	AMI	38.20	38.60	39.40	38.80	36.80	38.60
18.	HAR	38.20	36.60	36.40	36.40	36.60	36.60
19.	ROH	34.20	34.00	36.00	34.60	37.80	34.00
20.	MAL	31.60	36.80	37.20	34.80	37.20	36.60
21.	VAD	34.60	35.80	36.80	35.60	36.20	35.00
22.	PUS	33.40	34.60	36.00	38.20	34.20	34.80
23.	RAN	36.00	34.80	36.80	35.00	35.00	34.40
24.	SUP	37.00	36.80	37.20	36.20	37.80	38.80
25.	SHA	31.60	34.60	33.60	32.20	34.20	33.20
26.	KAR	36.60	32.40	34.00	36.80	37.00	35.80
27.	AJA	36.20	37.20	34.00	36.40	33.60	35.80
28.	ANA	36.40	37.80	37.20	35.60	36.40	36.40
29.	BHA	36.40	36.60	35.20	36.00	37.40	37.60
30.	JIT	36.80	37.20	37.20	37.00	38.20	35.20
31.	VEN	31.80	37.20	38.60	37.80	36.00	37.40
32.	ARV	33.40	32.60	32.40	35.60	35.60	32.20
33.	DEE	34.20	34.80	36.00	34.80	37.00	36.80
34.	SAN	34.80	31.60	35.80	34.20	37.60	34.40
35.	NAV	29.60	32.80	25.80	25.60	28.40	25.60
36.	ANU	36.80	36.20	35.20	36.00	37.00	35.20
37.	MAN1	34.80	36.20	37.00	36.80	35.40	35.60
38.	ARU	36.60	36.80	34.60	35.80	36.80	36.20
39.	DAT	33.80	35.60	33.20	35.40	34.60	35.20
40.	MAN2	36.20	37.60	36.60	37.00	36.80	37.60
41.	DIL	36.40	37.00	36.20	34.40	35.20	34.80

42.	JAI	35.60	34.40	34.60	34.00	34.60	35.60
43.	KUN	34.40	35.40	35.60	36.20	34.00	33.40
44.	NID	34.00	35.00	35.00	35.20	35.60	36.00
45.	GAJ	33.40	34.80	34.00	35.00	34.00	33.20
46.	RAV	37.80	37.60	39.80	39.60	36.20	38.80
47.	SUS	33.20	34.80	35.60	33.40	36.40	36.60
48.	SUM	37.40	36.80	38.20	37.20	37.00	39.00
49.	HEM	30.20	30.60	31.60	36.20	38.00	37.20
50.	HAR	32.80	33.40	33.80	32.60	36.00	34.80
51.	GAJ	39.00	38.60	37.40	38.60	33.80	38.60
52.	SHA	36.00	36.40	32.20	35.00	34.80	33.20
53.	RAJ	37.60	37.60	37.40	38.20	36.40	37.20
54.	AMI	30.60	31.80	33.40	33.60	34.40	32.80
55.	NAV	24.20	32.40	31.40	29.00	30.00	31.20
56.	SUD	37.80	39.60	36.40	37.60	37.80	37.80
57.	NAG	33.00	32.60	30.60	33.60	31.20	30.80
58.	HAN	37.60	38.60	38.20	40.60	38.00	38.80
59.	SAT	34.80	33.40	35.20	37.00	35.80	35.40
60.	NAG	37.00	35.00	36.80	36.40	38.80	36.00
	<b>Mean</b>	<b>34.60</b>	<b>35.18</b>	<b>35.19</b>	<b>35.33</b>	<b>35.55</b>	<b>35.25</b>
	<b>SD</b>	<b>2.89</b>	<b>2.35</b>	<b>2.57</b>	<b>2.58</b>	<b>2.08</b>	<b>2.78</b>

**Table. 23: Peak latencies of Nb wave recorded at pre, during and post *cañcalatā* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	70.00	64.20	68.60	63.40	68.00	68.20
2.	SOH	58.40	52.80	60.20	60.20	63.00	62.20
3.	SHR	66.60	66.00	67.20	66.40	65.80	66.60
4.	RAG	69.00	63.40	64.60	49.80	65.80	74.80
5.	SUB	40.00	39.20	40.40	42.40	47.40	48.80
6.	ARJ	44.40	67.40	62.60	67.80	63.00	59.00
7.	SUH	46.60	66.20	66.80	67.00	68.20	67.60
8.	PRA	48.60	53.00	51.40	49.40	53.80	51.00
9.	VIR	52.80	46.40	45.40	47.80	49.00	59.20
10.	SAU	65.80	65.60	63.00	64.80	65.80	67.20
11.	SHA	43.60	60.20	59.80	64.80	63.60	64.80
12.	GAU	46.40	46.00	52.60	46.40	47.00	48.20
13.	AYU	50.00	64.60	68.80	63.60	66.60	45.80
14.	HEM	47.40	54.00	50.60	50.20	50.80	46.60
15.	REV	56.40	67.80	69.60	68.20	65.80	61.80
16.	ANK	48.20	46.80	50.20	49.00	46.60	47.20
17.	AMI	48.00	45.60	46.80	48.00	48.20	49.20
18.	HAR	55.20	55.80	56.40	54.00	52.00	52.80
19.	ROH	54.00	47.60	47.80	52.40	52.20	51.60
20.	MAL	44.80	47.00	41.20	48.60	45.80	48.20
21.	VAD	63.20	54.00	56.00	54.40	62.60	66.20
22.	PUS	48.80	46.40	48.00	47.60	47.00	47.40
23.	RAN	46.40	47.40	45.60	48.00	48.80	48.80
24.	SUP	50.80	45.00	47.80	64.80	65.40	48.80
25.	SHA	42.40	40.20	40.60	41.20	42.80	46.60
26.	KAR	66.20	48.80	50.60	50.80	51.40	68.20
27.	AJA	49.20	47.20	47.80	48.00	54.80	49.40
28.	ANA	49.00	55.40	51.40	59.80	53.60	54.00
29.	BHA	59.20	66.40	66.40	67.80	65.80	65.00
30.	JIT	67.80	61.80	58.20	66.80	62.60	66.60
31.	VEN	67.40	68.00	64.80	66.20	66.40	68.80
32.	ARV	47.20	50.00	46.00	44.40	45.40	44.60
33.	DEE	48.80	48.40	47.20	48.20	50.60	45.40
34.	SAN	42.20	49.60	49.20	48.40	51.20	48.80
35.	NAV	48.80	49.20	50.20	50.00	46.40	46.40
36.	ANU	66.20	62.60	63.00	65.20	66.20	65.20
37.	MAN1	52.00	56.80	60.60	52.40	63.00	63.00
38.	ARU	66.80	48.20	48.60	63.00	48.00	47.00
39.	DAT	51.60	46.40	47.20	45.00	47.00	47.80
40.	MAN2	57.00	52.60	50.80	54.20	53.20	46.20

41.	DIL	66.60	56.00	57.20	47.40	64.00	65.40
42.	JAI	47.00	47.00	48.80	44.40	46.60	46.60
43.	KUN	52.20	46.20	64.20	63.20	61.60	59.00
44.	NID	45.20	49.40	48.00	64.60	62.60	45.00
45.	GAJ	45.60	48.00	43.60	50.40	49.80	51.40
46.	RAV	68.80	63.80	62.00	60.80	60.00	68.00
47.	SUS	66.80	67.60	66.00	61.00	64.00	69.20
48.	SUM	64.80	63.40	45.20	52.80	49.80	65.60
49.	HEM	37.00	44.00	49.60	50.00	49.40	54.40
50.	HAR	47.20	46.00	48.00	48.20	66.80	45.60
51.	GAJ	45.80	47.40	46.80	50.20	49.80	44.80
52.	SHA	50.60	44.20	59.80	47.40	53.60	51.40
53.	RAJ	59.00	57.80	60.20	50.40	56.80	60.20
54.	AMI	44.40	46.80	50.60	49.40	49.60	51.40
55.	NAV	47.40	46.00	47.80	48.00	49.60	48.40
56.	SUD	43.60	58.00	46.00	49.40	48.00	49.00
57.	NAG	40.80	40.60	42.80	44.00	42.20	44.00
58.	HAN	51.80	50.80	66.60	56.20	66.20	51.80
59.	SAT	45.80	44.20	46.20	47.40	51.20	43.00
60.	NAG	46.20	49.20	44.40	44.80	46.80	47.20
<b>Mean</b>		<b>52.73</b>	<b>53.01</b>	<b>53.63</b>	<b>54.01</b>	<b>55.48</b>	<b>54.77</b>
<b>SD</b>		<b>9.01</b>	<b>8.30</b>	<b>8.47</b>	<b>8.05</b>	<b>8.09</b>	<b>8.96</b>

**Table. 24: Peak latencies of Nb wave recorded at pre, during and post *ekāgratā* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	68.60	67.60	69.00	70.00	71.20	73.40
2.	SOH	60.00	61.00	62.00	61.00	62.40	58.00
3.	SHR	65.20	65.60	65.80	67.60	67.20	67.80
4.	RAG	65.20	65.00	67.40	67.40	69.20	66.80
5.	SUB	39.80	39.80	40.40	39.20	43.20	49.60
6.	ARJ	44.40	46.60	45.80	64.40	67.20	63.80
7.	SUH	45.00	47.40	63.80	69.20	67.60	66.40
8.	PRA	51.60	51.20	50.80	54.00	51.20	67.00
9.	VIR	64.60	63.40	56.80	59.80	63.20	60.40
10.	SAU	66.80	66.00	66.20	67.60	66.20	66.00
11.	SHA	45.20	49.60	59.00	61.80	52.00	58.40
12.	GAU	45.60	43.00	47.80	50.60	47.60	44.80
13.	AYU	65.00	62.20	50.00	65.20	64.60	65.00
14.	HEM	48.60	48.80	50.20	50.40	50.40	47.80
15.	REV	57.60	59.60	49.40	54.60	61.80	62.80
16.	ANK	67.80	64.40	65.60	64.20	65.80	66.80
17.	AMI	65.60	65.20	65.40	66.00	66.00	67.80
18.	HAR	55.20	59.40	52.60	58.80	55.40	56.00
19.	ROH	69.20	67.60	66.20	71.00	68.40	65.40
20.	MAL	65.40	47.20	56.60	62.60	52.60	65.60
21.	VAD	53.60	49.40	49.00	56.60	65.00	68.60
22.	PUS	44.60	45.80	44.20	46.00	46.40	46.20
23.	RAN	48.00	47.60	54.00	49.00	47.80	47.00
24.	SUP	48.40	64.80	64.60	65.60	65.40	64.60
25.	SHA	41.20	45.00	43.60	43.40	43.80	42.80
26.	KAR	48.20	50.80	48.20	50.00	53.80	61.20
27.	AJA	48.80	47.60	54.40	49.60	53.60	53.20
28.	ANA	56.60	48.00	51.40	62.20	66.60	65.60
29.	BHA	64.40	66.60	67.60	63.40	59.60	65.60
30.	JIT	45.00	47.40	53.40	60.00	63.20	66.80
31.	VEN	64.60	50.40	51.20	53.80	69.00	69.00
32.	ARV	46.00	48.00	48.00	45.00	46.20	49.60
33.	DEE	50.00	51.40	49.80	49.80	47.00	48.80
34.	SAN	45.60	49.40	46.20	52.00	50.40	49.40
35.	NAV	64.80	52.20	56.80	63.20	43.60	41.20
36.	ANU	67.80	64.00	65.00	69.00	67.00	67.60
37.	MAN1	53.80	56.60	52.80	52.20	54.20	58.80
38.	ARU	65.80	49.00	53.40	65.60	66.80	66.40
39.	DAT	45.80	48.80	49.80	47.80	49.40	50.20
40.	MAN2	49.20	51.00	53.40	52.60	55.00	52.40

41.	DIL	65.40	49.80	54.00	54.20	51.40	68.20
42.	JAI	46.40	49.00	50.40	50.80	50.40	49.00
43.	KUN	47.60	47.60	51.00	50.60	50.60	49.80
44.	NID	45.60	48.00	44.40	53.20	50.40	47.60
45.	GAJ	45.00	46.20	47.60	48.20	67.20	47.60
46.	RAV	66.00	62.80	65.80	66.80	60.40	68.40
47.	SUS	65.00	66.60	65.20	67.80	68.40	51.80
48.	SUM	65.80	60.40	64.60	50.20	51.60	66.20
49.	HEM	52.80	52.60	54.20	53.60	57.40	53.20
50.	HAR	47.40	47.60	49.80	44.20	47.20	48.60
51.	GAJ	48.40	65.40	46.20	51.40	44.60	49.20
52.	SHA	47.40	50.00	49.20	48.80	51.60	51.80
53.	RAJ	51.00	53.80	56.00	53.00	50.60	52.60
54.	AMI	47.20	46.00	46.00	47.20	51.60	50.80
55.	NAV	46.80	49.80	47.80	50.00	48.80	50.80
56.	SUD	45.60	46.40	52.20	50.40	48.00	46.60
57.	NAG	40.60	41.60	42.20	43.40	42.00	42.60
58.	HAN	51.40	53.40	52.20	51.60	53.60	49.80
59.	SAT	47.80	46.40	47.60	48.00	45.00	47.60
60.	NAG	43.80	45.20	46.80	47.00	47.40	45.00
<b>Mean</b>		<b>53.76</b>	<b>53.38</b>	<b>54.01</b>	<b>55.88</b>	<b>56.09</b>	<b>56.86</b>
<b>SD</b>		<b>9.15</b>	<b>7.93</b>	<b>7.68</b>	<b>8.31</b>	<b>8.70</b>	<b>9.03</b>

**Table. 25: Peak latencies of Nb wave recorded at pre, during and post *dhāraṇā* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	67.80	67.60	68.60	66.60	65.60	69.00
2.	SOH	58.20	56.00	63.20	55.20	60.40	54.20
3.	SHR	66.20	65.00	67.20	67.40	68.00	67.80
4.	RAG	69.80	66.80	67.80	68.80	65.00	65.20
5.	SUB	39.60	41.20	39.20	38.60	40.00	41.20
6.	ARJ	47.40	47.40	47.20	62.60	45.60	47.00
7.	SUH	68.80	68.00	64.20	64.00	65.60	68.20
8.	PRA	49.80	51.20	52.80	58.80	55.00	59.40
9.	VIR	52.40	59.40	60.40	55.00	60.80	58.80
10.	SAU	65.00	62.60	61.80	61.20	62.00	64.40
11.	SHA	48.60	62.20	55.80	55.40	50.40	50.80
12.	GAU	44.40	49.20	49.40	49.80	48.00	48.60
13.	AYU	45.60	49.80	48.60	47.00	46.60	47.40
14.	HEM	45.80	48.40	49.20	45.80	49.20	44.60
15.	REV	57.80	57.80	57.60	60.00	61.40	55.40
16.	ANK	69.40	68.00	68.40	68.60	70.20	67.60
17.	AMI	65.20	66.40	67.00	65.40	66.80	68.60
18.	HAR	51.60	55.80	54.40	56.40	63.60	54.00
19.	ROH	45.60	48.40	48.20	48.80	48.80	43.80
20.	MAL	62.80	68.60	63.40	61.20	62.40	63.20
21.	VAD	67.40	68.00	68.00	66.80	68.40	65.20
22.	PUS	44.00	47.20	47.00	48.20	42.60	46.40
23.	RAN	46.80	47.40	48.20	50.20	43.80	47.00
24.	SUP	49.20	46.20	62.60	65.60	50.00	47.40
25.	SHA	43.20	48.40	47.00	44.40	47.40	44.80
26.	KAR	48.80	49.80	64.80	60.60	49.80	66.60
27.	AJA	52.40	51.20	48.80	50.80	50.80	51.00
28.	ANA	53.00	53.00	66.40	53.00	54.80	63.60
29.	BHA	65.60	61.80	66.00	61.20	64.00	62.60
30.	JIT	43.40	44.80	46.00	46.20	51.60	49.00
31.	VEN	67.20	50.60	52.40	51.80	51.80	51.80
32.	ARV	48.00	46.60	50.60	47.60	49.40	47.00
33.	DEE	47.40	49.40	54.80	51.40	48.80	48.60
34.	SAN	46.60	49.20	48.80	50.40	48.40	48.00
35.	NAV	50.20	46.40	46.80	47.40	45.20	46.00
36.	ANU	68.60	67.00	66.80	68.80	66.60	67.60
37.	MAN1	54.20	57.00	57.80	59.00	67.80	55.00
38.	ARU	66.80	65.80	66.80	66.20	47.60	48.20
39.	DAT	46.60	48.20	48.60	46.80	50.40	47.40
40.	MAN2	54.60	54.00	52.60	56.80	57.80	56.20

41.	DIL	67.00	64.80	64.40	67.40	65.60	68.00
42.	JAI	47.20	49.00	47.80	48.00	48.00	49.00
43.	KUN	47.80	49.80	50.20	60.00	57.60	53.20
44.	NID	46.60	53.20	45.80	46.60	46.00	45.60
45.	GAJ	43.60	48.40	50.80	48.60	45.20	46.40
46.	RAV	64.20	60.60	64.00	54.00	60.00	69.40
47.	SUS	55.80	54.80	66.80	68.00	70.40	69.40
48.	SUM	68.80	53.60	68.00	68.20	68.20	63.40
49.	HEM	54.60	49.80	54.20	52.80	55.40	56.40
50.	HAR	46.80	50.20	49.00	48.60	48.40	46.20
51.	GAJ	48.20	46.40	49.00	52.20	46.20	56.20
52.	SHA	51.00	49.60	49.60	49.80	49.80	47.80
53.	RAJ	49.00	49.20	49.60	52.80	52.80	51.60
54.	AMI	45.40	50.40	48.60	50.80	50.20	48.40
55.	NAV	46.80	48.40	49.60	50.00	50.80	51.40
56.	SUD	48.20	47.00	49.60	49.20	47.00	46.60
57.	NAG	46.00	46.60	45.40	48.60	49.60	48.60
58.	HAN	49.20	47.80	47.80	50.60	49.60	70.00
59.	SAT	47.20	44.60	46.00	48.40	48.60	45.60
60.	NAG	44.20	46.60	46.00	45.20	45.60	47.80
<b>Mean</b>		<b>53.39</b>	<b>53.71</b>	<b>55.12</b>	<b>55.16</b>	<b>54.46</b>	<b>54.66</b>
<b>SD</b>		<b>8.96</b>	<b>7.70</b>	<b>8.35</b>	<b>7.94</b>	<b>8.40</b>	<b>8.77</b>

**Table. 26: Peak latencies of Nb wave recorded at pre, during and post *dhyāna* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	67.60	70.20	69.80	69.80	68.80	68.60
2.	SOH	58.00	54.20	59.40	57.00	58.80	58.80
3.	SHR	66.80	64.60	64.80	66.40	66.60	69.20
4.	RAG	66.80	63.20	63.00	65.60	65.80	65.20
5.	SUB	41.00	40.20	42.40	42.00	40.20	41.60
6.	ARJ	46.00	50.00	65.20	65.20	65.60	62.40
7.	SUH	66.40	66.00	65.00	65.00	64.80	66.20
8.	PRA	50.80	55.60	58.60	50.80	54.00	50.20
9.	VIR	54.20	52.20	60.60	61.20	55.00	60.40
10.	SAU	66.20	63.80	65.80	62.80	62.80	64.00
11.	SHA	54.00	50.80	50.00	48.60	51.20	50.40
12.	GAU	47.60	48.20	49.60	50.40	51.00	64.20
13.	AYU	45.60	45.40	53.80	50.80	52.80	46.40
14.	HEM	57.00	53.80	47.40	53.60	46.00	48.60
15.	REV	62.00	58.60	60.20	60.00	62.20	64.20
16.	ANK	46.40	46.20	50.00	48.20	48.40	48.00
17.	AMI	66.60	67.40	67.40	67.80	66.40	63.80
18.	HAR	53.40	51.20	51.00	54.80	57.40	58.20
19.	ROH	49.40	49.00	57.60	54.00	54.40	50.00
20.	MAL	49.60	64.60	67.80	63.60	63.00	63.80
21.	VAD	67.60	63.80	53.40	68.00	67.40	63.20
22.	PUS	45.80	43.00	47.00	46.40	48.60	47.40
23.	RAN	48.00	46.60	46.80	49.80	50.20	48.00
24.	SUP	48.40	48.00	48.20	49.80	47.80	47.80
25.	SHA	45.40	43.80	44.80	46.20	46.40	45.20
26.	KAR	49.80	48.40	46.80	65.40	49.40	49.20
27.	AJA	48.60	52.20	53.00	54.60	52.40	54.20
28.	ANA	56.60	52.80	67.80	59.80	55.60	52.80
29.	BHA	63.60	64.40	64.80	66.40	64.80	69.60
30.	JIT	46.80	45.60	46.60	64.60	65.00	68.20
31.	VEN	68.00	68.00	53.00	52.20	50.00	53.00
32.	ARV	46.20	49.00	45.60	46.80	68.00	45.60
33.	DEE	50.80	45.80	52.60	48.20	44.60	47.00
34.	SAN	46.40	48.80	50.80	49.20	48.60	49.00
35.	NAV	46.80	53.00	47.20	45.20	41.40	44.00
36.	ANU	67.20	66.80	68.40	62.60	65.00	65.80
37.	MAN1	61.00	61.20	66.40	63.40	58.40	54.60
38.	ARU	67.20	67.80	63.40	64.00	65.60	66.20
39.	DAT	48.20	46.00	49.00	48.00	47.80	46.00
40.	MAN2	50.20	51.80	53.60	53.40	53.40	54.60

41.	DIL	65.80	66.00	66.60	65.40	63.60	65.40
42.	JAI	47.40	51.20	48.00	54.20	49.80	47.00
43.	KUN	54.00	49.20	54.80	49.40	59.00	56.60
44.	NID	45.00	51.60	50.60	52.40	49.20	48.60
45.	GAJ	46.00	48.60	51.40	45.80	46.40	45.00
46.	RAV	64.80	58.20	66.80	65.80	68.20	66.80
47.	SUS	53.40	53.20	57.00	61.80	67.40	68.20
48.	SUM	67.00	67.20	65.20	66.40	65.00	63.40
49.	HEM	37.80	37.40	38.20	58.80	54.80	63.60
50.	HAR	44.00	49.60	47.60	48.00	51.40	47.00
51.	GAJ	46.40	47.80	47.60	49.20	44.80	43.20
52.	SHA	52.60	52.60	51.00	51.00	51.80	51.60
53.	RAJ	52.40	52.80	54.80	61.60	59.40	58.20
54.	AMI	46.00	48.20	46.00	47.00	51.20	47.00
55.	NAV	47.20	47.80	46.60	50.40	47.00	47.40
56.	SUD	46.00	46.80	46.80	46.40	51.00	51.00
57.	NAG	42.20	43.60	41.00	44.20	40.40	43.20
58.	HAN	62.80	48.80	50.40	52.60	46.80	50.40
59.	SAT	43.40	45.80	47.60	46.20	49.20	49.20
60.	NAG	45.20	46.60	47.20	47.40	49.20	47.40
<b>Mean</b>		<b>53.29</b>	<b>53.25</b>	<b>54.40</b>	<b>55.43</b>	<b>55.19</b>	<b>54.93</b>
<b>SD</b>		<b>8.75</b>	<b>8.17</b>	<b>8.35</b>	<b>7.89</b>	<b>8.21</b>	<b>8.55</b>

**Table. 27: Peak amplitudes of Na wave recorded at pre, during and post *cañcalatā* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	.05	.47	.14	.08	.30	.07
2.	SOH	.48	.63	.75	.60	1.03	1.04
3.	SHR	1.41	1.18	1.24	.38	.36	.61
4.	RAG	.42	.59	.63	.64	.40	.44
5.	SUB	1.86	.99	1.15	.60	.29	.25
6.	ARJ	.41	.54	.19	.36	.92	.27
7.	SUH	1.20	.48	.33	.46	.25	.64
8.	PRA	.61	.50	.67	.32	.51	.08
9.	VIR	.09	.14	.27	.21	.24	.03
10.	SAU	.35	.05	.31	.01	.39	.47
11.	SHA	.67	.34	.13	.28	.01	.07
12.	GAU	1.30	.38	.77	1.00	1.00	1.14
13.	AYU	2.58	.58	1.65	1.72	1.13	.80
14.	HEM	.97	.49	1.41	.39	.63	.99
15.	REV	.13	.24	.36	.11	.25	.33
16.	ANK	1.21	.67	1.09	.54	1.15	1.51
17.	AMI	.95	.63	.57	.35	.92	.60
18.	HAR	.16	.02	.40	.39	.32	.30
19.	ROH	.30	.03	.30	.25	.29	.24
20.	MAL	.49	.51	.58	.39	.45	.26
21.	VAD	.78	.60	.66	.66	.58	.72
22.	PUS	.23	.12	.43	.30	.51	.34
23.	RAN	.74	.50	.24	.45	.78	.24
24.	SUP	.87	.35	.28	.31	.13	.54
25.	SHA	.61	.70	.54	.30	.17	.02
26.	KAR	.56	.58	.33	.13	.04	.25
27.	AJA	.94	.88	1.33	.64	1.08	.56
28.	ANA	.45	.56	.21	.20	.55	.42
29.	BHA	.23	.79	.46	.64	.05	.27
30.	JIT	.04	.06	.04	.01	.36	.19
31.	VEN	.62	.41	.45	.24	.74	1.02
32.	ARV	.60	1.00	1.06	.93	.47	.47
33.	DEE	.67	.51	.38	.23	.05	.40
34.	SAN	.46	.44	.45	.26	.66	.51
35.	NAV	1.30	1.30	.94	1.07	1.15	1.54
36.	ANU	.04	.31	.16	.18	.17	.26
37.	MAN1	.21	.41	.41	.30	.49	.49
38.	ARU	.59	.80	.53	.32	.35	.15
39.	DAT	.64	.10	.03	.33	.28	.65
40.	MAN2	.08	.35	.19	.27	.45	.13

41.	DIL	.14	.62	.53	.78	.13	.37
42.	JAI	.60	.41	.81	1.60	.80	.80
43.	KUN	.54	.57	.61	.67	1.29	.65
44.	NID	.05	.42	.06	.60	.43	.48
45.	GAJ	1.18	1.03	.72	.50	.28	.74
46.	RAV	.26	.06	.32	.13	.11	.17
47.	SUS	.63	.82	.63	.24	.61	1.04
48.	SUM	.25	.57	.31	.13	.27	.02
49.	HEM	.11	.19	.16	.16	.11	.43
50.	HAR	.18	.51	.11	.14	.34	.12
51.	GAJ	.32	.22	.11	.07	.22	.41
52.	SHA	.22	.25	.09	.17	.02	.20
53.	RAJ	.06	.22	.36	.45	.03	.20
54.	AMI	.05	.35	.14	.25	.25	.04
55.	NAV	.65	.52	1.21	.67	.92	.50
56.	SUD	.25	.12	.06	.40	.77	.02
57.	NAG	1.45	.46	.41	.32	.56	1.51
58.	HAN	.65	.16	.25	.50	.39	.62
59.	SAT	.20	.10	.05	.37	.33	.03
60.	NAG	2.16	.21	1.43	1.57	.87	2.21
<b>Mean</b>		<b>0.60</b>	<b>0.47</b>	<b>0.51</b>	<b>0.44</b>	<b>0.48</b>	<b>0.50</b>
<b>SD</b>		<b>0.53</b>	<b>0.29</b>	<b>0.40</b>	<b>0.36</b>	<b>0.34</b>	<b>0.44</b>

**Table. 28: Peak amplitudes of Na wave recorded at pre, during and post *ekāgratā* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	.04	.34	.20	.52	.31	.02
2.	SOH	.35	.37	.27	.60	.36	.22
3.	SHR	1.27	.61	.29	.83	.57	.99
4.	RAG	.38	.50	.62	.60	.67	.53
5.	SUB	2.13	1.97	1.90	1.13	.61	.83
6.	ARJ	.76	.82	1.46	.74	1.07	1.07
7.	SUH	1.36	.68	.47	.57	.36	.56
8.	PRA	.80	.26	.40	1.18	.63	.44
9.	VIR	.32	.39	.20	.04	.40	.17
10.	SAU	.24	.38	.06	.07	.45	.01
11.	SHA	.92	.16	.71	.31	.26	.16
12.	GAU	.55	.87	.76	.63	1.68	.86
13.	AYU	2.40	2.13	.96	.74	.45	.70
14.	HEM	.73	.75	1.08	.89	.47	.88
15.	REV	.31	.60	.33	.16	.26	.09
16.	ANK	.04	.28	.26	.14	.23	.75
17.	AMI	2.02	1.46	1.32	1.30	1.75	1.40
18.	HAR	.07	.10	.23	.26	.31	.47
19.	ROH	.43	.52	.31	.59	.75	.74
20.	MAL	.17	.87	.54	.52	.63	.17
21.	VAD	.48	.27	.55	.51	.43	.06
22.	PUS	.56	.52	.69	.47	.39	.20
23.	RAN	.81	.62	.26	.75	.59	.16
24.	SUP	.49	.01	.08	.19	.43	.18
25.	SHA	.25	.03	.27	.26	.46	.07
26.	KAR	.85	.93	.77	.53	.14	.81
27.	AJA	1.00	.88	1.13	.81	.88	1.09
28.	ANA	.17	.66	.12	.66	.41	.36
29.	BHA	.02	.67	.75	.65	1.43	.57
30.	JIT	.06	.22	.14	.20	.01	.13
31.	VEN	.79	.60	.70	.69	.29	.29
32.	ARV	.36	.14	.46	1.42	.17	.36
33.	DEE	.43	.15	.35	.36	.38	.08
34.	SAN	.25	.51	.40	.66	.67	.46
35.	NAV	.16	.34	.79	.61	1.20	1.74
36.	ANU	.25	.35	.66	.33	.38	.03
37.	MAN1	.06	.45	.13	.28	.38	.03
38.	ARU	.24	.67	.58	.67	.48	.30
39.	DAT	1.08	.08	.37	.44	.33	.81
40.	MAN2	.18	.03	.03	.32	.33	.30

41.	DIL	.62	.66	.33	.17	.28	.22
42.	JAI	.90	.87	.60	.46	.66	.88
43.	KUN	1.39	1.08	1.31	.85	.85	.95
44.	NID	.12	.26	.82	.49	.83	.03
45.	GAJ	1.14	.65	.35	.47	.35	.08
46.	RAV	.14	.23	.07	.08	.45	.33
47.	SUS	.44	.33	.56	.66	.56	.19
48.	SUM	.31	.17	.22	.21	.19	.23
49.	HEM	.03	.01	.35	.37	.28	.02
50.	HAR	.27	.53	.21	.26	.34	.22
51.	GAJ	.03	.03	.09	.02	.00	.03
52.	SHA	.31	.14	.14	.54	.13	.07
53.	RAJ	.09	.19	.13	.14	.23	.11
54.	AMI	.27	.19	.21	.08	.03	.29
55.	NAV	1.15	.53	.74	.55	.72	.38
56.	SUD	.61	.53	.38	.12	.06	.07
57.	NAG	1.64	1.32	1.69	.54	.92	1.46
58.	HAN	.36	.45	.43	.09	.44	.53
59.	SAT	.34	.34	.08	.27	.06	.58
60.	NAG	.97	.69	.25	.82	.40	.47
<b>Mean</b>		<b>0.58</b>	<b>0.52</b>	<b>0.51</b>	<b>0.50</b>	<b>0.50</b>	<b>0.44</b>
<b>SD</b>		<b>0.54</b>	<b>0.43</b>	<b>0.41</b>	<b>0.31</b>	<b>0.37</b>	<b>0.40</b>

**Table. 29: Peak amplitudes of Na wave recorded at pre, during and post *dhāraṇā* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	.01	.15	.21	.08	.48	.14
2.	SOH	.31	.34	.72	.75	1.24	.81
3.	SHR	1.15	1.27	1.31	1.50	1.10	.62
4.	RAG	.40	.46	.63	.25	.64	1.09
5.	SUB	2.15	2.00	1.79	.51	1.36	2.30
6.	ARJ	2.02	1.62	1.16	2.05	2.04	3.60
7.	SUH	.93	.24	.34	.53	.53	.20
8.	PRA	.32	.20	.71	.04	.42	.26
9.	VIR	.08	.35	.10	.38	.12	.22
10.	SAU	.29	.27	.50	.01	.51	.20
11.	SHA	.30	.33	.12	.23	.09	.06
12.	GAU	.43	.51	.20	.09	.15	.30
13.	AYU	1.41	.67	.39	1.10	1.00	1.07
14.	HEM	.96	.37	.68	.39	1.14	.78
15.	REV	.19	.50	.30	.09	.14	.23
16.	ANK	.42	.34	.64	.62	.62	.34
17.	AMI	1.31	.52	.59	.24	.58	.48
18.	HAR	.45	.08	.32	.11	.16	.94
19.	ROH	.92	1.13	.94	1.12	1.53	1.45
20.	MAL	.42	.43	.05	.42	.28	.60
21.	VAD	.06	.47	.46	.15	.59	.45
22.	PUS	.02	.04	.07	.17	.25	.35
23.	RAN	.68	.80	.75	.96	.62	.47
24.	SUP	.42	.44	.42	.57	1.09	.14
25.	SHA	.92	.24	.16	.36	.16	.12
26.	KAR	.59	.64	.41	.06	.68	.30
27.	AJA	.66	.76	1.26	.40	.70	.70
28.	ANA	.01	.49	.78	.66	.41	.42
29.	BHA	.11	.81	.54	.23	.51	.20
30.	JIT	.04	.13	.03	.03	.09	.20
31.	VEN	.32	.24	.99	.86	.73	.52
32.	ARV	.13	.61	.91	.95	.53	.43
33.	DEE	1.02	.58	.09	.24	.94	.94
34.	SAN	.57	.61	.60	.32	.71	.92
35.	NAV	.54	.67	.35	.37	.52	.67
36.	ANU	.18	.48	.15	.23	.03	.37
37.	MAN1	.70	.23	.12	.31	.42	.07
38.	ARU	.10	.28	.22	.36	.59	.67
39.	DAT	.55	.13	.38	.44	.38	.65
40.	MAN2	.53	.05	.14	.12	.08	.04
41.	DIL	.02	.28	.36	.32	.77	.78

42.	JAI	.99	.50	.39	.21	.21	.68
43.	KUN	.92	.80	.54	.61	.86	.58
44.	NID	.52	.34	.33	.07	.63	.86
45.	GAJ	1.28	.53	.38	.87	.98	1.50
46.	RAV	.10	.11	.05	.06	.06	.01
47.	SUS	.37	.57	.41	.48	.55	.41
48.	SUM	.64	.44	.08	.02	.36	.39
49.	HEM	.09	.27	.20	.44	.07	.26
50.	HAR	.20	.27	.16	.63	.21	.38
51.	GAJ	.04	.22	.16	.27	.14	.09
52.	SHA	.36	.25	.11	.05	.10	.07
53.	RAJ	.04	.03	.05	.05	.06	.19
54.	AMI	.54	.11	.04	.28	.13	.17
55.	NAV	.72	.59	.25	.30	.43	.41
56.	SUD	.30	.70	.23	.07	.32	.33
57.	NAG	.74	.87	.69	.96	.83	.79
58.	HAN	.30	.54	.35	.45	.46	.48
59.	SAT	.29	.26	.49	.48	.02	.15
60.	NAG	1.12	1.38	1.42	1.72	1.03	1.37
<b>Mean</b>		<b>0.54</b>	<b>0.49</b>	<b>0.45</b>	<b>0.44</b>	<b>0.54</b>	<b>0.57</b>
<b>SD</b>		<b>0.47</b>	<b>0.38</b>	<b>0.38</b>	<b>0.42</b>	<b>0.42</b>	<b>0.58</b>

**Table. 30: Peak amplitudes of Na wave recorded at pre, during and post *dhyāna* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	.21	.51	.42	.31	.17	.40
2.	SOH	1.05	.87	.59	1.04	1.18	1.38
3.	SHR	.77	.45	.27	.41	.09	.96
4.	RAG	.65	.85	.48	.86	.68	.76
5.	SUB	2.14	1.87	1.01	.73	1.24	1.74
6.	ARJ	.68	.85	.43	.47	.52	1.91
7.	SUH	1.92	1.92	2.46	.78	2.04	2.42
8.	PRA	.34	.55	.84	.35	.63	.67
9.	VIR	.04	.16	.09	.14	.13	.39
10.	SAU	.20	.37	.33	.19	.37	.29
11.	SHA	.05	.31	.45	.16	.06	.08
12.	GAU	.19	.39	.12	.39	.47	.14
13.	AYU	.83	.91	.75	.67	.74	1.46
14.	HEM	.25	.45	.45	.41	.35	.78
15.	REV	.43	.48	.26	.43	.79	.66
16.	ANK	.55	1.09	.99	.84	1.18	1.68
17.	AMI	1.15	.95	.70	.41	.48	.53
18.	HAR	.04	.11	.08	.04	.20	.02
19.	ROH	.69	.51	.43	.68	.56	.35
20.	MAL	.86	.93	.53	.52	1.18	.33
21.	VAD	.07	.12	.86	.26	.38	.11
22.	PUS	.26	.22	.04	.08	.20	.33
23.	RAN	.76	.02	.37	.03	.08	.18
24.	SUP	.56	.90	.14	.27	.35	.22
25.	SHA	.19	.23	.24	.12	.27	.17
26.	KAR	.27	.57	.76	.49	.38	.85
27.	AJA	.74	.70	.41	.29	.61	.95
28.	ANA	.77	.44	.56	.17	.55	.79
29.	BHA	.12	.17	.71	.90	.53	.34
30.	JIT	.01	.10	.19	.24	.18	.02
31.	VEN	.87	1.01	.97	1.42	.37	1.03
32.	ARV	1.23	1.18	1.40	.93	.79	2.03
33.	DEE	.39	.28	.19	.23	.00	.02
34.	SAN	.48	.57	.44	.76	.46	.47
35.	NAV	.75	.10	.67	.46	.76	.76
36.	ANU	.40	.15	.35	.24	.20	.37
37.	MAN1	.02	.20	.44	.36	.20	.27
38.	ARU	.61	1.14	.45	.09	.22	.30
39.	DAT	.33	.61	.26	.38	.43	.61
40.	MAN2	.16	.04	.03	.11	.30	.18
41.	DIL	.23	.27	.11	.26	.22	.61

42.	JAI	.49	.48	.22	.45	.90	.31
43.	KUN	.70	.70	.82	.70	.68	2.34
44.	NID	.06	.31	.56	.45	.51	.44
45.	GAJ	.86	.64	.46	.88	.60	1.19
46.	RAV	.28	.03	.37	.12	.20	.17
47.	SUS	.24	.09	.53	.42	.56	.61
48.	SUM	.17	.41	.22	.25	.25	.26
49.	HEM	.04	.00	.32	.06	.21	.02
50.	HAR	.53	.63	.22	.33	.21	.68
51.	GAJ	.10	.16	.04	.10	.04	.04
52.	SHA	.02	.00	.32	.67	.28	.33
53.	RAJ	.12	.22	.13	.18	.26	.24
54.	AMI	.11	.13	.49	.01	.01	.15
55.	NAV	1.04	1.58	.71	.46	.90	2.27
56.	SUD	.42	.25	.14	.38	.20	.20
57.	NAG	.32	.61	1.06	.95	.37	.45
58.	HAN	.59	.37	.43	.26	1.20	.81
59.	SAT	.30	.35	.13	.03	.04	.26
60.	NAG	.65	.56	.77	.49	.28	.28
<b>Mean</b>		<b>0.49</b>	<b>0.52</b>	<b>0.49</b>	<b>0.42</b>	<b>0.47</b>	<b>0.64</b>
<b>SD</b>		<b>0.43</b>	<b>0.43</b>	<b>0.39</b>	<b>0.30</b>	<b>0.38</b>	<b>0.62</b>

**Table. 31: Peak amplitudes of Pa wave recorded at pre, during and post *cañcalatā* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	1.31	.78	.71	.98	.96	1.05
2.	SOH	1.79	1.38	1.13	1.36	1.32	1.87
3.	SHR	1.56	1.54	1.00	1.35	1.46	1.89
4.	RAG	1.32	1.13	.67	.56	.63	.51
5.	SUB	2.78	.92	.56	.10	.26	.29
6.	ARJ	.69	.62	.68	.54	.90	1.08
7.	SUH	1.33	1.29	.76	.41	.82	1.70
8.	PRA	.69	.83	.12	.33	.49	1.12
9.	VIR	1.36	.76	.40	.77	.81	1.78
10.	SAU	1.53	1.59	1.25	1.71	.87	1.06
11.	SHA	1.90	.99	1.09	1.20	1.19	2.04
12.	GAU	.86	.89	.58	.73	.72	.77
13.	AYU	1.82	.94	1.21	1.45	1.36	.93
14.	HEM	1.45	.82	.63	.63	.63	1.62
15.	REV	.86	.42	.52	.47	.51	.95
16.	ANK	1.80	1.37	.74	1.65	1.05	1.14
17.	AMI	1.70	.97	.44	.78	.87	2.04
18.	HAR	1.72	.69	.50	.51	.48	.78
19.	ROH	.51	.56	.41	.63	.70	1.47
20.	MAL	.95	.75	.43	.72	1.18	1.17
21.	VAD	.43	.80	1.37	1.29	1.28	1.80
22.	PUS	1.11	.96	.69	.46	.48	1.04
23.	RAN	1.04	.37	.66	.05	.08	1.43
24.	SUP	1.44	.76	.69	.96	.83	1.10
25.	SHA	.83	.54	.24	.47	.57	.86
26.	KAR	1.44	.93	.63	1.08	1.32	.94
27.	AJA	2.03	.80	.57	1.21	1.68	1.79
28.	ANA	2.17	1.11	1.19	1.18	1.21	1.87
29.	BHA	1.00	.40	.85	.39	1.06	1.68
30.	JIT	.86	.46	.50	.44	.48	.65
31.	VEN	2.09	1.27	1.42	1.85	1.22	2.82
32.	ARV	1.19	.73	.45	.15	.70	2.08
33.	DEE	.46	.28	.62	.47	.35	.36
34.	SAN	1.39	.97	1.03	1.22	.86	1.72
35.	NAV	1.23	.59	.99	.97	1.09	1.08
36.	ANU	1.03	.49	.50	.69	.58	.89
37.	MAN1	1.37	.91	.73	.68	.95	.95
38.	ARU	1.17	1.51	1.17	1.07	.73	1.65
39.	DAT	1.66	1.51	1.17	.77	1.06	1.19
40.	MAN2	1.31	.61	.93	.70	.46	.95

41.	DIL	1.48	.95	1.05	.58	1.78	1.64
42.	JAI	1.43	.70	.87	1.16	1.27	1.27
43.	KUN	1.61	.56	.86	.89	1.11	2.90
44.	NID	1.09	.68	.46	.09	.64	1.31
45.	GAJ	1.57	.70	1.16	.97	1.37	.93
46.	RAV	2.01	1.76	.87	1.27	1.58	1.94
47.	SUS	.94	1.06	1.14	1.29	1.30	.89
48.	SUM	1.30	.23	.34	1.54	1.28	1.83
49.	HEM	1.12	.28	.54	.44	.43	.82
50.	HAR	1.41	.29	.92	.98	.39	1.06
51.	GAJ	.56	.64	.40	.28	.51	.60
52.	SHA	.88	.65	.93	.78	1.25	.91
53.	RAJ	1.40	.81	.78	.73	1.19	2.39
54.	AMI	1.29	.88	.68	.91	.87	1.44
55.	NAV	1.90	1.07	.70	.89	.68	1.83
56.	SUD	1.02	.56	.64	.04	.64	.66
57.	NAG	.99	.34	.76	1.12	.79	.22
58.	HAN	.86	.96	.72	.66	.89	.69
59.	SAT	2.10	1.07	1.31	1.14	1.26	2.46
60.	NAG	1.67	.90	.76	.97	.82	1.55
<b>Mean</b>		<b>1.33</b>	<b>0.84</b>	<b>0.77</b>	<b>0.83</b>	<b>0.90</b>	<b>1.32</b>
<b>SD</b>		<b>0.47</b>	<b>0.35</b>	<b>0.30</b>	<b>0.43</b>	<b>0.37</b>	<b>0.59</b>

**Table. 32: Peak amplitudes of Pa wave recorded at pre, during and post *ekāgratā* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	.95	.83	.98	.92	.66	1.13
2.	SOH	.95	.97	.96	.82	1.13	1.85
3.	SHR	2.46	1.98	1.98	1.42	1.66	1.58
4.	RAG	1.54	1.05	.70	.71	1.59	1.37
5.	SUB	1.27	1.06	.63	.90	.47	.26
6.	ARJ	.55	1.05	.71	.74	.60	1.77
7.	SUH	1.76	1.09	.83	.84	.74	1.26
8.	PRA	.91	.68	.90	.18	.50	1.02
9.	VIR	1.31	.70	.91	.93	.47	1.16
10.	SAU	2.39	2.26	1.68	1.75	1.12	2.22
11.	SHA	2.23	1.43	1.11	1.75	1.05	1.32
12.	GAU	.53	.47	.90	.66	.87	.32
13.	AYU	1.91	1.01	1.35	.52	.77	1.46
14.	HEM	1.53	1.59	1.56	2.05	.91	1.63
15.	REV	.68	.50	.60	.75	.52	1.24
16.	ANK	2.05	1.17	1.30	1.71	1.00	1.92
17.	AMI	.62	.97	.76	.97	.22	1.21
18.	HAR	1.42	.77	.94	.89	.81	1.09
19.	ROH	.70	.37	.64	.36	.35	.84
20.	MAL	1.43	.49	1.05	1.12	.70	1.48
21.	VAD	.64	.93	.33	.76	.40	.83
22.	PUS	.26	.48	.19	.61	.63	.76
23.	RAN	.75	.28	.23	.11	.51	.94
24.	SUP	.71	1.16	.70	.56	.94	.88
25.	SHA	.78	.91	.94	.66	.09	1.04
26.	KAR	.69	.26	.99	1.57	1.21	1.35
27.	AJA	1.18	1.36	.94	1.41	1.45	1.39
28.	ANA	2.19	1.15	1.82	1.56	1.46	1.95
29.	BHA	1.73	1.25	.57	1.09	.60	1.56
30.	JIT	.41	.29	.46	.42	.68	.70
31.	VEN	2.92	2.25	2.06	2.20	3.37	3.39
32.	ARV	.94	1.40	.58	.35	1.69	2.30
33.	DEE	.80	.62	.20	.50	.34	.83
34.	SAN	.98	.86	1.45	.99	1.02	1.44
35.	NAV	1.32	.71	.39	.44	1.03	1.54
36.	ANU	.61	.56	.70	.99	.36	1.42
37.	MAN1	1.66	1.38	1.13	1.22	1.07	1.83
38.	ARU	1.30	.69	1.50	1.05	1.35	1.60
39.	DAT	1.07	1.29	1.23	1.11	1.03	1.32
40.	MAN2	1.16	.99	1.10	.90	.94	1.97

41.	DIL	1.25	.86	.52	1.48	1.39	2.04
42.	JAI	.81	.49	.65	1.05	.92	.92
43.	KUN	1.01	1.03	1.07	1.32	1.32	2.43
44.	NID	1.49	1.24	.31	.67	1.39	1.05
45.	GAJ	1.00	.89	1.00	1.03	1.39	1.63
46.	RAV	2.07	1.39	1.49	1.73	2.15	2.64
47.	SUS	1.34	1.38	1.60	1.53	1.42	1.62
48.	SUM	1.80	.99	.84	.98	.92	1.86
49.	HEM	.80	1.06	.62	.69	.84	.97
50.	HAR	1.06	.77	.98	1.05	1.08	.92
51.	GAJ	.75	.61	.55	.64	.48	.54
52.	SHA	.76	.59	.49	.65	1.19	1.14
53.	RAJ	1.38	.76	1.02	1.01	.57	1.54
54.	AMI	.91	.99	.98	1.43	1.13	2.22
55.	NAV	2.50	.69	1.06	.93	1.23	1.32
56.	SUD	.08	.24	.52	.52	.87	.65
57.	NAG	.59	.81	1.32	1.04	.83	1.05
58.	HAN	.95	.74	.87	1.16	.68	1.31
59.	SAT	1.58	1.22	1.34	1.51	1.48	2.47
60.	NAG	1.73	.91	.81	1.05	1.08	1.44
<b>Mean</b>		<b>1.22</b>	<b>0.95</b>	<b>0.93</b>	<b>1.00</b>	<b>0.98</b>	<b>1.42</b>
<b>SD</b>		<b>0.61</b>	<b>0.43</b>	<b>0.43</b>	<b>0.45</b>	<b>0.52</b>	<b>0.58</b>

**Table. 33: Peak amplitudes of Pa wave recorded at pre, during and post *dhāraṇā* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	1.48	1.25	1.69	1.29	1.39	1.40
2.	SOH	1.57	1.41	1.64	1.52	1.43	1.64
3.	SHR	2.25	2.10	2.22	2.06	2.14	1.97
4.	RAG	1.60	1.37	.91	1.49	1.51	1.24
5.	SUB	1.28	1.16	1.05	1.18	1.01	2.03
6.	ARJ	.94	.79	1.08	.72	1.17	1.59
7.	SUH	1.69	1.05	.91	1.19	1.19	1.47
8.	PRA	.47	.74	.08	.64	.77	.70
9.	VIR	.89	.40	.98	.64	.83	.80
10.	SAU	2.37	1.51	1.53	2.03	1.70	1.82
11.	SHA	1.63	1.75	1.62	1.80	1.44	1.23
12.	GAU	.36	.34	.42	.92	.49	.84
13.	AYU	1.37	1.55	2.22	1.54	1.46	1.61
14.	HEM	1.53	1.59	1.56	2.05	.91	1.63
15.	REV	1.21	.55	.88	.71	1.24	.88
16.	ANK	1.33	1.64	1.14	1.70	1.35	1.69
17.	AMI	1.44	.69	.71	.64	.24	.78
18.	HAR	.68	1.28	1.11	1.11	1.10	.92
19.	ROH	1.68	1.13	1.57	.82	1.02	1.85
20.	MAL	1.23	1.04	1.36	1.16	1.34	1.48
21.	VAD	.53	.48	.35	.61	.45	.78
22.	PUS	.80	.66	.87	.71	1.06	.14
23.	RAN	.82	.61	.34	.94	.55	.92
24.	SUP	1.04	.73	.51	.94	.64	1.18
25.	SHA	.18	.53	1.04	.85	.91	1.38
26.	KAR	1.23	.81	1.19	1.40	.88	1.05
27.	AJA	1.55	1.65	1.30	1.22	1.66	1.66
28.	ANA	1.75	1.75	1.83	1.92	2.13	1.83
29.	BHA	1.32	.76	.89	1.03	1.33	1.52
30.	JIT	.71	.84	.75	.58	.91	.35
31.	VEN	3.19	2.83	2.19	2.21	2.19	2.63
32.	ARV	1.36	1.12	1.01	1.46	1.90	1.60
33.	DEE	.59	.19	.92	.85	1.03	1.03
34.	SAN	.97	1.16	1.19	1.66	1.32	1.15
35.	NAV	1.16	.92	.90	.89	1.40	1.52
36.	ANU	.87	.23	.76	.83	1.09	.65
37.	MAN1	1.65	1.43	2.03	1.92	1.84	1.62
38.	ARU	1.25	1.23	1.59	1.55	1.14	1.00
39.	DAT	.93	1.26	1.11	.97	1.37	1.00
40.	MAN2	1.48	.95	1.31	1.16	1.27	1.12
41.	DIL	1.61	1.33	1.54	1.40	1.54	1.55

42.	JAI	1.24	.91	1.24	1.83	1.39	1.24
43.	KUN	1.33	.53	1.14	1.82	1.85	1.92
44.	NID	.97	.84	.96	1.09	.96	.79
45.	GAJ	1.78	1.85	1.88	1.70	1.58	1.57
46.	RAV	1.82	1.47	1.90	1.55	2.49	1.50
47.	SUS	1.45	1.18	1.56	1.37	1.09	1.53
48.	SUM	2.03	.78	1.19	1.33	1.54	1.94
49.	HEM	1.19	.59	1.15	.83	1.18	1.34
50.	HAR	1.18	.69	1.25	1.23	1.15	1.55
51.	GAJ	1.09	.95	.78	.54	.41	.53
52.	SHA	1.02	.87	1.43	.89	1.47	.83
53.	RAJ	1.59	1.57	1.76	1.72	2.05	2.39
54.	AMI	.05	1.29	1.42	1.31	1.53	1.56
55.	NAV	1.50	.95	1.29	1.32	1.29	1.24
56.	SUD	.62	.19	.68	.84	.71	.78
57.	NAG	1.10	.97	1.26	1.12	1.16	1.18
58.	HAN	.97	.88	.91	.79	1.25	1.05
59.	SAT	2.23	2.00	1.91	2.44	2.33	1.91
60.	NAG	1.62	1.32	1.55	1.31	1.31	1.26
<b>Mean</b>		<b>1.28</b>	<b>1.08</b>	<b>1.23</b>	<b>1.26</b>	<b>1.29</b>	<b>1.32</b>
<b>SD</b>		<b>0.54</b>	<b>0.51</b>	<b>0.48</b>	<b>0.47</b>	<b>0.47</b>	<b>0.48</b>

**Table. 34: Peak amplitudes of Pa wave recorded at pre, during and post *dhyāna* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	1.49	1.63	1.42	1.17	1.45	1.54
2.	SOH	1.56	1.91	1.74	2.00	1.76	2.44
3.	SHR	3.19	2.36	2.60	2.19	2.82	1.74
4.	RAG	2.32	1.28	1.70	1.14	1.15	1.28
5.	SUB	2.02	1.49	1.53	1.42	1.18	1.57
6.	ARJ	.84	.35	.85	.43	.86	.89
7.	SUH	1.74	1.52	1.78	.80	.86	1.70
8.	PRA	.25	.71	.37	.27	.86	.39
9.	VIR	1.31	.34	1.35	1.97	1.49	2.23
10.	SAU	2.19	2.28	1.96	1.77	1.31	2.32
11.	SHA	1.99	2.33	1.92	1.35	1.53	1.82
12.	GAU	1.02	.80	.53	1.18	1.01	.31
13.	AYU	1.20	1.11	.80	1.02	1.15	1.31
14.	HEM	.17	.20	.12	.32	.69	.28
15.	REV	.56	.80	.88	.60	.41	.87
16.	ANK	1.50	1.62	1.79	1.59	1.68	2.02
17.	AMI	.86	1.10	.64	.39	.31	.84
18.	HAR	1.33	1.58	.94	.92	1.30	.64
19.	ROH	.60	.56	.51	.47	.47	.66
20.	MAL	1.08	.75	1.03	.93	1.28	1.59
21.	VAD	1.08	1.14	.09	1.12	.18	1.18
22.	PUS	.59	.77	.92	1.11	.53	.88
23.	RAN	1.33	2.11	.60	.99	.80	.95
24.	SUP	.67	.39	1.17	.66	.76	1.27
25.	SHA	.69	.74	.88	1.10	.88	.71
26.	KAR	.97	.67	.67	.96	1.18	.65
27.	AJA	1.56	1.30	1.50	1.75	1.69	1.05
28.	ANA	1.61	2.38	2.13	2.37	1.74	1.77
29.	BHA	1.19	1.34	.66	.69	1.62	1.42
30.	JIT	.89	.66	.41	.40	.43	.64
31.	VEN	2.92	3.00	2.68	2.89	3.30	2.94
32.	ARV	.55	1.37	1.15	.66	1.41	.91
33.	DEE	.67	.10	.67	.49	.31	.24
34.	SAN	1.16	1.23	1.28	1.10	1.42	1.35
35.	NAV	1.21	1.07	.73	1.37	1.33	1.48
36.	ANU	1.83	1.00	1.27	1.37	1.43	.62
37.	MAN1	1.71	1.34	1.69	1.28	1.36	1.83
38.	ARU	.55	.47	.98	1.27	1.20	1.12
39.	DAT	1.19	.74	1.10	1.12	.61	1.20
40.	MAN2	1.23	1.07	1.23	1.43	1.73	1.31
41.	DIL	1.44	1.61	1.34	1.17	1.77	1.44

42.	JAI	1.24	.73	1.19	1.31	1.45	1.43
43.	KUN	1.25	1.71	1.53	1.36	1.51	1.91
44.	NID	.99	1.02	.31	1.18	.59	.83
45.	GAJ	2.10	1.54	1.27	1.03	1.99	1.70
46.	RAV	1.60	1.84	1.87	1.99	2.17	2.46
47.	SUS	1.89	1.67	1.62	1.45	1.37	1.31
48.	SUM	1.62	.92	1.41	.96	.94	1.93
49.	HEM	.72	.75	.40	.69	.60	.89
50.	HAR	.96	.77	.63	.63	1.00	.36
51.	GAJ	.86	.95	.52	.88	.54	.77
52.	SHA	1.35	1.11	1.08	.85	.68	.37
53.	RAJ	1.61	1.46	1.28	1.33	1.06	1.99
54.	AMI	1.28	1.45	1.02	1.26	1.62	1.43
55.	NAV	2.99	1.46	1.78	1.37	1.50	1.40
56.	SUD	1.13	.42	.74	.78	.13	.13
57.	NAG	.55	.98	.08	1.29	.65	.63
58.	HAN	.55	.71	.98	1.12	1.20	1.16
59.	SAT	2.08	2.23	1.67	1.96	1.89	1.82
60.	NAG	1.20	.97	1.07	1.24	1.20	1.57
<b>Mean</b>		<b>1.30</b>	<b>1.20</b>	<b>1.13</b>	<b>1.17</b>	<b>1.19</b>	<b>1.26</b>
<b>SD</b>		<b>0.63</b>	<b>0.61</b>	<b>0.58*</b>	<b>0.52</b>	<b>0.60</b>	<b>0.62</b>

**Table. 35: Peak amplitudes of Nb wave recorded at pre, during and post *cañcalatā* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	.93	.14	.51	.09	.44	.21
2.	SOH	.37	.10	.09	.21	.33	.60
3.	SHR	.09	.01	.06	.01	.03	.14
4.	RAG	.73	.27	.17	.09	.22	1.15
5.	SUB	1.14	.16	.09	.36	.29	.59
6.	ARJ	.12	.52	.17	.60	.32	.43
7.	SUH	.01	.23	.47	.68	.69	.31
8.	PRA	.68	.35	.57	.75	.03	.27
9.	VIR	.46	.09	.29	.17	.05	.27
10.	SAU	.63	.76	.06	.50	.05	.54
11.	SHA	.50	.15	.09	.50	.27	.38
12.	GAU	.36	.04	.08	.25	.22	.23
13.	AYU	.25	.08	.17	.19	.09	.19
14.	HEM	.28	.03	.59	.07	.25	.41
15.	REV	.50	.62	.56	.45	.55	.61
16.	ANK	.76	.26	.12	.83	.05	.48
17.	AMI	.12	.07	.46	.41	.49	.36
18.	HAR	.28	.48	.76	.70	.91	.57
19.	ROH	.17	.23	.21	.38	.09	.33
20.	MAL	.19	.27	.41	.64	.02	.14
21.	VAD	1.11	1.02	.46	1.00	1.02	.83
22.	PUS	.56	.20	.11	.19	.19	.75
23.	RAN	.38	.17	.00	.87	.85	.39
24.	SUP	.33	.17	.02	.45	.54	.32
25.	SHA	.34	.43	.15	.11	.10	.30
26.	KAR	.21	.04	.16	.28	.05	1.16
27.	AJA	.46	.29	.62	.14	.05	.24
28.	ANA	.16	.50	.12	.32	.76	.77
29.	BHA	.39	.39	.54	.56	.20	.38
30.	JIT	.09	.11	.01	.17	.21	.15
31.	VEN	.41	.59	.76	.07	.28	.54
32.	ARV	.08	.08	1.40	.49	.14	.09
33.	DEE	.99	.33	.02	.76	.15	.61
34.	SAN	.75	.30	.41	.51	.13	.94
35.	NAV	.39	.86	.52	.84	.53	.79
36.	ANU	.44	.36	.10	.22	.57	.16
37.	MAN1	.37	.88	1.01	.61	.70	.80
38.	ARU	.08	.77	.05	.17	.00	.92
39.	DAT	.93	.90	.53	.18	.30	.05
40.	MAN2	.09	.04	.20	.33	.45	.12

41.	DIL	.06	.17	.04	.65	.17	.13
42.	JAI	.61	.03	.21	.55	.07	.07
43.	KUN	.35	.62	.75	.88	1.18	.05
44.	NID	.11	.29	.18	1.11	.21	.21
45.	GAJ	.33	.52	.15	.05	.41	.34
46.	RAV	.46	.14	.47	.98	.13	.21
47.	SUS	1.11	1.35	1.24	.61	1.02	2.38
48.	SUM	.11	.45	.31	.45	.20	.14
49.	HEM	.39	.20	.24	.01	.16	.42
50.	HAR	.64	.02	.31	.34	.37	.58
51.	GAJ	.60	.50	.20	.26	.15	.24
52.	SHA	.15	.09	.66	.20	1.03	.93
53.	RAJ	.36	.64	.59	.71	.03	.87
54.	AMI	.05	.08	.18	.03	.10	.03
55.	NAV	.43	.24	.62	.31	.69	.22
56.	SUD	.69	.04	.18	.81	.22	.28
57.	NAG	.06	.08	.03	.53	.41	.93
58.	HAN	.22	.16	.60	.04	.60	.39
59.	SAT	.89	.32	.59	.32	.28	1.40
60.	NAG	.46	.15	.35	.06	.08	.23
<b>Mean</b>		<b>0.42</b>	<b>0.32</b>	<b>0.35</b>	<b>0.42</b>	<b>0.34</b>	<b>0.48</b>
<b>SD</b>		<b>0.30</b>	<b>0.29</b>	<b>0.30</b>	<b>0.29</b>	<b>0.30</b>	<b>0.40</b>

**Table. 36: Peak amplitudes of Nb wave recorded at pre, during and post *ekāgratā* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	1.02	.82	1.07	1.31	1.35	1.33
2.	SOH	.34	.38	.59	.54	.23	.13
3.	SHR	.24	.16	.32	.64	.93	1.89
4.	RAG	.06	.39	.26	.45	.15	.22
5.	SUB	.25	.12	.05	.02	.22	.50
6.	ARJ	.25	.27	.19	.49	.88	.79
7.	SUH	.41	.22	.80	.49	.67	.01
8.	PRA	.61	.40	.17	1.44	.80	1.01
9.	VIR	.07	.04	.41	.05	.65	.17
10.	SAU	1.67	1.31	.46	.22	.28	1.18
11.	SHA	1.58	.53	.27	.25	.07	.17
12.	GAU	.21	.29	.02	.15	.56	.53
13.	AYU	.26	.57	.27	.50	.36	.14
14.	HEM	.11	.13	.59	.56	.44	.75
15.	REV	.78	.21	.47	.40	.48	.62
16.	ANK	1.23	.44	.46	.91	.25	.25
17.	AMI	.43	.15	.30	.09	.70	.13
18.	HAR	.06	.30	.18	.30	.07	.40
19.	ROH	.91	.88	.98	1.33	.99	.56
20.	MAL	.27	.11	.40	.49	.35	.16
21.	VAD	.78	.09	.53	.34	.67	.64
22.	PUS	.07	.19	.44	.03	.26	.47
23.	RAN	.29	.03	.32	.83	.11	.53
24.	SUP	.15	.06	.48	.81	.09	.08
25.	SHA	.64	.63	.32	.01	.76	.63
26.	KAR	.13	.86	.04	.17	.12	.62
27.	AJA	.81	.51	.69	.26	.34	.37
28.	ANA	.25	.23	.41	.71	.60	.72
29.	BHA	.33	.06	.87	.45	.82	.22
30.	JIT	.32	.09	.16	.26	.29	.19
31.	VEN	.03	.51	.10	.29	.49	.49
32.	ARV	.14	.35	.05	.74	.72	.60
33.	DEE	.49	.02	.47	.44	.21	.04
34.	SAN	.47	.24	.48	.12	.20	.95
35.	NAV	.59	.40	.98	1.02	.37	.54
36.	ANU	.27	.07	.03	.09	.41	.66
37.	MAN1	.47	.49	.88	.41	.74	.61
38.	ARU	.02	.20	.45	.36	.12	.28
39.	DAT	.21	.61	.41	.36	.04	.36
40.	MAN2	.39	.00	.18	.12	.01	1.08

41.	DIL	.01	.19	.13	.09	.19	.37
42.	JAI	.36	.31	.66	.27	.45	.31
43.	KUN	.77	.65	.29	.66	.66	.02
44.	NID	.33	.32	.39	.29	.46	.08
45.	GAJ	.09	.19	.00	.08	.25	.43
46.	RAV	.12	.03	.46	.10	.14	.63
47.	SUS	.30	1.05	.78	.99	1.19	.06
48.	SUM	1.09	.04	.09	.10	.08	.77
49.	HEM	.34	.22	.02	.04	.22	.07
50.	HAR	.16	.05	.08	.11	.17	.47
51.	GAJ	.35	.12	.23	.31	.20	.25
52.	SHA	.10	.53	.45	.59	.29	.08
53.	RAJ	.24	.18	.16	.29	.32	.43
54.	AMI	.11	.03	.05	.28	.02	1.12
55.	NAV	.96	.60	.88	.37	.38	.55
56.	SUD	.28	.13	.39	.26	.39	.39
57.	NAG	.09	.01	.61	.68	.09	.69
58.	HAN	.04	.14	.07	.32	.06	.10
59.	SAT	.52	.36	.26	.73	.69	1.30
60.	NAG	.70	.14	.37	.30	.36	.90
<b>Mean</b>		<b>0.41</b>	<b>0.31</b>	<b>0.38</b>	<b>0.42</b>	<b>0.41</b>	<b>0.50</b>
<b>SD</b>		<b>0.37</b>	<b>0.28</b>	<b>0.27</b>	<b>0.33</b>	<b>0.30</b>	<b>0.38</b>

**Table. 37: Peak amplitudes of Nb wave recorded at pre, during and post *dhāraṇā* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	1.36	.57	.90	.90	1.01	1.36
2.	SOH	.63	.32	.15	.52	.66	.59
3.	SHR	.43	.32	.98	1.35	.99	1.47
4.	RAG	.19	.10	.69	.33	.20	.15
5.	SUB	.10	.51	.51	.58	.45	.49
6.	ARJ	.41	.30	.25	.57	.52	.78
7.	SUH	.12	.89	.04	.18	.14	.07
8.	PRA	.47	.55	1.35	.95	.35	.28
9.	VIR	.05	.84	.07	.59	.12	.70
10.	SAU	1.92	1.10	1.22	1.53	.96	1.16
11.	SHA	.54	.56	.45	.55	.33	.05
12.	GAU	.46	.17	.08	.67	.06	.30
13.	AYU	.99	.32	.13	.16	.07	.15
14.	HEM	.05	.10	.04	.26	.44	.48
15.	REV	.67	.70	.95	1.29	1.16	.94
16.	ANK	.58	.26	.12	.46	.47	.29
17.	AMI	.16	.18	.12	.29	.14	.26
18.	HAR	.33	.03	.43	.54	.41	.54
19.	ROH	.18	.61	.04	.74	.76	.88
20.	MAL	.59	.60	.19	.45	.48	.12
21.	VAD	1.23	.48	.99	.20	1.10	.90
22.	PUS	.29	.29	.01	.16	.83	.03
23.	RAN	.32	.02	.51	.29	.03	.51
24.	SUP	.22	.05	.83	.68	.39	.42
25.	SHA	.58	.61	.28	.18	.09	.73
26.	KAR	.05	.25	.84	.18	.10	1.19
27.	AJA	.63	.47	.88	.57	.31	.31
28.	ANA	.43	.09	.85	.06	.12	.65
29.	BHA	.09	.04	.48	.24	.31	.63
30.	JIT	.40	.47	.54	.32	.51	.11
31.	VEN	.22	.94	.17	.11	.03	.57
32.	ARV	.06	.06	.03	.20	.50	.22
33.	DEE	.89	.86	.03	.31	.20	.21
34.	SAN	.23	.26	.22	.64	.46	.02
35.	NAV	.13	.29	.31	.29	.09	.00
36.	ANU	.20	.37	.11	.22	.23	.10
37.	MAN1	.63	.84	.79	.89	1.45	.02
38.	ARU	.14	.12	.19	.15	.12	.48
39.	DAT	.01	.40	.17	.00	.21	.34
40.	MAN2	.39	.24	.25	.13	.15	.01
41.	DIL	.29	.08	.16	.04	.37	.41

42.	JAI	.31	.26	.34	1.15	.50	.27
43.	KUN	.04	.89	.67	.38	.19	.10
44.	NID	.04	.14	.43	.01	.19	.39
45.	GAJ	.06	.65	.29	.29	.03	.16
46.	RAV	.56	.13	.56	.11	.15	.49
47.	SUS	.55	.71	1.34	1.06	1.66	1.57
48.	SUM	.40	.28	.20	.14	.20	.71
49.	HEM	.63	.24	.31	.02	.23	.62
50.	HAR	.51	.30	.78	.88	.62	.88
51.	GAJ	.76	.62	.48	.27	.24	.42
52.	SHA	.86	.61	.27	.70	.05	.12
53.	RAJ	.52	.29	.60	.47	.58	.87
54.	AMI	1.48	.10	.14	.22	.24	.27
55.	NAV	.59	.68	.42	.66	.82	.29
56.	SUD	.32	.20	.09	.24	.35	.20
57.	NAG	.41	.03	.51	.32	.56	.64
58.	HAN	.26	.20	.20	.02	.32	1.14
59.	SAT	.96	.74	.86	1.24	1.23	1.01
60.	NAG	.74	.48	.74	.26	.76	.45
<b>Mean</b>		<b>0.46</b>	<b>0.40</b>	<b>0.44</b>	<b>0.45</b>	<b>0.44</b>	<b>0.49</b>
<b>SD</b>		<b>0.38</b>	<b>0.28</b>	<b>0.35</b>	<b>0.37</b>	<b>0.37</b>	<b>0.39</b>

**Table.38: Peak amplitudes of Nb wave recorded at pre, during and post *dhyāna* session.**

Sl.No.	Participant's code	Pre	Dur1	Dur 2	Dur 3	Dur 4	Post
1.	PAR	.60	.18	.43	.71	.87	.91
2.	SOH	.77	.41	.47	.58	.57	.02
3.	SHR	.16	.52	.71	1.02	.61	1.60
4.	RAG	.07	.31	.58	.09	.18	.26
5.	SUB	1.32	.59	1.01	.64	.64	.84
6.	ARJ	.04	.28	.08	.47	.23	.47
7.	SUH	.38	.45	.15	.09	.53	.21
8.	PRA	.79	.36	.09	.42	.30	.81
9.	VIR	.36	.99	.35	.37	.53	.68
10.	SAU	1.30	1.18	1.09	1.19	.60	1.05
11.	SHA	.81	1.19	.95	.31	.29	.54
12.	GAU	.41	.01	.12	.70	.45	.35
13.	AYU	.35	.00	.06	.14	.20	.43
14.	HEM	.43	.18	.18	.21	.13	.79
15.	REV	1.27	.86	.89	1.02	1.55	1.25
16.	ANK	1.09	.61	1.00	.87	.96	.83
17.	AMI	.06	.08	.53	.55	.52	.04
18.	HAR	.47	.34	.09	.05	.25	.67
19.	ROH	.37	.39	.58	.44	.18	.45
20.	MAL	.12	.52	.22	.51	.67	.81
21.	VAD	1.20	.03	.38	.15	1.23	.17
22.	PUS	.17	.37	.29	.51	.05	.40
23.	RAN	.06	1.20	.03	.57	.08	.03
24.	SUP	.25	.43	.28	.00	.04	.47
25.	SHA	.09	.18	.15	.28	.06	.09
26.	KAR	.08	.40	.38	.80	.11	.55
27.	AJA	.17	.61	.54	.20	.11	.55
28.	ANA	.54	.14	.80	.18	.53	.75
29.	BHA	.12	.42	.09	.98	.10	.29
30.	JIT	.64	.42	.12	.38	.18	.08
31.	VEN	.32	.67	.00	.22	1.64	.74
32.	ARV	.66	.14	.16	.12	.92	1.15
33.	DEE	.37	.33	.20	.17	.03	.63
34.	SAN	.82	.47	.83	.25	.71	.69
35.	NAV	.06	.40	.29	.14	.54	.64
36.	ANU	.93	.22	.41	.33	.58	.45
37.	MAN1	.86	.90	1.28	1.13	1.33	.71
38.	ARU	.41	.47	.46	.06	.13	.19
39.	DAT	.18	.14	.38	.36	.17	.35
40.	MAN2	.39	.08	.06	.43	.32	.46
41.	DIL	.14	.43	.34	.75	.20	.08

42.	JAI	.47	.02	.05	.14	.41	.02
43.	KUN	.10	.34	.53	.83	.67	.30
44.	NID	.16	.07	.71	.05	.32	.34
45.	GAJ	.62	.30	.02	.20	.43	.33
46.	RAV	.17	.46	.20	.46	.19	.55
47.	SUS	.00	.36	.46	.66	1.19	1.33
48.	SUM	.30	.11	.20	.02	.15	.17
49.	HEM	.30	.37	.19	.43	.05	.32
50.	HAR	.03	.34	.01	.62	.20	.48
51.	GAJ	.49	.66	.38	.57	.38	.59
52.	SHA	.04	.46	.29	.70	.66	.69
53.	RAJ	.22	.22	.18	.14	.42	.66
54.	AMI	.44	.42	.19	.08	.02	.17
55.	NAV	.44	.97	.24	.46	.46	1.32
56.	SUD	.73	.20	.08	.47	.45	.45
57.	NAG	.32	.44	.72	.01	.16	.12
58.	HAN	1.17	.11	.22	.13	.59	.18
59.	SAT	1.12	1.22	.47	1.10	.83	1.05
60.	NAG	.52	.09	.19	.48	.45	1.05
<b>Mean</b>		<b>0.45</b>	<b>0.42</b>	<b>0.37</b>	<b>0.43</b>	<b>0.46</b>	<b>0.54</b>
<b>SD</b>		<b>0.37</b>	<b>0.31</b>	<b>0.31</b>	<b>0.32</b>	<b>0.38</b>	<b>0.37</b>

**Table 39: TN in d2 test of attention administered before and after *ekāgratā* and *dhāraṇā* session.**

Sl. No.	Participant's code	<i>Ekāgratā</i>		<i>Dhāraṇā</i>	
		Pre	Post	Pre	Post
1.	AKA	646	646	549	594
2.	AMI	505	513	516	586
3.	ANA1	618	650	531	623
4.	ANA2	508	536	525	574
5.	ANI	518	583	520	580
6.	ARU	498	514	518	552
7.	BAI	646	645	605	653
8.	BHA	348	602	419	623
9.	BIS	592	650	652	652
10.	CHI	486	482	536	549
11.	HEM	492	532	528	547
12.	IBO	534	585	368	501
13.	JOY	605	599	601	606
14.	KAS	504	562	539	589
15.	KAU	572	592	584	594
16.	KHI	479	624	610	630
17.	KHO	653	645	553	638
18.	KIR	525	600	512	652
19.	KRI	389	480	486	529
20.	KUL	615	650	533	592
21.	LEE	484	521	592	620
22.	MAD	407	462	479	522
23.	MAH	604	640	632	650
24.	MAN1	516	542	562	574
25.	MAN2	537	653	651	653
26.	MAN3	508	533	518	549
27.	MOH	381	540	528	593
28.	NIL	606	653	584	653
29.	PAR	625	653	622	653
30.	PRA1	548	652	653	650
31.	PRA2	583	612	612	622
32.	PRA3	515	561	441	547
33.	PRA4	512	624	484	548
34.	PRA5	568	578	570	584
35.	RAH	440	447	430	487
36.	RAJ1	429	454	420	462
37.	RAJ2	484	520	364	455
38.	RAM1	534	522	560	548
39.	RAM2	652	653	574	627
40.	RAN	649	649	571	648

41.	RAT	526	555	519	481
42.	SAN1	588	637	478	604
43.	SAN2	410	522	482	627
44.	SAN3	340	396	352	386
45.	SAN4	607	647	640	653
46.	SAN5	294	392	302	412
47.	SHA1	643	597	605	568
48.	SHA2	494	576	560	568
49.	SHR1	512	578	510	582
50.	SHR2	489	502	413	485
51.	SUD	521	621	614	653
52.	SUM	545	591	520	610
53.	SUN	422	419	458	530
54.	SUP	609	653	509	625
55.	SUV	652	650	627	653
56.	VAS1	563	590	575	600
57.	VAS2	604	615	594	602
58.	VIJ	488	517	534	546
59.	VIK	556	592	520	586
60.	VIN	542	519	538	550
<b>Mean</b>		<b>528.67</b>	<b>572.13</b>	<b>531.37</b>	<b>580.50</b>
<b>SD</b>		<b>84.27</b>	<b>70.83</b>	<b>77.98</b>	<b>62.75</b>

**Table 40: Error (E) in d2 test of attention administered before and after *ekāgratā* and *dhāraṇā* session.**

Sl. No.	Participant's code	<i>Ekāgratā</i>		<i>Dhāraṇā</i>	
		Pre	Post	Pre	Post
1.	AKA	152	112	151	126
2.	AMI	56	47	53	38
3.	ANA1	44	57	73	59
4.	ANA1	50	38	47	36
5.	ANI	46	16	40	15
6.	ARU	65	68	58	50
7.	BAI	23	17	10	5
8.	BHA	16	56	38	74
9.	BIS	94	59	61	37
10.	CHI	62	53	63	48
11.	HEM	41	38	46	35
12.	IBO	19	18	33	28
13.	JOY	137	75	57	28
14.	KAS	81	85	65	60
15.	KAU	74	35	72	51
16.	KHI	118	118	80	55
17.	KHO	60	36	80	55
18.	KIR	43	57	18	24
19.	KRI	9	4	8	8
20.	KUL	25	14	51	44
21.	LEE	87	47	53	54
22.	MAD	39	25	11	15
23.	MAH	38	42	141	54
24.	MAN1	25	30	28	18
25.	MAN2	16	14	14	6
26.	MAN3	33	30	35	24
27.	MOH	27	30	39	26
28.	NIL	159	104	79	51
29.	PAR	36	16	2	14
30.	PRA1	62	55	50	37
31.	PRA2	18	15	16	12
32.	PRA3	18	17	29	26
33.	PRA4	27	18	70	27
34.	PRA5	42	35	38	27
35.	RAH	31	15	58	34
36.	RAJ1	28	16	22	12
37.	RAJ2	19	86	34	20
38.	RAM1	22	18	36	30
39.	RAM2	20	21	51	29
40.	RAN	150	123	181	147

41.	RAT	15	12	80	16
42.	SAN1	9	7	25	12
43.	SAN2	52	32	55	37
44.	SAN3	67	67	50	35
45.	SAN4	120	120	92	57
46.	SAN5	35	52	42	40
47.	SHA1	143	70	68	30
48.	SHA2	80	127	59	52
49.	SHR1	147	100	102	98
50.	SHR2	27	19	34	31
51.	SUD	28	34	11	12
52.	SUM	35	38	28	19
53.	SUN	38	30	46	40
54.	SUP	35	30	24	45
55.	SUV	44	19	3	3
56.	VAS1	28	20	26	15
57.	VAS2	38	32	32	20
58.	VIJ	66	60	56	46
59.	VIK	55	52	51	41
60.	VIN	44	40	38	27
<b>Mean</b>		<b>53.63</b>	<b>45.35</b>	<b>50.22</b>	<b>36.92</b>
<b>SD</b>		<b>39.82</b>	<b>32.12</b>	<b>33.70</b>	<b>26.14</b>

**Table 41: TN- E in d2 test of attention administered before and after *ekāgratā* and *dhāraṇā* session.**

Sl. No.	Participant's code	<i>Ekāgratā</i>		<i>Dhāraṇā</i>	
		Pre	Post	Pre	Post
1.	AKA	494	534	398	468
2.	AMI	449	466	463	548
3.	ANA1	574	593	458	564
4.	ANA2	458	498	478	538
5.	ANI	472	567	480	565
6.	ARU	433	446	460	502
7.	BAI	623	628	595	648
8.	BHA	332	546	381	549
9.	BIS	498	591	591	615
10.	CHI	424	429	473	501
11.	HEM	451	494	482	512
12.	IBO	515	567	335	473
13.	JOY	468	524	544	578
14.	KAS	423	477	474	529
15.	KAU	498	557	512	543
16.	KHI	361	506	530	575
17.	KHO	593	609	473	583
18.	KIR	482	543	494	628
19.	KRI	380	476	478	521
20.	KUL	590	636	482	548
21.	LEE	397	474	539	566
22.	MAD	368	437	468	507
23.	MAH	566	598	491	596
24.	MAN1	491	512	534	556
25.	MAN2	521	639	637	647
26.	MAN3	475	503	483	525
27.	MOH	354	510	489	567
28.	NIL	447	549	505	602
29.	PAR	589	637	620	639
30.	PRA1	486	597	603	613
31.	PRA2	565	597	596	610
32.	PRA3	497	544	412	521
33.	PRA4	485	606	414	521
34.	PRA5	526	543	532	557
35.	RAH	409	432	372	453
36.	RAJ1	401	438	398	450
37.	RAJ2	465	434	330	435
38.	RAM1	512	504	524	518
39.	RAM2	632	632	523	598
40.	RAN	499	526	390	501

41.	RAT	511	543	439	465
42.	SAN1	579	630	453	592
43.	SAN2	358	490	427	590
44.	SAN3	273	329	302	351
45.	SAN4	487	527	548	596
46.	SAN5	259	340	260	372
47.	SHA1	500	527	537	538
48.	SHA2	414	449	501	516
49.	SHR1	365	478	408	484
50.	SHR2	462	483	379	454
51.	SUD	493	587	603	641
52.	SUM	510	553	492	591
53.	SUN	384	389	412	490
54.	SUP	574	623	485	580
55.	SUV	608	631	624	650
56.	VAS1	535	570	549	585
57.	VAS2	566	583	562	582
58.	VIJ	422	457	478	500
59.	VIK	501	540	469	545
60.	VIN	498	479	500	523
<b>Mean</b>		<b>475.03</b>	<b>526.78</b>	<b>481.15</b>	<b>543.58</b>
<b>SD</b>		<b>82.42</b>	<b>73.40</b>	<b>80.09</b>	<b>64.09</b>

**Table 42: E% in d2 test of attention administered before and after *ekāgratā* and *dhāraṇā* session.**

Sl. No.	Participant's code	<i>Ekāgratā</i>		<i>Dhāraṇā</i>	
		Pre	Post	Pre	Post
1.	AKA	23.53	17.34	27.50	21.21
2.	AMI	11.09	9.16	10.27	6.48
3.	ANA1	7.12	8.77	13.75	9.47
4.	ANA2	9.84	7.09	8.95	6.27
5.	ANI	8.88	2.74	7.69	2.59
6.	ARU	13.05	13.23	11.20	9.06
7.	BAI	3.56	2.64	1.65	0.77
8.	BHA	4.60	9.30	9.07	11.88
9.	BIS	15.88	9.08	9.36	5.67
10.	CHI	12.76	11.00	11.75	8.74
11.	HEM	8.33	7.14	8.71	6.40
12.	IBO	3.56	3.08	8.97	5.59
13.	JOY	22.64	12.52	9.48	4.62
14.	KAS	16.07	15.12	12.06	10.19
15.	KAU	12.94	5.91	12.33	8.59
16.	KHI	24.63	18.91	13.11	8.73
17.	KHO	9.19	5.58	14.47	8.62
18.	KIR	8.19	9.50	3.52	3.68
19.	KRI	2.31	0.83	1.65	1.51
20.	KUL	4.07	2.15	9.57	7.43
21.	LEE	17.98	9.02	8.95	8.71
22.	MAD	9.58	5.41	2.30	2.87
23.	MAH	6.29	6.56	22.31	8.31
24.	MAN1	4.84	5.54	4.98	3.14
25.	MAN2	2.98	2.14	2.15	0.92
26.	MAN3	6.50	5.63	6.76	4.37
27.	MOH	7.09	5.56	7.39	4.38
28.	NIL	26.24	15.93	13.53	7.81
29.	PAR	5.76	2.45	0.32	2.14
30.	PRA1	11.31	8.44	7.66	5.69
31.	PRA2	3.09	2.45	2.61	1.93
32.	PRA3	3.50	3.03	6.58	4.75
33.	PRA4	5.27	2.88	14.46	4.93
34.	PRA5	7.39	6.06	6.67	4.62
35.	RAH	7.05	3.36	13.49	6.98
36.	RAJ1	6.53	3.52	5.24	2.60
37.	RAJ2	3.93	16.54	9.34	4.40
38.	RAM1	4.12	3.45	6.43	5.47
39.	RAM2	3.07	3.22	8.89	4.63
40.	RAN	23.11	18.95	31.70	22.69

41.	RAT	2.85	2.16	15.41	3.33
42.	SAN1	1.53	1.10	5.23	1.99
43.	SAN2	12.68	6.13	11.41	5.90
44.	SAN3	19.71	16.92	14.20	9.07
45.	SAN4	19.77	18.55	14.38	8.73
46.	SAN5	11.90	13.27	13.91	9.71
47.	SHA1	22.24	11.73	11.24	5.28
48.	SHA2	16.19	22.05	10.54	9.15
49.	SHR1	28.71	17.30	20.00	16.84
50.	SHR2	5.52	3.78	8.23	6.39
51.	SUD	5.37	5.48	1.79	1.84
52.	SUM	6.42	6.43	5.38	3.11
53.	SUN	9.00	7.16	10.04	7.55
54.	SUP	5.75	4.59	4.72	7.20
55.	SUV	6.75	2.92	0.48	0.46
56.	VAS1	4.97	3.39	4.52	2.50
57.	VAS2	6.29	5.20	5.39	3.32
58.	VIJ	13.52	11.61	10.49	8.42
59.	VIK	9.89	8.78	9.81	7.00
60.	VIN	8.12	7.71	7.06	4.91
<b>Mean</b>		<b>10.08</b>	<b>7.96</b>	<b>9.52</b>	<b>6.36</b>
<b>SD</b>		<b>6.85</b>	<b>5.41</b>	<b>5.92</b>	<b>4.24</b>

**Table 43: Concentration Performance (CP) in d2 test of attention administered before and after *ekāgratā* and *dhāraṇā* session.**

Sl. No.	Participant's code	<i>Ekāgratā</i>		<i>Dhāraṇā</i>	
		Pre	Post	Pre	Post
1.	AKA	139	181	93	135
2.	AMI	153	164	168	213
3.	ANA1	232	240	162	220
4.	ANA2	164	191	176	216
5.	ANI	196	241	184	240
6.	ARU	138	149	159	171
7.	BAI	267	286	262	298
8.	BHA	124	218	139	206
9.	BIS	166	236	237	262
10.	CHI	139	145	166	189
11.	HEM	165	190	185	198
12.	IBO	205	240	122	178
13.	JOY	132	193	234	241
14.	KAS	130	160	165	198
15.	KAU	175	226	183	210
16.	KHI	84	166	192	227
17.	KHO	239	250	150	234
18.	KIR	177	210	196	274
19.	KRI	151	196	194	216
20.	KUL	247	283	174	215
21.	LEE	115	171	209	235
22.	MAD	130	168	190	206
23.	MAH	231	252	144	245
24.	MAN1	210	212	218	234
25.	MAN2	215	285	283	290
26.	MAN3	177	199	201	213
27.	MOH	135	200	183	233
28.	NIL	114	195	177	248
29.	PAR	257	283	278	285
30.	PRA1	178	245	242	253
31.	PRA2	239	257	256	266
32.	PRA3	207	227	155	208
33.	PRA4	189	261	135	198
34.	PRA5	205	219	211	231
35.	RAH	151	168	120	173
36.	RAJ1	152	172	156	179
37.	RAJ2	181	194	138	174
38.	RAM1	214	212	215	213
39.	RAM2	278	278	202	253
40.	RAN	152	173	73	147
41.	RAT	227	210	138	183

42.	SAN1	250	284	179	256
43.	SAN2	110	192	150	272
44.	SAN3	72	103	97	142
45.	SAN4	150	174	201	243
46.	SAN5	93	112	85	143
47.	SHA1	151	189	201	205
48.	SHA2	123	123	172	196
49.	SHR1	92	154	111	156
50.	SHR2	173	196	142	172
51.	SUD	193	244	272	287
52.	SUM	200	227	192	254
53.	SUN	141	147	148	188
54.	SUP	233	267	187	239
55.	SUV	252	279	280	295
56.	VAS1	218	243	227	251
57.	VAS2	230	244	227	247
58.	VIJ	141	160	171	190
59.	VIK	187	211	169	217
60.	VIN	177	179	205	220
<b>Mean</b>		<b>176.10</b>	<b>207.90</b>	<b>181.35</b>	<b>219.68</b>
<b>SD</b>		<b>49.45</b>	<b>45.79</b>	<b>47.95</b>	<b>39.86</b>

**Table 44: Scores in digit symbol substitution test administered before and after *ekāgratā* and *dhāraṇā* session.**

Sl. No.	Participant's code	<i>Ekāgratā</i>		<i>Dhāraṇā</i>	
		Pre	Post	Pre	Post
1.	AKA	65	67	49	71
2.	AMI	51	55	54	58
3.	ANA1	44	43	38	50
4.	ANA2	61	71	60	64
5.	ANI	46	56	47	58
6.	ARU	61	45	59	71
7.	BAI	42	62	70	70
8.	BHA	42	60	40	64
9.	BIS	59	53	79	69
10.	CHI	67	65	62	68
11.	HEM	64	69	66	72
12.	IBO	64	60	47	55
13.	JOY	59	61	62	63
14.	KAS	44	49	45	46
15.	KAU	57	46	54	61
16.	KHI	61	54	66	86
17.	KHO	48	50	47	46
18.	KIR	51	63	70	70
19.	KRI	33	38	51	53
20.	KUL	48	65	56	67
21.	LEE	59	64	68	78
22.	MAD	44	50	57	60
23.	MAH	67	70	60	67
24.	MAN1	56	50	59	62
25.	MAN2	52	66	75	79
26.	MAN3	51	35	53	61
27.	MOH	33	50	51	54
28.	NIL	51	58	70	65
29.	PAR	73	75	82	82
30.	PRA1	40	61	60	69
31.	PRA2	58	56	61	62
32.	PRA3	81	72	54	75
33.	PRA4	46	52	36	53
34.	PRA5	64	72	63	71
35.	RAH	62	67	50	66
36.	RAJ1	43	43	42	52
37.	RAJ2	60	50	50	54
38.	RAM1	78	75	57	75
39.	RAM2	58	57	60	60
40.	RAN	58	51	50	61
41.	RAT	64	54	63	72

42.	SAN1	71	75	61	58
43.	SAN2	50	61	68	70
44.	SAN3	34	38	37	51
45.	SAN4	57	57	58	80
46.	SAN5	38	40	36	47
47.	SHA1	48	63	75	70
48.	SHA2	56	67	65	94
49.	SHR1	63	57	53	54
50.	SHR2	39	44	37	48
51.	SUD	64	64	84	75
52.	SUM	75	72	70	79
53.	SUN	44	45	42	55
54.	SUP	87	69	68	81
55.	SUV	54	69	51	70
56.	VAS1	69	75	65	70
57.	VAS2	49	36	51	53
58.	VIJ	55	59	52	61
59.	VIK	62	64	60	65
60.	VIN	52	54	52	59
<b>Mean</b>		<b>55.53</b>	<b>57.82</b>	<b>57.13</b>	<b>64.67</b>
<b>SD</b>		<b>11.76</b>	<b>10.80</b>	<b>11.43</b>	<b>10.54</b>

**Table 45: Scores on visual analog scale following *cañcalatā*, *ekāgratā*, *dhāraṇā* and *dhyāna*.**

Sl. No.	Participant's	<i>Cañcalatā</i>	<i>Ekāgratā</i>	<i>Dhāraṇā</i>	<i>Dhyāna</i>
1.	PAR	7.70	8.00	7.00	8.50
2.	SOH	7.80	7.80	6.90	7.30
3.	SHR	8.10	8.30	8.40	8.80
4.	RAG	8.10	8.10	7.80	8.40
5.	SUB	8.00	7.40	7.00	7.20
6.	ARJ	8.00	8.20	7.50	8.20
7.	SUH	8.00	8.00	7.60	8.10
8.	PRA	7.40	8.10	7.00	8.50
9.	VIR	8.00	8.00	7.80	7.90
10.	SAU	8.20	7.10	7.20	7.30
11.	SHA	7.20	8.10	7.70	7.90
12.	GAU	8.30	8.00	7.60	8.80
13.	AYU	8.00	8.40	7.60	9.00
14.	HEM	8.00	8.10	7.30	6.70
15.	REV	8.30	8.50	8.10	8.90
16.	ANK	8.40	8.00	7.90	8.90
17.	AMI	8.30	8.00	7.60	8.20
18.	HAR	8.50	8.50	8.40	8.80
19.	ROH	8.00	8.20	6.90	8.90
20.	MAL	7.80	7.20	7.10	7.20
21.	VAD	8.20	8.30	7.50	7.40
22.	PUS	8.00	8.20	8.30	8.70
23.	RAN	8.10	8.20	7.30	7.40
24.	SUP	8.40	8.20	7.00	8.20
25.	SHA	7.90	8.20	8.20	8.30
26.	KAR	8.00	8.30	7.00	8.60
27.	AJA	8.20	8.20	8.00	8.40
28.	ANA	8.30	8.40	6.90	6.90
29.	BHA	8.00	8.20	8.30	8.40
30.	JIT	8.00	8.40	7.80	8.80
31.	VEN	8.00	8.50	7.50	8.60
32.	ARV	7.90	7.70	6.50	8.50
33.	DEE	8.00	8.30	8.40	9.00
34.	SAN	8.40	8.50	8.50	8.60
35.	NAV	8.40	8.60	8.30	8.10
36.	ANU	8.20	7.50	7.90	8.50
37.	MAN1	8.30	8.60	6.90	8.40
38.	ARU	7.90	7.80	7.60	9.00
39.	DAT	7.90	8.20	7.50	8.20
40.	MAN2	9.00	8.20	5.70	6.40

41.	DIL	8.30	8.60	7.30	7.80
42.	JAI	8.00	6.80	7.20	8.40
43.	KUN	8.00	8.00	8.10	8.40
44.	NID	7.90	8.10	8.20	8.20
45.	GAJ	8.40	8.20	7.50	8.70
46.	RAV	7.60	7.30	8.20	8.30
47.	SUS	8.50	8.40	7.10	8.60
48.	SUM	8.50	8.40	7.50	8.60
49.	HEM	9.30	9.50	6.90	8.70
50.	HAR	7.60	8.00	7.30	8.20
51.	GAJ	8.00	8.20	7.20	8.50
52.	SHA	8.00	8.10	6.80	8.10
53.	RAJ	8.20	8.30	6.00	8.60
54.	AMI	9.10	8.20	8.00	9.40
55.	NAV	8.50	8.60	7.50	7.60
56.	SUD	5.40	5.30	5.60	7.20
57.	NAG	8.60	8.60	8.00	9.40
58.	HAN	7.70	7.60	6.90	6.00
59.	SAT	7.90	7.90	6.50	8.20
60.	NAG	7.90	7.70	7.60	8.20
<b>Mean</b>		<b>8.08</b>	<b>8.07</b>	<b>7.45</b>	<b>8.22</b>
<b>SD</b>		<b>0.50</b>	<b>0.56</b>	<b>0.65</b>	<b>0.70</b>

## APPENDIX – 7

### PUBLICATIONS EMERGING FROM THIS DOCTORAL WORK

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1. **Raghavendra, B. R** and Telles, S. (2012). Performance in attentional tasks following meditative focusing and focusing without meditation. *Ancient Science of Life*, [In review].
2. **Raghavendra, B. R.**, Telles, S., and Nagendra, H. R. (2012). Self-rated ability to follow instructions for four mental states described in yoga texts. *TANG International Journal of Genuine Traditional Medicine*, 2(3):e28.
3. Telles, S., **Raghavendra, B. R.**, Naveen, K. V., Manjunath, N. K., and Subramanya P. (2012). Physiological effects of two meditative states described in yoga texts. *Clinical EEG and Neuroscience*, 43(2):154-60.
4. Telles, S., and **Raghavendra, B. R.** (2011). Neurophysiological Changes in Meditation Correlated with Descriptions from the Ancient Texts. *Biofeedback*, 39(2):56-59.

**ORIGINAL ARTICLE**

**PERFORMANCE IN ATTENTIONAL TASKS FOLLOWING MEDITATIVE  
FOCUSING AND FOCUSING WITHOUT MEDITATION**

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**Running title: Attentional task performance and meditation**

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## **Abstract**

Ancient Indian yoga texts have described four mental states. These are *canalata* (random thinking), *ekagrata* (focusing without meditation), *dharana* (meditative focusing) and *dhyana* (defocused meditative expansiveness). A previous study compared the performance in a cancellation task at the beginning and end of each of the four states (practiced for 20 minutes each, on four separate days) and showed an increase in the scores after *dharana* (meditative focusing). Hence, the present study was designed to assess the effects of *dharana* (meditative focusing) and *ekagrata* (focusing without meditation), practiced on two separate days, on two attention tasks (i) d2 test of attention and (ii) digit symbol substitution test. Sixty normal healthy male volunteers with ages ranging from 17 to 38 years (group mean age  $\pm$  S.D.,  $24.87 \pm 4.95$ ) were studied. Assessments were made before and after the practice of *ekagrata* and *dharana* on two separate days. After both types of focusing there was a significant improvement in all measures of the d2 test of attention (TN, E, TN-E, E%, and CP). However, the performance in the digit symbol substitution test was better after *dharana* but did not change after *ekagrata*. Hence, in summary, *dharana* (meditative focusing) and *ekagrata* (focusing without meditation) produce nearly comparable results though *dharana* (meditative focusing) results in better incidental learning and better accuracy (assessed by the substitution task).

**Key words:** *dharana*, *ekagrata*, attention, incidental learning, concentration

## **Introduction**

Meditation has been defined as a training in awareness, which when practiced over a period of time produces definite changes in perception, attention, and cognition.<sup>[1]</sup> Meditation is also recognized as a specific consciousness state in which deep relaxation and increased internalized attention exist at the same time.<sup>[2]</sup>

All meditation practices have been considered as two main styles, based on how attention is directed.<sup>[3]</sup> One category is called focused attention meditation (FA), during which attention is sustained and focused on a given object. The second category is called open monitoring meditation (OM), where meditators are required not to react, while monitoring the content of ongoing experience. This style is a method by which the practitioner is aware of all mental content from one moment to the next.

More recently, the description has been expanded to include a third state i.e., automatic self-transcending. A study described the three broad categories of meditation techniques and their EEG patterns.<sup>[4]</sup> The three categories were, (i) focused attention meditation, (ii) open monitoring meditation, and (iii) automatic self-transcending which includes techniques intended to transcend their own activity. The changes in EEG were higher gamma power and coherence during focused attention meditation, decreased frontal delta and increased frontal midline theta during open monitoring meditation, and higher frontal alpha coherence during automatic self-transcending meditation. These changes were consistent with the idea that focused attention meditation would be associated with EEG changes seen during directed attention, whereas open monitoring meditation and self-transcending were associated with lower frequency EEG bands, usually associated with relaxation.<sup>[4]</sup>

These classifications are compatible with the concept of meditation in an ancient Indian yoga text (Patanjali's *Yoga Sutras*; circa 900 B.C.). Meditation was considered as the final practice before the individual reaches the state of ultimate transcendence called *samadhi*. There were eight stages systematically described by the Sage Patanjali in the *Yoga Sutras* (aphorisms). These eight stages are (i) and (ii) *yamas* and *niyamas* (rules for good conduct), (iii) *asanas* (physical postures), (iv) *pranayamas* (voluntarily regulated breathing), (v) *pratyahara* (withdrawal, particularly from external sensations), (vi) *dharana* (meditative focusing), (vii) *dhyana* (a defocused state of mental expansiveness), and (viii) *samadhi* (an experience of transcendence or ultimate realization). The sixth and seventh stages pertain to meditation. The sixth stage is known as *dharana* (meditative focusing) which is defined as confining the mind within a limited mental area (*'desha-bandhashchittasya dharana'*; Patanjali's *Yoga Sutras*, Chapter III, Verse 1).<sup>[5]</sup> The seventh stage, *dhyana* is supposed to inevitably follow the stage of *dharana* (meditative focusing). The eighth stage is one of ultimate spiritual realization (*samadhi*).

Apart from *dharana* and *dhyana* there are two other mental states, i.e., *cancelata* and *ekagrata*, described in another ancient text (the *Bhagavad Gita*, compiled circa 500 B.C.). *Cancelata*, is a state of random thinking (*Bhagavad Gita*, Chapter VI, Verse 34).<sup>[7]</sup> The second state is *ekagrata*, during which the attention is directed to a series of associated thoughts

(Bhagavad Gita, Chapter VI, Verse 12).<sup>[7]</sup> Hence, *ekagrata* is a state of focusing without meditation.

A study compared the performance in a cancellation task in seventy normal healthy male volunteers at the beginning and end of the four types of sessions (20 minutes each on four separate days, in a random order) viz., *cancelata*, *ekagrata*, *dharana* and *dhyana*.<sup>[6]</sup> The results showed that scores in the cancellation task improved after *dharana* (meditative focusing). The letter cancellation task assesses selective attention and concentration.<sup>[8]</sup> It was interesting to note that, meditative focusing improved selective attention whereas focusing without meditation did not show such an effect.

Hence, the present study was designed to determine the effects of *ekagrata* (focusing without meditation) and *dharana* (meditative focusing) practiced on two separate days using two different tests used to assess attention, i.e., (i) d2 test of attention and (ii) digit symbol substitution test.

## **Materials and Methods**

### **Participants**

Sixty male volunteers with ages ranging from 17 to 38 years (group mean age  $\pm$  S.D., 24.87  $\pm$  4.95 months) were recruited for the study. They were all students at a yoga university in South India. Their health status was evaluated by a routine case history and clinical examination. They had normal health and were not on any medication. The conditions to exclude participants from the study were any chronic illness, particularly psychiatric or neurological disorders, cognitive disorders and visual deformities. Male volunteers alone were selected as the mental state is known to vary with the phases of the menstrual cycle.<sup>[9]</sup> All participants had been practicing meditation on the Sanskrit syllable, OM for 30 minutes each day, for 5 days in a week (group average experience  $\pm$  SD; 14.83  $\pm$  8.63 months). Apart from their prior experience of meditation on OM, they were given a three month orientation program to practice *dharana* (meditative focusing) under the guidance of an experienced meditation teacher. The project was approved by the institution's ethics committee. The study protocol was explained to the subjects and their signed consent was obtained.

## **Design**

Each participant was assessed in two sessions on separate days. These two sessions were *dharana* (meditative focusing) and *ekagrata* (focusing without meditation). Half of the total participants were randomly allocated to *dharana* session first and *ekagrata* session later and the other half had the order reversed. Assessments were done before and after the practice of *dharana* and *ekagrata* sessions. After one week (as a wash-out period) the order of the sessions was reversed and assessments were done before and after the sessions. Participants who did *dharana* first, practiced *ekagrata* second and those who did *ekagrata* first, practiced *dharana* second. This one week gap was given to wash out any possible learning effect. The time of the day for assessment was kept constant for both sessions. Both sessions were of 20 minutes duration.

## **Assessments**

### **d2 Test of attention**

The d2 test is a timed test of selective attention and concentration.<sup>[10]</sup> The one page test form provides sections for recording data about the subject, test scores and has a practice sample. On the reverse side is the standardized test, consisting of 14 lines, each comprised of 47 characters for a total of 658 items. The test items are composed of the characters “d” and “p” with one to four dashes, arranged either individually or in pairs above and below the letter. The subject is required to scan across each line to identify and cross out all “d’s” with two dashes. The subject is allowed 20 seconds per line.

### **Digit symbol substitution test**

The Digit Symbol Test is a subset of the Wechsler Adult Intelligence Scale-Revised (WAISR) administered using paper and pencil.<sup>[11]</sup> It measures sustained attention, response speed, and visuo-motor coordination. The participant is given a key grid of numbers and matching symbols and a test section with numbers and empty boxes. The test consists of filling in as many empty boxes as possible with a symbol matching each number. Ninety seconds were given to complete the task. The score was computed as the number of correctly substituted symbols within the 90-s time limit. To avoid a re-test effect parallel worksheets were prepared by changing the digit-symbol pairs in the key and by randomly changing the sequence of digits in the working section.

## **Interventions**

Participants were given a three month training to practice *dharana* (meditative focusing) based on specific instructions under the guidance of an experienced meditation teacher who had no other part in the trial. The evaluation of the participants' practice of *dharana* was based on their self-report as well as consultations with the meditation teacher.

Brief descriptions of both sessions are given below:

### *(i) Focusing without meditation (ekagrata)*

Participants listened to a pre-recorded lecture on meditation. This was not about meditation on the Sanskrit syllable Om, but about meditation in general. It was speculated that listening to a lecture on a particular topic might induce the state of non-meditative focusing.

### *(ii) Meditative focusing (dharana)*

Participants were asked to open their eyes and gaze at the syllable 'Om' as it is written in Sanskrit for 30 seconds. Followed by this, participants were asked close their eyes and audio instructions for *dharana* were played. The meditative focusing on the Sanskrit syllable Om consisted of mental visualization of the symbol Om. *Dharana* involves conscious effort to keep the focus on the syllable 'Om'.

## **Data analysis**

Statistical analysis was done using SPSS (Version 19.0). Since the same individuals were assessed in repeat sessions on separate days (i.e., *ekagrata* and *dharana*), repeated measures analysis of variance was used (ANOVA). Repeated measures analysis of variance (ANOVA) were performed with two 'within subjects' factors, i.e., Factor 1: Sessions; *ekagrata* and *dharana* and Factor 2: States; "Pre", and "Post". This was followed by a *post-hoc* analyses with Bonferroni adjustment comparing 'pre' with 'post' values.

## Results

The group mean and standard deviation for scores obtained in the d2 test of attention and digit symbol substitution test are presented in Table 1.

### Repeated measures analysis of variance (ANOVA)

The significant changes in d2 test of attention and digit symbol substitution test are given in Table 2.

### Post-hoc analyses with Bonferroni adjustment

There was a significant increase in total number processed (TN), TN – E, and concentration performance (CP) after *ekagrata* as well as *dharana* ( $P < 0.001$ , *post hoc* analyses following ANOVA). There was a significant decrease in errors (E) after *ekagrata* ( $P < 0.01$ ) and *dharana* ( $P < 0.001$ ). And also, there was a significant decrease in E% after *ekagrata* ( $P < 0.001$ ) and *dharana* ( $P < 0.001$ ). Digit symbol substitution test scores showed a significant increase after *dharana* ( $P < 0.001$ ) while *ekagrata* showed no change.

## Discussion

In the present study sixty male volunteers with experience in meditation were assessed in the d2 test of attention and digit symbol substitution test after *dharana* (meditative focusing) and *ekagrata* (focusing without meditation).

The digit symbol substitution test is used to assess perceptual-motor speed during copying, visual scanning, and incidental learning.<sup>[12,13]</sup> The d2 test of attention is essentially a cancellation task, which measures selective attention and concentration.<sup>[10,14]</sup> After both types of focusing there was a significant improvement in all measures of the d2 test of attention (TN, E, TN-E, E%, and CP). However, the performance in the digit symbol substitution test was better after *dharana* but did not change after *ekagrata*.

The main difference between two tests is that the digit symbol substitution test has a component of incidental learning. It is possible that, incidental learning improves after *dharana* due to greater relaxation which may not be occurring after *ekagrata*. Learning and memory are closely related to relaxation.<sup>[15]</sup> A previous study showed that 23 minutes of a ‘moving meditation’ called cyclic meditation (CM) improved primary working memory.<sup>[16]</sup> The improvement was attributed to better relaxation following cyclic meditation. The same reason

may be the basis for the results in the present study though this is just a speculation as it was not actually studied by objective variables.

With respect to the d2 test of attention, following both *ekagrata* and *dharan*, there was a comparable improvement, particularly in the (i) total number processed (TN) (ii) TN-E and (iii) concentration performance (CP).

The total number processed is a reliable measure of attention allocation, processing speed, amount of work completed, and motivation.<sup>[10]</sup> When the errors are subtracted from total number (TN-E), the value is a measure of attentional and inhibitory control, and the relationship of speed and accuracy of performance.<sup>[10]</sup> Concentration performance (CP) is derived from the number of correctly crossed out relevant items minus the errors of commission or over-inclusion when irrelevant letters are crossed out. This is good indicator of the coordination of speed and accuracy of performance.<sup>[10]</sup> Despite the fact that concentration performance (CP) appeared comparably improved after *ekagrata* and *dharana*, the reduction in errors was more after *dharana* (26.48%) compared to *ekagrata* (15.44%).

Errors (E) include both errors of omission (E1) or under-inclusion and errors of commission (E2) or over-inclusion. The number of errors is sensitive to attentional control, rule compliance, accuracy of visual scanning, carefulness and cognitive flexibility. Perhaps the only difference between the two states (*dharana* and *ekagrata*) with respect to the d2 test could be related to the accuracy of visual scanning, and cognitive flexibility. Though, even this is difficult to conclude the given comparable scores in concentration performance (CP) after *dharana* (21.14%) and *ekagrata* (18.06%).

The findings did not reveal noticeable results between *dharana* and *ekagrata* except for the digit symbol substitution test performance. This suggests that *dharana* and *ekagrata* did not bring about marked differences in attention task performance. It would have been ideal to have a simultaneous assessment of the physiological measures to assess the level autonomic arousal during the two states. This is particularly of interest as attention is known to modulate sympathetic activation.<sup>[17]</sup> The other limitation of the study is that, there was no assessment on third day when a participant was given no intervention.

Hence in summary, *dharana* (meditative focusing) and *ekagrata* (focusing without meditation) produce nearly comparable results though *dharana* results in better incidental learning and better accuracy (based on the digit symbol substitution test performance).

### **Conflict of interest notification**

The authors declare that they have no conflict of interest.

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**Table1. Scores in d2 test of attention and digit symbol substitution test, before and after *ekagrata* (Focusing without meditation) and *dharana* (Meditative focusing). Values are group mean  $\pm$  S.D. and arrows show the direction of change.**

Task	Variable	<i>Ekagrata</i> (Focusing without meditation)		<i>Dharana</i> (Meditative focusing)	
		Pre	Post	Pre	Post
<b>D2 test of attention</b>	TN	528.67 $\pm$ 84.27	572.13 $\pm$ 70.83*** $\uparrow$	531.37 $\pm$ 77.98	580.50 $\pm$ 62.75*** $\uparrow$
	% change	-	8.22	-	9.25
	E	53.63 $\pm$ 39.82	45.35 $\pm$ 32.12** $\downarrow$	50.22 $\pm$ 33.70	36.92 $\pm$ 26.14*** $\downarrow$
	% change	-	15.44	-	26.48
	TN - E	475.03 $\pm$ 82.42	526.78 $\pm$ 73.40*** $\uparrow$	481.15 $\pm$ 80.09	543.58 $\pm$ 64.09*** $\uparrow$
	% change	-	10.89	-	12.98
	E %	10.08 $\pm$ 6.85	7.96 $\pm$ 5.41*** $\downarrow$	9.52 $\pm$ 5.92	6.36 $\pm$ 4.24*** $\downarrow$
	% change	-	21.03	-	33.19
	CP	176.10 $\pm$ 49.45	207.90 $\pm$ 45.79*** $\uparrow$	181.35 $\pm$ 47.95	219.68 $\pm$ 39.86*** $\uparrow$
	% change	-	18.06	-	21.14
<b>DSST</b>	Scores on DSST	55.53 $\pm$ 11.76	57.82 $\pm$ 10.80	57.13 $\pm$ 11.43	64.67 $\pm$ 10.54 *** $\uparrow$
	% change	-	4.12	-	13.20

\*\*\* $p < 0.001$ ; RM ANOVA with Bonferroni adjustment comparing Post values with Pre values.

TN: Total Number Processed; E: Error; CP: Concentration performance; DSST: digit symbol substitution test

**Table 2. Summary of the repeated measures analysis of variance (ANOVA) showing statically significant results.**

<b>Variables</b>	<b>Factor</b>	<b>F value</b>	<b><i>df</i></b>	<b>Huynh-Feldt epsilon</b>	<b>Level of significance</b>
<b>Total Number Processed (TN)</b>	States	79.13	(1, 59)	1.00	P <0.001
<b>Errors (E)</b>	States	26.69	(1, 59)	1.00	P <0.001
<b>TN - E</b>	States	161.88	(1, 59)	1.00	P <0.001
<b>E %</b>	States	59.14	(1, 59)	1.00	P <0.001
<b>Concentration Performance (CP)</b>	States	201.43	(1, 59)	1.00	P <0.001
<b>Scores on Digit Symbol Substitution Test</b>	Sessions	14.86	(1, 59)	1.00	P <0.001
	States	40.43	(1, 59)	1.00	P <0.001
	Sessions X States	11.13	(1, 59)	1.00	P <0.01

## Self-rated ability to follow instructions for four mental states described in yoga texts

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### ABSTRACT

There were no studies available measuring the ability to follow instructions for meditation. Hence, the present study was planned to assess the ability to follow instructions for the four mental states viz., *canalata* (random thinking), *ekagrata* (non-meditative concentration), *dharana* (focused meditation) and *dhyana* (defocused meditation or effortless meditation) described in yoga texts. Sixty male volunteers with ages ranging from 18 to 31 years (group mean age  $\pm$  S.D., 22.78  $\pm$  2.73) participated in the study. They were assessed using a visual analog scale immediately after each of the four states on four different days. The results showed that following *dharana*, scores on the visual analog scale were significantly lower compared to those related to *canalata*, *ekagrata* and *dhyana*. Hence, *dharana* is the most difficult of the four states.

**Keywords** four mental states, *canalata*, *ekagrata*, *dharana*, *dhyana*, visual analog scale

### INTRODUCTION

The practice of meditation has become increasingly popular all over the world in the last few decades. Positive physiological and psychological changes following meditation are supported by a number of research studies (Cahn and Polich, 2006; Keng et al., 2011). However, the results are distinct and different. This may be due to differences in the methods and principles of the practice of meditation.

Recently, there was a report which described three broad categories of meditation techniques and their EEG patterns (Travis and Shear, 2010). The three categories were (i) focused attention, which involves voluntary and sustained attention on a chosen object, (ii) open monitoring meditation in which there is non-reactive monitoring of the moment-to-moment content of the experience, and (iii) automatic self-transcending, which includes techniques intended to transcend the practitioner's own activity. All these modern derived meditation techniques are supposed to fit in the above-mentioned categories. Specific meditation techniques may be more effective for certain persons based on their psychological characteristics.

In Patanjali's *Yoga Sutras* (PYS), ancient Indian yoga text (Circa 900 B.C.), there are two meditative states described (Taimini, 1986). Sage Patanjali lays out eight stages of yoga in *Yoga Sutras* (aphorisms). These are (i) and (ii) *yamas* and *niyamas* (rules for good conduct), (iii) *asanas* (physical postures), (iv) *pranayamas* (voluntarily regulated breathing), (v) *pratyahara* (withdrawal, particularly from external sensations), (vi) *dharana* (focused meditation), (vii) *dhyana* (defocused meditation or effortless meditation), and (viii) *samadhi* (an experience of transcendence or ultimate realization). The sixth and seventh stages are pertaining to meditation. *Dharana*

(focused meditation), is defined as confining the mind within a limited mental area (PYS 3.1). The next stage is *dhyana* (effortless meditation or defocused meditation) (PYS 3.2) which is characterized by the uninterrupted flow of the mind towards the object chosen for meditation. *Dharana* and *dhyana* may be considered as the last two of four stages, which form a continuum in the process and practice of meditation. The first two stages are described in another ancient Indian text the *Bhagavad Gita* (Sarasvati and Swami, 1998). The first stage is *canalata*, which is a stage of random thinking. The second stage is *ekagrata*, during which the attention is directed to a series of associated thoughts. The concept of the four mental states described in yoga texts is schematically presented in Fig. 1.

A study was conducted on 30 volunteers to assess the changes in these mental processes in brainstem auditory-evoked potentials (Kumar et al., 2010). The peak latency of wave V increased significantly during the *dharana*, *ekagrata* and *canalata* sessions, but there was no change during the practice of *dhyana*. The findings suggest that *dhyana* practice alone does not delay auditory transmission at the level of the brainstem, showing the effectiveness *dhyana* has over other processes. In another study, mid-latency auditory-evoked potentials were assessed in 60 participants during the four mental states (Telles et al., 2012). The results showed prolongation in the latencies of Na and Pa waves during meditation (*dhyana*), suggesting that auditory information transmissions at the levels of the medial geniculate and primary auditory cortex were delayed. Similarly, performances in a cancellation task studied in 70 normal, healthy male volunteers showed a significant increase after *dharana* and a decrease after *canalata*, suggesting better attention after *dharana* (Kumar and Telles, 2009). There were no changes in *dhyana* and *ekagrata*.

The concept of an analog scale to assess subjective feelings was described early in 1921 (Hayes and Patterson, 1921). Lately, a visual analog scale has been widely used in rating the subjective feelings (Aitken, 1969). The advantages include it is

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Received June 5, 2012; Accepted August 23, 2012; Published August 31, 2012

doi: <http://dx.doi.org/10.5667/tang.2012.0023>

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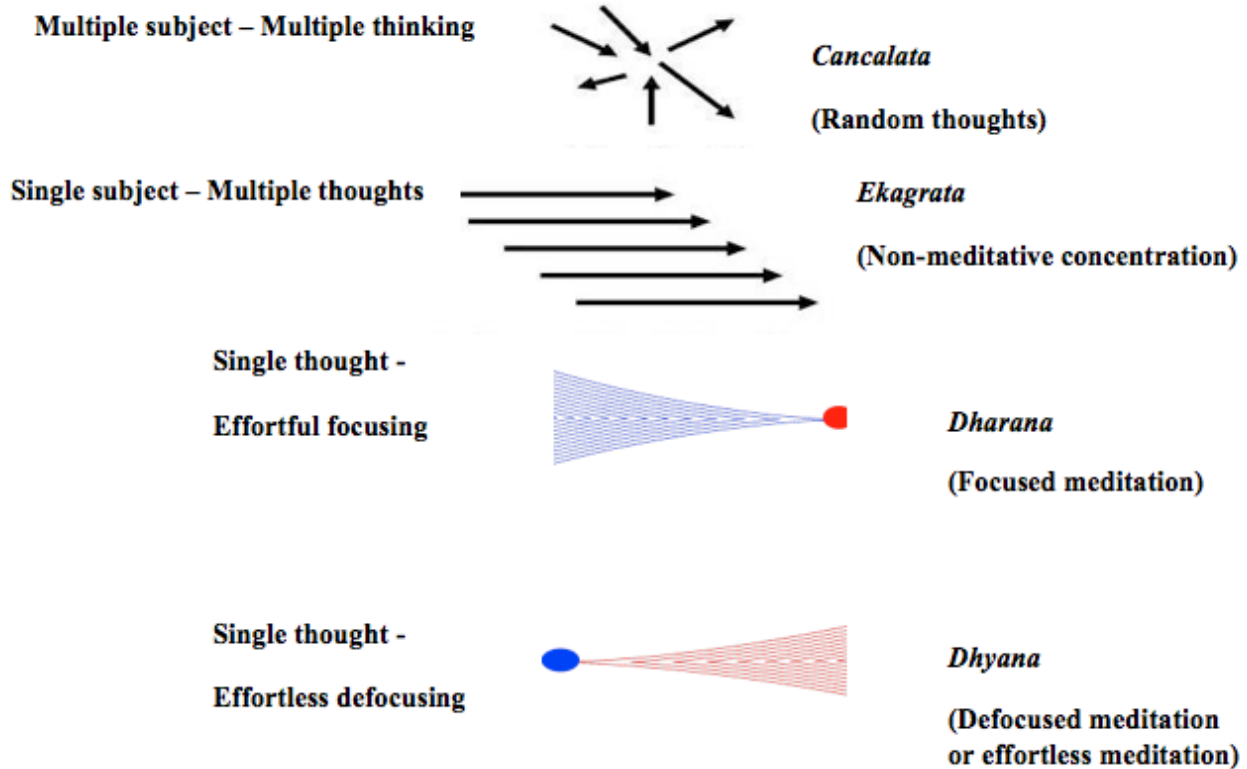


Fig. 1. Schematic representation of four mental states described in yoga texts.

easy for the subject to grasp, quick to fill out and score, and as the subject is not restricted to direct quantitative terms, one can make a fine discrimination. In an early study on the effect of meditation on shooting performance, a visual analog scale was used to assess the experience of tension during shooting (Solberg et al., 1996). In another study, a visual analog scale was used to assess global well-being, pain, sleep, fatigue, and tiredness upon awakening in fibromyalgia patients before and after participation in a stress-reduction cognitive-behavioral treatment program (Don et al., 1994). Recently, in a study on the effects of yoga on the quality of life in cancer patients, their satisfaction levels related to the yoga program were evaluated using a visual analog scale (Ulger, 2010).

However, there have been no studies available measuring the ability to follow instructions for meditation. Hence, the present study was planned to assess the ability to follow instructions for the four mental states (*canalata*, *ekagrata*,

*dharana*, and *dhyana*) described in yoga texts.

## MATERIALS AND METHODS

### Participants

Sixty male volunteers with ages ranging from 18 to 31 years (group mean age  $\pm$  S.D., 22.78  $\pm$  2.73) were recruited to the study. All of them were of normal health based on a routine case history and clinical examination. They were all students at a yoga University in South India. They had a minimum of six months experience in meditation (group average experience  $\pm$  S.D., 20.95  $\pm$  14.21 months). Apart from their prior experience of meditation on Om, they were given a three-month orientation program under the guidance of an experienced meditation teacher. Male volunteers alone were selected as their mental state is known to vary with the phases of the menstrual cycle in females (Little and Zahn, 1974). All participants expressed their willingness to participate in the experiment, and the project was approved by the institution's ethics committee. The study protocol was explained to the subjects and their signed consent was obtained.

### Design

Assessments were made on four different days, which were not necessarily on consecutive days, but at the same time of the day. The allocation of participants to the four sessions was random using a standard random number table. Two of them were meditation sessions viz., *dharana* and *dhyana*; whereas the other two were non-meditation sessions viz., *ekagrata* and *canalata*. Instructions for all four sessions were played from a compiled audio CD. The duration of all the four sessions was 20 min. A visual analog scale was given immediately after the session. The study design has been schematically presented in Fig. 2.

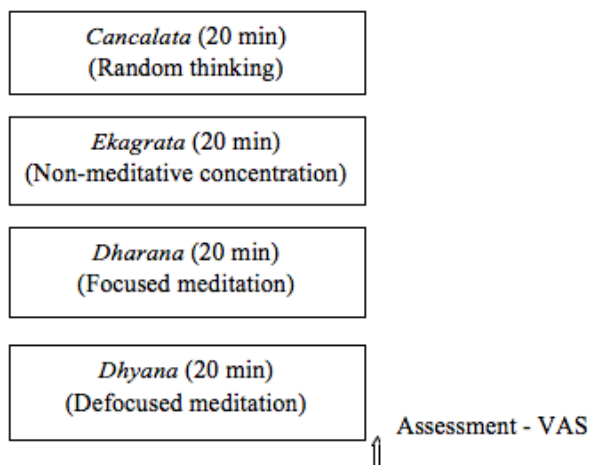


Fig. 2. Schematic representation of the design.



Fig. 3. Visual analog scale.

**Interventions**

Throughout all the sessions participants sat cross legged and kept their eyes closed following the pre-recorded instructions for a period of 20 min.

Cancelata (Random thinking)

Participants were asked to allow their thoughts to wander freely as they listened to a compiled audio CD consisting of brief periods of conversation, announcements, advertisements and talks on diverse topics recorded from a local radio station transmission. All these conversations were not connected and could induce the state of random thinking.

Ekagrata (Non-meditative concentration)

Participants listened to a pre-recorded lecture on meditation. This was not about meditation on the Sanskrit syllable Om, but about meditation, in general. This was supposed to induce a state of non-meditative concentration.

Dharana (Focused meditation)

Participants were asked to open their eyes and gaze at the syllable ‘Om’ as it is written in Sanskrit. During this time, guided instructions required them to direct their thoughts to the physical attributes of the syllable (i.e., the shape and color), and then to close their eyes and continue to visualize the syllable mentally.

Dhyana (Effortless meditation or defocused meditation)

During this session participants were instructed to keep their eyes closed and dwell on the Om picture without any effort, particularly on the subtle (rather than physical) attributes and connotations of the syllable. This involved the effortless chanting of Om, bringing about the effect of defocusing.

**Assessments**

A Visual Analogue Scale (VAS) is an instrument that tries to measure a characteristic or attitude that is believed to range across a continuum of values and cannot easily be directly measured (Wewers and Lowe, 1990). A visual analogue scale is a horizontal line, 10 cm in length, anchored by word descriptors at each end, as illustrated in Fig. 3. Immediately after the session, participants were asked to put a mark on the line which represents how much they were able to follow the instructions for the four mental states.

**Data analysis**

Statistical analysis was done using SPSS (Version 16.0). Repeated measured analysis of variance (ANOVA) was performed with one ‘within subjects’ factor, i.e., sessions: *cancelata*, *ekagrata*, *dharana*, and *dhyana*. This was followed by a *post-hoc* analysis with a Bonferroni adjustment for multiple comparisons between the mean values of different sessions.

**RESULTS**

The group mean values ± SD for *cancelata*, *ekagrata*, *dharana* and *dhyana* are given in Table I. Repeated measures of the analysis of variance (ANOVA) showed significant differences between sessions [ $F = 31.04$ ,  $df = (2.46, 145.13)$ , Huynh-Feldt epsilon = 0.820,  $p < 0.001$ ]. *Post-hoc* analyses with a Bonferroni adjustment were performed to see the changes between the sessions. Following *dharana*, scores on the visual analog scale were significantly lower compared to those for *cancelata* ( $p < 0.001$ ), *ekagrata* ( $p < 0.001$ ), and *dhyana* ( $p < 0.001$ ).

**DISCUSSION**

The present study was conducted to assess the self-rated ability to follow the instructions to achieve the four mental state’s viz., *cancelata*, *ekagrata*, *dharana* and *dhyana* using a visual analog scale. The results showed that following *dharana*, scores on the visual analog scale were significantly lower compared to those for *cancelata*, *ekagrata* and *dhyana*.

A study has shown the brain areas involved in FA (Focused Attention) and OM (Open Monitoring) meditations are distinct and different (Lutz et al., 2008). FA meditation improves the practitioner’s ability to sustain attention on a particular object for prolonged periods. During FA meditation, functional magnetic resonance imaging (fMRI) has shown activation in the brain regions involved in monitoring, engaging attention and attentional orienting. In contrast, OM meditation has shown activation in the brain regions implicated in monitoring, vigilance and disengaging attention from stimuli which could distract attention from the experience at that moment. Hence, it is very much evident that the brain areas involved in these four mental states are different.

*Dharana* involves mental visualization and intense focusing on the Sanskrit syllable Om. Some people may have difficulties in mentally visualizing the symbol for a long time. Also, participants might have had difficulties in keeping the intense focus on the syllable Om for 20 min. The average attention span in healthy adults is between 15 - 20 min. *Dharana* requires focused attention; whereas *dhyana*, *ekagrata* and *cancelata* do not need focused attention.

The usefulness of practicing *dharana* is well known. Focused attention on a single object removes *cancelata* and takes us to a higher state than *ekagrata* by moving the mind from multiple thoughts to a single thought of a visual picture as ‘Om’ used here. However, according to yoga, it is well known that *dharana* involves intense effort to keep the focus on the given object for longer durations. It causes fatigue as it drains

**Table 1.** Scores on visual analog scale following four mental states

Sessions	<i>Cancelata</i>	<i>Ekagrata</i>	<i>Dharana</i>	<i>Dhyana</i>
Mean ± S.D.	8.08 ± 0.50	8.07 ± 0.56	7.45 ± 0.65***	8.22 ± 0.70

\*\*\* Comparing *dharana* with *cancelata*, *ekagrata*, and *dhyana* sessions shows significant differences with all three ( $p < 0.001$  for each).

away the energy. However, it is useful for removing drowsiness (*Tamas*) and inducing alertness.

Hence, traditionally (PYS 3.2) *dharana* is used for a short duration, about a minute and then one proceeds to perform *dhyana* by making the mind to stay on a single thought effortlessly. The five main features of the *dhyana* state are single thought, effortlessness, slowness, wakefulness and expansiveness. A long duration of meditation helps one to gain mastery over the mind and leads to a state of superconsciousness called *samadhi* (PYS 3.4).

In summary, the study has shown that, (i) *canalata* and *ekagrata* and *dhyana* can be done with equal ease, and (ii) *dharana* is the most difficult state compared to the *canalata*, *ekagrata* and *dhyana* states.

## ACKNOWLEDGEMENTS

The authors gratefully acknowledge the funding from the Indian Council of Medical Research (ICMR), Government of India, as part of a grant (Project No. 2001-05010) towards the Center for Advanced Research in Yoga and Neurophysiology (CAR-Y&N).

## CONFLICT OF INTEREST

The authors have no conflicting financial interests.

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# Mid-Latency Auditory Evoked Potentials in 2 Meditative States

Clinical EEG and Neuroscience  
43(2) 154-160  
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sagepub.com/journalsPermissions.nav  
DOI: 10.1177/1550059412439963  
http://eeg.sagepub.com



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Pailoor Subramanya<sup>1</sup>

## Abstract

Mid-latency auditory evoked potentials (MLAEPs) were assessed in 60 participants during 4 mental states described in traditional yoga texts. These 4 mental states are random thinking, nonmeditative-focused thinking, meditative focusing, and meditation. Assessments were made before (5 minutes), during (20 minutes), and after (5 minutes) each of the 4 states, on 4 separate days. There were prolonged latencies of 2 MLAEPs components, the Na and Pa waves during meditation ( $P < .05$ , post hoc analyses following analysis of variance [ANOVA]), suggesting that auditory information transmission at the level of the medial geniculate and primary auditory cortex (ie, the neural generators corresponding to the Na and Pa waves) was delayed. Hence, meditation influenced MLAEPs, while meditative focusing did not.

## Keywords

mid-latency auditory evoked potentials, meditation, yoga

Received February 19, 2011; revised December 13, 2011; accepted December 14, 2011.

## Introduction

MLAEPs have been used to assess cortical and subcortical changes in meditation.<sup>1</sup> It is believed that even if the main changes occur in the cortex, corticoefferent connections would result in subcortical changes.<sup>2</sup> The auditory modality of stimuli was chosen as it was found to be least disturbing to the mediator during their practice.<sup>3</sup>

An early study on experienced meditators who were asked to mentally repeat the Sanskrit syllable, OM, showed a group with a significant decrease in the Nb latency.<sup>4</sup> Reduced latency of a specific component signifies that neural transmission in the generator corresponding to that component is occurring sooner than usual.<sup>5</sup> The Nb component corresponds to the dorsoposterior medial part of the Heschl gyrus, that is the primary auditory cortex.<sup>6</sup> Therefore, it is suggested that, in experienced meditators, mental repetition of OM facilitates the transmission of neural information at the level of the dorsoposterior medial area of the Heschl gyrus.

In a subsequent study on experienced and naive meditators, who were asked to mentally repeat “OM” on 1 day and “one” on another day, there was a significant change in the Na component.<sup>1</sup> When both experienced and naive meditators repeated “one” there was a significant decrease in the peak amplitude of the Na wave. The Na wave is known to correspond to the mesencephalic or diencephalic level.<sup>7</sup> An increased peak amplitude suggests recruitment of a greater number of

neurons.<sup>2</sup> Therefore, the decreased Na amplitude indicated a possible decrease in neurons recruited at the mesencephalic or diencephalic level while mentally repeating “one.”

In contrast, when experienced meditators and naive persons were asked to mentally repeat “OM” on another day, the results were quite different. The Na wave peak amplitude significantly increased in experienced meditators but significantly decreased in naive persons.<sup>1</sup> These results were suggestive of recruitment of increased neurons at the mesencephalic–diencephalic level in experienced meditators repeating OM, whereas naive practitioners had fewer neurons recruited at that level. Since the number of neurons recruited generally correlates with the level of activity,<sup>8</sup> the results showed that mental repetition of a syllable with specific connotations and significance (ie, OM) produces changes in opposite directions in the peak amplitude in experienced and naive meditators.

MLAEPs during another meditation (Brahmakumaris Raja Yoga meditation practiced with eyes open), in experienced

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meditators showed a significant decrease in the peak latency of the Na wave during meditation.<sup>9</sup> Hence, these results support the idea that Brahmakumaris Raja Yoga meditation facilitated transmission at the mesencephalic–diencephalic level. Another study evaluated both auditory evoked potentials and visual contrast sensitivity in epileptics who practiced Sahaja Yoga meditation,<sup>10</sup> which is characterized by thoughtless awareness or mental silence.<sup>11</sup> Among other changes, an increased Na-Pa amplitude was reported.

Most of these meditation techniques (ie, Brahmakumaris Raja Yoga meditation, Sahaja Yoga meditation, and meditation on OM) have been derived within the last 200 years. Differences in results between meditation techniques could be related to the method used.<sup>1</sup> So far, a single study attempted to assess the effects of meditation as described in the traditional yoga texts.<sup>12</sup>

The first, and possibly most recent, comprehensive compilation among the ancient texts is the Patanjali's *Yoga Sutras* (circa 900 BC). In Patanjali's *Yoga Sutras* (circa 900 BC), there are 2 meditative states described, one leading to the other.<sup>13</sup> The first stage is meditative focusing, confining the mind within a limited mental area (Patanjali's *Yoga Sutras*, chapter III, verse 1). The next stage is meditation or effortless expansion (Patanjali's *Yoga Sutras*, chapter III, verse 2). This state is characterized by the uninterrupted flow of the mind toward the object chosen for meditation. When the mind is not in meditation, the ancient texts say that it may be in 2 states, random thinking (*Bhagavad Gita*, chapter VI, verse 34) and nonmeditative-focused thinking (*Bhagavad Gita*, chapter VI, verse 12).<sup>14</sup>

When brain stem auditory evoked potentials were studied in meditators who practiced meditative focusing, meditation without focusing, nonmeditative-focused thinking, and random thinking on 4 separate days, the effects of the 4 different mental states differed.<sup>12</sup> The wave V peak latency increased significantly in random thinking, nonmeditative-focused thinking, and meditative focusing, but not in meditation. Since the wave V is considered to correspond to the inferior colliculus,<sup>5</sup> these results suggest that neural transmission at the mid-brain level may be improved by meditation without focusing.

There has been no study assessing the changes, if any, in MLAEPs during the 4 mental states described in the ancient yoga texts. The present study was aimed at assessing whether MLAEPs corresponding to thalamic and cortical generators change with meditation, when the description of meditation was based on the ancient texts.

## Materials and Methods

### Participants

Participants were recruited by announcements in the university newsletter and flyers on the notice boards. The 110 volunteers were screened for age, health status, meditation experience, and socioeconomic status. Sixty male volunteers with ages ranging from 18 to 31 years (group mean age  $\pm$  standard

**Table 1.** Characteristics of Participants

Characteristics	
Age (in years), group mean $\pm$ SD	22.78 $\pm$ 2.73
Education	
Postgraduates	23 (38.3%)
Graduates	27 (45%)
Undergraduates	10 (16.7%)
Type of meditation	Meditation on the Sanskrit syllable OM
Experience of meditation practice (in months)	20.95 $\pm$ 14.21
6-12 months	29 (48.3%)
13-24 months	17 (28.3%)
25-36 months	7 (11.7%)
37-48 months	5 (8.3%)
48-60 months	2 (3.3%)
Socioeconomic status	
High-income group	5 (8.3%)
Mid-income group	52 (86.7%)
Low-income group	3 (5%)

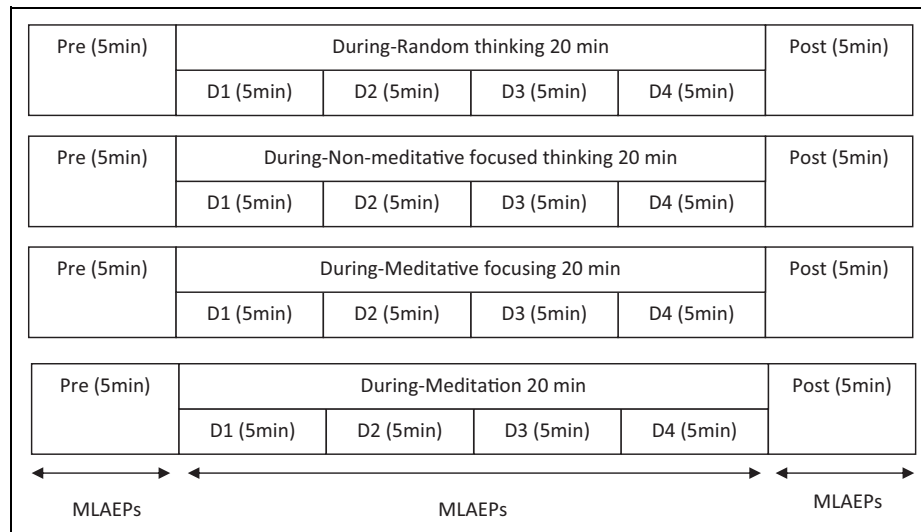
deviation [SD], 22.78  $\pm$  2.73) who met the criteria were recruited for the trial. They were all students at a yoga university in South India. Their health status was assessed by a routine case history and clinical examination.<sup>15</sup> The participants had normal health and were not on any medication or herbal remedies. The conditions to exclude participants from the trial were any chronic illness, particularly psychiatric or neurological disorders. Male volunteers alone were selected as evoked potentials are known to vary with the phases of the menstrual cycle.<sup>16</sup> All meditators had been practicing meditation on the Sanskrit syllable OM for 30 minutes each day, for 4 days in a week. They had a minimum of 6 months of experience in meditation (group average experience  $\pm$  SD, 20.95  $\pm$  14.21 months). The characteristics of participants are shown in Table 1.

The project was approved by the institution's ethics committee. The study protocol was explained to the participants and their signed consent was obtained. They were not compensated for their time and participation in the study.

### Design

Each participant was assessed in 4 sessions, to which they were assigned randomly. Two of them were meditation sessions (these were meditative focusing and meditative de-focusing or effortless meditation sessions) and 2 of them were nonmeditation sessions (these were nonmeditative-focused thinking and random thinking). All 4 sessions consisted of 3 states: pre (5 minutes), during (20 minutes), and post (5 minutes). The nonmeditative-focused thinking and random thinking sessions were the 2 nonmeditation sessions and were considered as control sessions for the 2 meditation sessions, viz, meditative focusing and meditation. The design is presented schematically in Figure 1.

Apart from their prior experience of meditation on OM, they were given a 3-month orientation program under the guidance of an experienced meditation teacher. The purpose of this



**Figure 1.** Schematic representation of the study design. D1 indicates during 1; D2, during 2; D3, during 3; D4, during 4.

orientation was for all participants to practice the 2 different states of meditation, viz, meditative focusing and meditation based on specific instructions, in the same way.

### Assessments

**Recording conditions.** MLAEPs were assessed in the 4 sessions (ie, random thinking, nonmeditative-focused thinking, meditative focusing, and meditation). Participants were seated in a sound attenuated, dimly lit cabin and monitored on a closed circuit television. Instructions were given through a 2-way intercom, so that participants could remain undisturbed during a session. Participants were observed on the closed-circuit television to detect whether they moved or fell asleep during a session. The temperature in the cabin and the recording room was maintained at  $24.0^{\circ}\text{C} \pm 1.0^{\circ}\text{C}$ . The average humidity was 56% on the days the experiments were conducted. The background noise level of the acoustically shielded chamber was 26 dB. MLAEPs were recorded in the 100 ms, poststimulus time period without any prestimulus delay, using a 4-channel system (Nicolet Biomedical Inc, Madison, WI, USA). Recordings were from the vertex (Cz) referred to linked earlobes, with the ground electrode on the forehead (FPz). Electrodes were placed according to the International 10-20 System.<sup>17</sup> Electrode impedance was kept below 5 kilo-ohms at all sites.

The amplifier bandwidth was set at 10 to 1500 Hz and 1500 responses were averaged for each assessment. Rejection was set at 90% of the full-scale range of the analog-to-digital converter. Binaural click stimuli of 50  $\mu\text{s}$  duration and alternating polarity at the rate of 5.0 Hz were delivered through acoustically shielded earphones (Amplivox, United Kingdom). The threshold of hearing was noted for each participant to verify that their hearing was normal. The threshold of hearing was checked as follows: (i) decreasing the intensity in 5 dB steps until the participant could no longer hear the clicks and (ii) increasing the intensity in 5 dB steps until the clicks were

**Table 2.** Components of MLAEPs and Their Neural Generators

Sl. no.	MLAEPs component	Latency range (ms)	Neural generators
1	Na	14-19	Medial geniculate
2	Pa	25-32	Superior temporal gyrus
3	Nb	35-65	Dorsoposterior medial part of the Heschl gyrus

Abbreviations: MLAEPs, mid-latency auditory evoked potentials.

audible. The click threshold was taken as the midpoint between the intensities at which the clicks could and could not be heard. This procedure was repeated twice. The threshold of hearing was noted for each participant and the intensity was kept at 80 dB normal hearing level (nHL).

### Components of MLAEPs

Components of MLAEP, viz, Na, Pa, and Nb waves, were measured from a 0 DC baseline. Peak latency was measured from the time of click delivery. The peak latencies and peak amplitudes of the following components were measured: the Na wave (a negative wave between 14 and 19 ms), is the maximum negative peak preceding the Pa wave which is a positive component between 25 and 32 ms. The Nb wave, which is a negative component between 35 and 65 ms, is also the first maximum negative component immediately following the Pa wave.<sup>18</sup> Components of MLAEPs and their neural generators are described in Table 2.

Participants' compliance for the meditation orientation program and for the recordings was 100%.

### Interventions

Throughout all sessions, participants sat cross-legged and kept their eyes closed following pre-recorded instructions. An

emphasis was placed on carrying out the practices slowly, with awareness of physical and mental sensations, and relaxed. For all sessions, the duration was 20 minutes. The sessions were conducted 6 days a week, between 06.00 and 06.30 hours. On the first day theoretical aspects of the 2 meditative states, viz, meditative focusing and meditation, were detailed by the meditation teacher. After this, the practice sessions started with pre-recorded instructions. The evaluation of the participants' practice of meditative focusing and meditation was based on their self-report as well as consultations with the meditation teacher.

**Random thinking.** Participants were asked to allow their thoughts to wander freely as they listened to a compiled audio CD consisting of brief periods of conversation, announcements, advertisements, and talks on diverse topics recorded from a local radio station transmission. All these conversations were not connected and could induce the state of random thinking.

**Nonmeditative-focused thinking.** Participants listened to a pre-recorded lecture on meditation. This was not about meditation, on the Sanskrit syllable OM, but about meditation, in general, which was supposed to induce a state of nonmeditative focusing.

**Meditative focusing.** Participants were asked to open their eyes and gaze at the syllable "OM" as it is written in Sanskrit. During this time, guided instructions required them to direct their thoughts to the physical attributes of the syllable (ie, the shape and color) and then to close their eyes and continue to visualize the syllable mentally. The main emphasis during meditative focusing was that thoughts are consciously brought back (if they wander) to the single thought of OM.

**Meditative de-focusing or effortless meditation.** During this session, participants were instructed to keep their eyes closed and dwell on thoughts of OM, without any effort, particularly on the subtle (rather than physical) attributes and connotations of the syllable. This involved effortless de-focusing combined with mental chanting of OM. This would gradually allow the participants to experience brief periods of silence, which they reported after the sessions.

## Data Analysis

Statistical analysis was done using SPSS (version 16.0). Data were tested for normality by the Kolmogorov-Smirnov test. Since the same individuals were assessed in repeat sessions on separate days (ie, random thinking, nonmeditative-focused thinking, meditative focusing, and meditation), repeated measures analyses of variance (ANOVAs) were performed with 2 within-participant factors, that is factor 1: sessions; random thinking, nonmeditative-focused thinking, meditative focusing, and meditation and factor 2: states; "pre," "during" (Dur1 to Dur4), and "Post." Repeated measures ANOVAs were carried

out for each wave of MLAEPs separately, for both peak latencies and peak amplitudes. This was followed by post hoc analyses with Bonferroni adjustment for multiple comparisons between the mean values of different states (during and post), and all comparisons were made with the respective pre state.

## Results

The group mean values  $\pm$  SD for the peak latencies (ms) and peak amplitudes ( $\mu$ V) of Na, Pa, and Nb components of MLAEPs in 4 sessions (random thinking, nonmeditative-focused thinking, meditative focusing, and meditation) in pre, during, and post states are given in Tables 3 and 4, respectively.

## Analysis of Variance

The significant changes in the peak latencies (ms) and peak amplitudes ( $\mu$ V) of Na, Pa, and Nb components of MLAEPs in 4 sessions are shown in Table 5.

## Post Hoc Analyses With Bonferroni Adjustment

Post hoc analyses with Bonferroni adjustment were performed and all comparisons were made with respective "pre" states summarized in Table 6.

In summary, there was a significant increase in the peak latencies of Na and Pa waves during meditation ( $P < .05$ , post hoc analyses following ANOVA) and of Nb wave in the post-period of nonmeditative-focused thinking ( $P < .05$ ) compared to pre-period. The peak amplitude of Pa wave was significantly decreased during random thinking ( $P < .001$ ), nonmeditative-focused thinking ( $P < .001$ ), meditative focusing ( $P < .01$ ), and meditation ( $P < .05$ ) compared to the respective pre-states.

## Discussion

Mid-latency auditory evoked potentials were recorded during random thinking, nonmeditative focusing, meditative focusing, and meditation. A consistent finding was prolonged peak latencies of 2 components (the Na wave and the Pa wave) during meditation. The Pa wave amplitude decreased during all 4 sessions.

Among MLAEPs, the Na wave is believed to be due to activity at the mesencephalic or diencephalic level,<sup>7</sup> and the Pa wave corresponds to activity at the superior temporal gyrus,<sup>18</sup> while the Nb wave appears relatively localized in the dorsoposterior medial area of the Heschl gyrus, that is the primary auditory cortex.<sup>6</sup>

A decrease in peak latency is considered suggestive of facilitated transmission due to increased speed of conduction in the underlying neural generators.<sup>5</sup> On the other hand, an increase in peak latency can be assumed to suggest inhibited transmission due to slower conduction in the underlying neural generators. Increased amplitudes of evoked potential components are interpreted as activation of the underlying neural generator with recruitment of a greater number of neurons.<sup>2</sup>

**Table 3.** Mid-Latency Auditory Evoked Potentials (MLAEPs) Showing Peak Latencies for 4 Sessions in 6 States for Na, Pa, and Nb Waves<sup>a</sup>

		Peak latency (ms)					
Waves	Sessions	Pre	During				Post
			During 1	During 2	During 3	During 4	
Na wave	Random thinking	16.02 ± 1.59	16.22 ± 1.71	16.44 ± 1.80	16.48 ± 1.97	15.88 ± 1.94	16.14 ± 1.78
	Nonmeditative-focused thinking	16.24 ± 1.80	16.33 ± 1.55	16.37 ± 1.53	16.34 ± 1.90	16.32 ± 1.73	16.26 ± 2.08
	Meditative focusing	16.03 ± 1.62	16.36 ± 1.59	16.36 ± 1.66	16.44 ± 1.65	16.33 ± 1.63	16.01 ± 1.64
	Meditation	15.97 ± 1.59	16.43 ± 1.58	16.49 ± 1.72	16.49 ± 1.75 <sup>b</sup>	16.43 ± 1.75	16.13 ± 1.95
Pa wave	Random thinking	34.76 ± 2.79	34.47 ± 2.86	34.82 ± 2.64	34.58 ± 2.85	35.30 ± 2.52	35.17 ± 2.74
	Nonmeditative-focused thinking	35.01 ± 2.50	35.28 ± 2.59	35.38 ± 1.70	35.33 ± 2.00	34.93 ± 2.48	35.50 ± 2.38
	Meditative focusing	34.95 ± 2.61	35.44 ± 1.87	35.08 ± 2.35	35.70 ± 2.39	35.32 ± 2.38	35.17 ± 3.17
	Meditation	34.60 ± 2.89	35.18 ± 2.35	35.19 ± 2.57	35.33 ± 2.58	35.55 ± 2.08 <sup>b</sup>	35.25 ± 2.78
Nb wave	Random thinking	52.73 ± 9.01	53.01 ± 8.30	53.63 ± 8.47	54.01 ± 8.05	55.48 ± 8.09	54.77 ± 8.96
	Nonmeditative-focused thinking	53.76 ± 9.15	53.38 ± 7.93	54.01 ± 7.68	55.88 ± 8.31	56.09 ± 8.70	56.86 ± 9.03 <sup>b</sup>
	Meditative focusing	53.39 ± 8.96	53.71 ± 7.70	55.12 ± 8.35	55.16 ± 7.94	54.46 ± 8.40	54.66 ± 8.77
	Meditation	53.29 ± 8.75	53.25 ± 8.17	54.40 ± 8.35	55.43 ± 7.89	55.19 ± 8.21	54.93 ± 8.55

Abbreviations: SD, standard deviation; RM-ANOVA, repeated measures analysis of variance.

<sup>a</sup> Values are group mean ± SD.

<sup>b</sup> P < .05, RM-ANOVA with Bonferroni adjustment comparing during and post values with pre values.

**Table 4.** Mid-Latency Auditory Evoked Potentials (MLAEPs) Showing Peak Amplitude for 4 Sessions in 6 States for Na, Pa, and Nb Waves<sup>a</sup>

		Peak amplitude (µV)					
Waves	Sessions	Pre	During				Post
			During 1	During 2	During 3	During 4	
Na wave	Random thinking	0.60 ± 0.53	0.47 ± 0.29	0.51 ± 0.40	0.44 ± 0.36	0.48 ± 0.34	0.50 ± 0.44
	Nonmeditative-focused thinking	0.58 ± 0.54	0.52 ± 0.43	0.51 ± 0.41	0.50 ± 0.31	0.50 ± 0.37	0.44 ± 0.40
	Meditative focusing	0.54 ± 0.47	0.49 ± 0.38	0.45 ± 0.38	0.44 ± 0.42	0.54 ± 0.42	0.57 ± 0.58
	Meditation	0.49 ± 0.43	0.52 ± 0.43	0.49 ± 0.39	0.42 ± 0.30	0.47 ± 0.38	0.64 ± 0.62
Pa wave	Random thinking	1.33 ± 0.47	0.84 ± 0.35 <sup>d</sup>	0.77 ± 0.30 <sup>d</sup>	0.83 ± 0.43 <sup>d</sup>	0.90 ± 0.37 <sup>d</sup>	1.32 ± 0.59
	Nonmeditative-focused thinking	1.22 ± 0.61	0.95 ± 0.43 <sup>d</sup>	0.93 ± 0.43 <sup>d</sup>	1.00 ± 0.45 <sup>b</sup>	0.98 ± 0.52 <sup>b</sup>	1.42 ± 0.58
	Meditative focusing	1.28 ± 0.54	1.08 ± 0.51 <sup>c</sup>	1.23 ± 0.48	1.26 ± 0.47	1.29 ± 0.47	1.32 ± 0.48
	Meditation	1.30 ± 0.63	1.20 ± 0.61	1.13 ± 0.58 <sup>b</sup>	1.17 ± 0.52	1.19 ± 0.60	1.26 ± 0.62
Nb wave	Random thinking	0.42 ± 0.30	0.32 ± 0.29	0.35 ± 0.30	0.42 ± 0.29	0.34 ± 0.30	0.48 ± 0.40
	Nonmeditative-focused thinking	0.41 ± 0.37	0.31 ± 0.28	0.38 ± 0.27	0.42 ± 0.33	0.41 ± 0.30	0.50 ± 0.38
	Meditative focusing	0.46 ± 0.38	0.40 ± 0.28	0.44 ± 0.35	0.45 ± 0.37	0.44 ± 0.37	0.49 ± 0.39
	Meditation	0.45 ± 0.37	0.42 ± 0.31	0.37 ± 0.31	0.43 ± 0.32	0.46 ± 0.38	0.54 ± 0.37

Abbreviations: SD, standard deviation; RM-ANOVA, repeated measures analysis of variance.

<sup>a</sup> Values are group Mean ± S.D.

<sup>b</sup> P < .05.

<sup>c</sup> P < .01.

<sup>d</sup> P < .001; RM-ANOVA with Bonferroni adjustment comparing during and post values with pre values.

**Table 5.** Summary of ANOVA Showing Statistically Significant Results

Variables	Factor	F value	df	Huynh-Feldt epsilon	Level of significance
Pa wave amplitude	Sessions	18.05	(2.7, 159.56)	.901	P < .001
Na wave latency	States	3.63	(4.29, 253.33)	.859	P < .01
Na wave amplitude	States	3.19	(3.65, 215.35)	.73	P < .05
Pa wave amplitude	States	31.56	(4.27, 252.15)	.855	P < .001
Nb wave latency	States	9.30	(3.58, 211.47)	.717	P < .001
Nb wave amplitude	States	5.40	(4.42, 261.02)	.885	P < .001
Na wave amplitude	Sessions × States	2.58	(11.52, 679.91)	.768	P < .01
Pa wave latency	Sessions × states	1.86	(13.38, 789.43)	.892	P < .05
Pa wave amplitude	Sessions × states	9.69	(15, 885)	.967	P < .001

Abbreviation: ANOVA, analysis of variance.

**Table 6.** Significant Results of Post Hoc Analyses, Where the Arrows Show the Direction of Change

Variable	Session	During				Post
		During 1	During 2	During 3	During 4	
Na wave latency	Meditation	NS	NS	<.05 ↑	NS	NS
Pa wave latency	Meditation	NS	NS	NS	<.05 ↑	NS
Nb wave latency	Nonmeditative-focused thinking	NS	NS	NS	NS	<.05 ↑
Pa wave amplitude	Random thinking	<.001 ↓	<.001 ↓	<.001 ↓	<.001 ↓	NS
	Nonmeditative-focused thinking	<.001 ↓	<.001 ↓	<.05 ↓	<.05 ↓	NS
	Meditative focusing	<.01 ↓	NS	NS	NS	NS
	Meditation	NS	<.05 ↓	NS	NS	NS

Abbreviations: NS, not significant; ↑, increase; ↓, decrease.

In the present study, the prolonged latencies of the Na and Pa waves suggest slowing of auditory information transmission at mesencephalic–diencephalic levels and at the level of the primary auditory cortex. These findings are similar to those of an earlier study which reported a prolonged latency of the Nb wave related to the practice of a meditation called cyclic meditation.<sup>19</sup> The results following cyclic meditation were believed to be related to the activation of inhibitory mechanisms in cortical areas within the auditory pathway. A previous study which reported increased gamma-amino-butyric-acid (GABA) levels following a 1-hour yoga session<sup>20</sup> was considered to support the results. This is because GABA is a well-recognized inhibitory neurotransmitter in the central nervous system.<sup>21</sup>

As described above, GABA activity increased after yoga practice. In one study, experienced yoga practitioners had a significant 27% increase in GABA levels using magnetic resonance spectroscopy.<sup>20</sup> The increase in GABA levels was seen in experienced yoga practitioners after a 60-minute session of practicing yoga postures compared to no change in GABA levels in controls after they were asked to read for the same amount of time. This study raised the question whether the increase in GABA levels was specific to yoga or was due to an overall increase in physical activity. The same authors provided the answer for this in the subsequent study which compared GABA levels in a yoga and a walking group.<sup>22</sup> The 12-week yoga intervention was associated with greater improvements in mood and lower anxiety, compared to a metabolically matched walking exercise group. This study was also the first to demonstrate that increased thalamic GABA levels are associated with improved mood and decreased anxiety. The implications of the study were that GABA may be mediating some, if not all, of the beneficial effects of yoga on mood and anxiety. The present results cannot be directly compared to these studies, as meditation differs from yoga postures. However, the mental state during yoga postures is ideally the same as in meditation.<sup>13</sup>

The increased latency of the Nb wave after nonmeditative focusing in the present study suggests that following, but not during, focusing without meditation there is also cortical inhibition, though at a different level along the auditory pathway, compared to meditation. The Nb wave corresponds to a neural generator which is more distal along the auditory pathway, viz,

the Heschl gyrus.<sup>6</sup> The delay in auditory transmission following nonmeditative focusing may be related to the fact that attention modulates excitatory and inhibitory lateral interactions in the cortex.<sup>23</sup> During selective attention, there is effective filtering of irrelevant information by modulatory influences.<sup>24</sup> Therefore, for selective attention during nonmeditative focusing, inhibition of auditory transmission at the level of the Heschl gyrus may be necessary.

Decreased amplitudes of the Pa wave occurred during all 4 sessions. As already mentioned, an increase in amplitude suggests that a greater number of neurons were recruited. It may have been expected that listening to the pre-recorded instructions during the sessions would have activated the primary auditory cortex in all 4 sessions. The present results show that this did not occur. The reason for the decrease in Pa amplitudes in all sessions may be due to selective inhibition of certain areas within the primary auditory cortex. Hence, we speculate that sensory responses may have been suppressed to reduce distracting auditory stimuli, so that participants could direct their attention to the taped instructions.<sup>25</sup>

The findings are limited by the fact that (i) there was no way to be certain that the participants were in the 2 meditative states, except for their self-reports and reports of the teacher and (ii) it was also not possible to rule out that participants fell asleep during recordings despite CCTV monitoring and reviewing the raw electroencephalogram (EEG) trace. These limitations may be corrected in future studies if a reliable physiological marker for the 2 stages is found, and the EEG is recorded throughout along with the eye movements and muscle tone to rule out sleep episodes. Despite these limitations, the present study showed that when meditation was considered as 2 stages, as it is described in the ancient texts, changes in MLAEPs occurred in 1 stage, that is meditation without focusing but not in the other, that is meditative focusing. Hence, separating the stages based on the way they were described in the ancient texts may yield new and different effects of meditation.

### Acknowledgment

The authors gratefully acknowledge the funding from the Indian Council of Medical Research (ICMR), Government of India, as part

of a grant (Project No. 2001-05010) toward the Center for Advanced Research in Yoga and Neurophysiology (CAR-Y&N).

### Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

### Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The study was funded by the Indian Council of Medical Research (ICMR), Government of India, as part of a grant (Project No. 2001-05010) toward the Center for Advanced Research in Yoga and Neurophysiology (CAR-Y&N).

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## SPECIAL ISSUE

# Neurophysiological Changes in Meditation Correlated with Descriptions from the Ancient Texts

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Keywords: meditation, autonomic changes, evoked potentials, neuroimaging, attention task

*Meditation is currently considered to be associated with increased awareness. In ancient yoga texts, two separate meditative states have been described. These are meditative focusing (dharana) and a state of mental expansiveness (dhyana). Two more mental states are described in another yoga text. These are random thinking (cancalata) and focusing while not in meditation (ekagrata). The physiological effects of these states have been assessed using autonomic variables, evoked potentials, functional magnetic resonance imaging, and performance in a cancellation task. The findings suggest that dhyana is associated with reduced sympathetic activity and increased vagal tone, whereas dharana does indeed improve performance in an attention task. Hence, correlating findings from ancient texts with contemporary science can be useful.*

Meditation was described early on as a training in awareness, which when practiced for some time leads to changes in perception, attention, and cognition (Brown, 1977). More recently, meditation has been recognized as a state of consciousness in which deep relaxation and increased internalized attention exist, simultaneously (Murata et al., 2004). Perhaps this is the reason why the concepts of directing and regulating attention are considered inherent parts of different meditation techniques (Davidson & Goleman, 1977).

The concepts of meditation described in ancient yoga texts are rather different, as meditation is not supposed to be associated with heightened attention or even of being aware of the experience as it happens. This is most clearly mentioned in the aphorisms (*sutras*) of the sage, Patanjali (ca. 900 B.C.). According to Patanjali, there are eight stages, which are to follow each other in sequence to lead to a stage of ultimate realization (Taimini, 1986). These eight stages are (i) and (ii) rules for good conduct (*yamas* and *niyamas*), (iii) physical postures (*asanas*), (iv) voluntarily regulated breathing (*pranayamas*), (v) withdrawal, particularly from external sensations (*pratyahara*), (vi) focused thinking (*dharana*), (vii) a defocused state of mental expansiveness

(*dhyana*), and (viii) an experience of transcendence or ultimate realization (*samadhi*). While the ideal yoga practice would involve going from one stage to the other in sequence, there have been reports of benefits when novices to yoga practice begin with practicing yoga postures (Khattab, Khattab, Ortak, Richardt, & Bonnemeier, 2007) or voluntarily regulated breathing (Telles, Gaur, & Balkrishna, 2009). This also applies to meditation (Tang et al., 2007). The sixth (*dharana*) and seventh (*dhyana*) stages described by Patanjali are both meditative states.

The sixth stage (*dharana*) fits in with the known descriptions of meditation (Brown, 1977). *Dharana* means confining the mind within a limited mental area (“*deshabandhashchittasya dharana*”; Patanjali’s *Yoga Sutras*, Chapter 3, Verse 1). The description of *dharana* fits in with the contemporary categorization of meditation practices as two main styles (Telles, Naveen, & Balkrishna, 2010). This categorization is based on how attention is directed (Lutz, Slagter, Dunne, & Davidson, 2008). One category is called focused attention (FA), during which attention is sustained and focused on a given object. The second category is called open monitor meditation, where meditators are required not to react, while monitoring the content of ongoing experience. This style is a method by which the practitioner is aware of all mental content from one moment to the next. Both types of meditation styles require mental activity, though the nature of the activity is different. Specifically “open monitor meditation” does not involve a specific attentional focus, but involves brain regions that are active in disengaging attention from ongoing experience. Hence, while *dharana* does include the current descriptions of meditation, *dhyana* does not fit either category. Unlike *dharana*, which requires special effort, during *dhyana* there is no special focusing or effort. The description of *dhyana*, is as an uninterrupted flow of the mind toward the object chosen for meditation (“*tatra pratyayaikatanata dhyanam*”; Patanjali’s *Yoga Sutras*, Chapter 3, Verse 2).

A series of experiments have been carried out to understand whether the physiological effects of *dharana*

and *dhyana* are distinct and different. In these experiments, two more mental states described in another yoga text (the *Bhagavad Gita*, which was compiled ca. 500 B.C.) were considered as control sessions. The first was *cancelata* (*Bhagavad Gita*, Chapter 6, Verse 34; Sarasvati & Swami, 1998), which is a stage of random thinking. The second state was *ekagrata* (*Bhagavad Gita*, Chapter 6, Verse 12), during which the attention is directed to a number of associated thoughts. If a person chooses thoughts related to meditation, it would be easier for them to practice *dharana* and *dhyana*.

These studies were carried out on healthy male volunteers whose ages ranged between 20 and 55 years (group mean age  $\pm$  SD,  $29.0 \pm 6.8$  years). All of them were residing at a yoga center in South India and were actively engaged in studying yoga. Their normal health status was based on a routine case history and chemical examination.

While they were practicing other yoga techniques as well, all of them had a minimum of 6 months experience of meditation on the Sanskrit syllable, Om (group average experience  $\pm$  SD,  $22.5 \pm 17.5$  months). This meditation technique can be separately practiced as *dharana* (focusing on thoughts of Om) and *dhyana* (where the practitioner does not focus on Om but reaches an expansive mental state where all thoughts are about Om, but no effort is involved). Participants can be trained to practice the two techniques (*dharana* and *dhyana*) separately and at will. To ensure that all of them were doing it correctly, they were given a 3-month orientation course, during which time they were supervised by an experienced meditation teacher.

All participants were assessed in four sessions on four separate days, at the same time of the day. The four sessions were *dharana*, *dhyana*, *ekagrata* and *cancelata*. The evaluation of the participants' ability to attain these four mental states was based on their self-report (on a scale of 0 to 10), as well as on consultations with the meditation teacher.

The assessments included (i) autonomic variables and the breath rate, (ii) brainstem auditory evoked potentials, (iii) functional magnetic resonance imaging, and (iv) performance in a letter cancellation task. Each of these assessments and the results obtained will be discussed below in detail.

### Autonomic Variables and the Breath Rate

The autonomic variables assessed included the heart rate, heart rate variability (for both time and frequency domain analysis), skin resistance, finger plethysmogram amplitude, and the breath rate. Assessment were made before (5 minutes), during (20 minutes), and after (5 minutes),

the four practices. These were: (i) *dharana*, (ii) *dhyana*, (iii) *cancelata*, and (iv) *ekagrata*, practiced on four separate days. Data were analyzed using a repeated measure ANOVA and Bonferroni adjusted post hoc analysis. Most of the significant changes were observed during *dhyana*. These were an increase in the finger plethysmogram amplitude, a decrease in heart rate, breath rate, and changes in both the frequency and time domain analyses of the heart rate variability (HRV) (Indian Council of Medical Research Project Report, 2009). Frequency domain analysis of the HRV resulted in a significant decrease in low frequency (LF) power, an increase in high frequency (HF) power, and decrease in the LF/HF ratio during *dhyana*.

Time domain analysis of the HRV resulted in an increase in the NN50 count and the pNN50 during *dhyana*. During *dharana* there was a significant increase in the skin resistance level, with no other change during the practice. During *ekagrata* there was a significant increase in the skin resistance level, LF power, and a decrease in the HF power of the HRV. During *cancelata* the skin resistance level increased, as did the breath rate and LF power of the HRV.

In all four sessions there was an increase in the skin resistance level. However, apart from this, the changes during *ekagrata* and *cancelata* suggested increased sympathetic activity, whereas all the changes seen in *dhyana* were suggestive of reduced sympathetic activity and a shift towards vagal dominance. The decrease in the breath rate during *dhyana* is in keeping with this state being associated with increased relaxation.

### Brainstem Auditory Evoked Potentials

Evoked potentials are used in meditation studies since the correlation between different evoked potential components and the underlying neural generators is fairly well worked out (Woods & Clayworth, 1985). Another reason is that the cerebral cortex is actively involved in meditation (Lazar et al., 2005). Hence cortico-efferent gating may occur with changes at subcortical relay centers (Napadow et al., 2008). Brainstem auditory evoked potentials (BAEPs) provide an objective physiological index of auditory functions subcortically. BAEPs were recorded with binaural click stimuli (of 50  $\mu$ s duration, 40 Hz frequency, and 80 dB nHL intensity), averaged for 1,500 stimuli (Kumar, Nagendra, Manjunath, Naveen, & Telles, 2010).

The peak latency of a specific component, the wave V, increased significantly during *dharana*, *ekagrata*, and *cancelata* sessions, but there was no change during the practice of *dhyana*. An increase in the latency of an evoked potential component is understood to suggest that sensory information processing at the level of the underlying

neural generator is delayed (Subramanya & Telles, 2009). Wave V is considered to correspond to the inferior colliculi, located in the tectum (midbrain) (McEvoy, Frumkin, & Harkins, 1980). The present results suggest that *dhyana* practice alone does not delay auditory sensory transmission at the brainstem level, whereas *dharana* practice is associated with a delay, as are the practices of *ekagrata* and *canalata*.

### Functional Magnetic Resonance Imaging

Functional magnetic resonance imaging (fMRI) measures hemodynamic changes related to neural activity in the brain or spinal cord (Deyoe, Bandettini, Neitz, Miller, & Winans, 1994). A 3.0 T scanner (Philips) was used to obtain echo-planar images (Indian Council of Medical Research Project Report, 2009; Dawn, Telles, George, & Naveen, 2010). For this experiment, participants switched among *canalata*, *ekagrata*, *dharana*, and *dhyana* phases, spending one minute in each stage. The sequence was then repeated once more. All comparisons were made with respect to the *canalata* phase, which was taken as the control phase.

During *ekagrata* there was bilateral activation of the middle temporal gyrus, (whose exact function is not known, but is believed to be connected with recognition of faces), contemplating distance related to spatial orientation, and accessing meanings of words during reading (Duara et al., 2008). The left parahippocampal gyrus activated in *ekagrata*, which is concerned with the formation of spatial memory. There was also bilateral fusiform gyri activation, which is correlated with face and body recognition, recognition of numbers and words, and abstraction of concepts (Thomaes et al., 2009). The bilateral activation of the cerebellum during *ekagrata* may suggest a certain level of involvement in regulation of tone and posture, which may be related to the fact that *ekagrata* is associated with paying greater attention (in this case) to the auditory information supplied.

*Dharana* is like *ekagrata*, a mental state characterized by increased attention. During *dharana* the increased activation of the anterior cingulate is suggestive of enhanced cognitive and attentional processing (Leroux et al., 2009). The bilateral activation of the dorsolateral prefrontal cortex suggests that *dharana* would facilitate functions known to be subserved by the prefrontal cortex, such as planning, cognitive behavior, and various functions, which come under the broad category of "executive functions" (Bertolino et al., 2009).

In *dhyana* (compared to *canalata*) the changes were more complex. White matter hyperintensities were seen in the frontal region. White matter hyperintensities in the

frontal region have been correlated with reduced frontal rCMRglc (regional glucose metabolism) and low executive scores (Tullberg et al., 2004). *Dhyana* was also associated with increased activation in the right orbitofrontal cortex, a region of the association cortex involved in cognitive processes such as decision making, as well as being involved in emotion regulation and reward.

### Performance in a Letter Cancellation Task

The letter cancellation task assesses selective attention and concentration (Uttl & Pilkenton-Taylor, 2001). The performance in a six-letter cancellation task was assessed before and after each of the four practices separately (Kumar & Telles, 2009). There was also a control group of non-meditators, for comparison. All assessments were made before and after the practices. The net scores in the task were significantly higher after the *dharana* session and lower after the *canalata* session. The results suggest that focusing on the symbol Om in *dharana* sessions may have a favorable effect on selective attention, concentration, visual scanning abilities, and a repetitive motor response, all of which are involved in a cancellation task. The absence of change after the *ekagrata* session suggests that non-meditative focusing did not have this effect.

### Summary

Objective assessments of autonomic variables, brainstem auditory evoked potentials, functional magnetic resonance imaging, and performance in a cancellation task, showed differences between *dharana* and *dhyana* meditative sessions. The findings were mainly in keeping with the descriptions of these two meditative states mentioned in ancient yoga texts. It is also interesting to speculate that even if a particular meditation technique requires focusing (hence, resembling *dharana*), meditators may inadvertently enter the *dhyana* phase. Accordingly, differences observed in a group may occur because participants are in different stages (i.e., *dharana* or *dhyana*) of meditation. These observations suggest that knowing the descriptions of these practices in the ancient texts may help in understanding contemporary research findings.

### Acknowledgment

The authors gratefully acknowledge the funding from Patanjali Research Foundation, Haridwar and the Indian Council of Medical Research (ICMR), Government of India, as part of a grant (Project No. 2001-05010) towards the Center for Advanced Research in Yoga and Neurophysiology (CAR-Y&N).

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